Piles Redesigned: A Comparison of Concrete and Timber

ARCE 453 Senior Project

Riley Mullen

James Mwangi

12/7/2021

Table of Contents:

Part I: Timber Pile Design

Abstract

The idea for this project arose during my internship this past summer with IMEG Corp. I had the opportunity to learn about life cycle analyses which are used as a tool to assess the sustainability of buildings and construction. I gained experience using Life Cycle Analysis (LCA) software and explored the environmental impacts of various past projects with other interns and the guidance of IMEG's Sustainability Task Force. The major finding from this research was that concrete was the most detrimental material and the foundation system frequently had the largest contribution of harmful environmental impacts. This is because concrete is the most common material used for foundation systems, although it is not the only option. An executive structural engineer at the San Francisco office, where I was interning, mentioned his previous experience using timber pile systems in the Bay Area. This led to the idea to investigate timber piles as possibly a more sustainable alternative foundation system for my senior project. IMEG kindly allowed me to use one of their completed buildings and assisted me throughout my project. Various engineers from IMEG's San Francisco office and the Geotechnical Engineer that worked on the project helped me establish a starting point for my senior project by providing all necessary documents and drawings, as well as answering my questions throughout the project.

This report explores a comparison of a timber pile system and the actual cast-in-place auger pile system of IMEG's past project, Building 1 on the Coleman Highline site in San Jose, California. After reading through the Geotechnical Report completed prior to construction in 2016 and other necessary documents, I reached out to a Senior Consultant at Langan. He was the principal engineer who provided the original geotechnical report and helped me better understand the report. From the test results of timber piles provided by the Geotechnical Engineer and with his help, I estimated capacities for various sizes of timber piles to use in the redesign. Then, the piles and pile caps were redesigned for the Building 1 foundation system. A new foundation plan and pile cap details were made to help visualize this new system and help with the design process. Next, two LCA's were completed using the online OneClick LCA Software. Each LCA looked at the entire structural system of the building with the only difference being in the foundation systems. These two LCA's are analyzed and compared in this report. The report assesses each foundation system and their effect on the buildings total environmental impacts. The construction process and cost of each system is also considered in an overall comparison of timber and concrete pile systems.

Background Information

Piles are a type of deep foundation system, which is used when a site has poor soil quality and shallow foundations are prone to failure. A pile is essentially a long, slender member that can be installed into the soil in various ways including driving and pouring. Piles are often categorized by material and can be made from concrete, steel, timber, or a combination of those materials.

Concrete piles are a very common deep foundation system. They can be precast, meaning they are manufactured before construction and driven into the ground. Concrete piles can also be cast-in-place, meaning they are poured into place rather than driven. This eliminates the potential for damage during the driving process. A cast-in-place concrete pile can require a shell, which can be permanent or temporary. If the pile is poured into the shell, the shell stays in the ground and it is a cased pile. The shell can also be removed while the concrete is being poured which makes it an uncased pile. Coleman Highline Building 1 is supported by an auger cast pile system. An auger pile is installed by drilling the auger into the ground and injecting the concrete as the auger is removed. Auger cast piles can be installed quickly and are relatively inexpensive. Concrete auger cast piles have a high capacity, which in addition to the other advantages, makes them a popular choice (Gallagher and Fritzges, 2015).

Timber piles have been historically used but are no longer as popular because new materials, such as concrete, have been introduced. Timber is an economical and sustainable material which makes it a responsible material to use. But timber is not always an appropriate choice. Timber piles have a lower capacity than concrete piles. This means when the loading is very high, they are not an efficient choice and more timber piles will be required than concrete piles under the same load. This can potentially increase cost due to the additional material. Each pile is also limited in length by the height of the tree it comes from, which has the potential to be a problem. In addition, they have the potential to rot or decay if untreated (Evett and Liu, 2014). This can reduce their life span, especially when they are not installed below the water table. When permanently encapsulated by water the timber is protected from harmful insects and slows the decaying process due less exposure to oxygen. Various treatments can be used to minimize this damage.

This site was specifically chosen because of the geotechnical conditions. IMEG helped decide on this site and the assumption was made that timber piles could be used for design assuming they had proper treatment where above the water table. The geotechnical report states that the groundwater table is approximately 6-8 feet below the ground surface (Walker and Rogers, 2014). Although the timber piles will not be completely submerged it water, the conditions were assumed to be suitable for the design if treated. Further testing would likely be required if the timber pile design was going to be used.

Procedure

Pile capacity is formed from end-bearing, skin friction or a combination of both. An end-bearing pile must be long enough to reach hard soil or rock that can support the pile load. This is not possible or reasonable to do when this layer is extremely far below the ground surface, and this is when friction piles are a better choice. A friction pile supports the pile load through adhesion between the pile surface and surrounding soil (Evett and Liu, 2014). This forms the pile capacity equation:

$$Q_{ultimate} = Q_{friction} + Q_{bearing} = f \cdot A_{surface} + q \cdot A_{tip} \qquad \text{(Eq. 1)}$$

Here the term (f) refers to the unit skin friction or adhesion between the pile and surrounding soil . The term ($A_{surface}$) refers to the surfaced area of one pile and (A_{tip}) refers to the cross-sectional area of the pile at the tip of the pile. The term (q) refers to the ultimate bearing capacity of the soil under the tip of the pile. Since these terms are not only dependent on the pile but also the soil surrounding it, different methods are used for different soil types.

Piles capacity can also be found or verified on-site through testing. Test are done by driving test piles and adding load with dead weight or hydraulic jacking. From the loading a load versus settlement graph which is used to analyze the piles behavior. The settlements found are then verified with the allowable settlements given in applicable building codes (Evett and Liu, 2014). *Figure 1* below is an example of a load versus settlement graph found in *Soils and Foundations 8th Edition*:

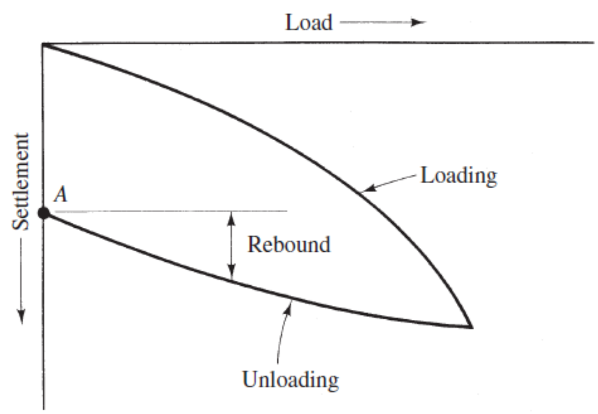


Figure 1

The Davisson's (1973) Method was used to determine pile capacity from given load versus settlement graphs. This method calculates the deflection at failure through the formula (McCarthy, 2008):

$$\delta_{failure} = \delta_E + \left(0.15 + \frac{D}{120}\right) \qquad \text{(Eq. 2)}$$

The term (δ_E) is a pile's elastic deflection and (D) is the pile diameter. This deflection can be found using the test load (P), length of pile (L), cross sectional area of the pile (A), and Young's Modulus of the pile material, (E). The elastic deflection can be calculated with Eq. 3:

$$\delta_E = \frac{PL}{AE} \qquad \text{(Eq. 3)}$$

The elastic deflection curve is then plotted onto the corresponding load versus settlement graph. The Davisson Curve from Eq. 2 is also plotted on the load versus settlement graph. The Davisson curve and elastic deflection line should be parallel and a value of $\left(0.15 + \frac{d}{120}\right)$ apart. This will look like *Figure 2* with the intersection of the Davisson Curve and the load versus settlement graph being the ultimate load (Infratech Energy, 2003):

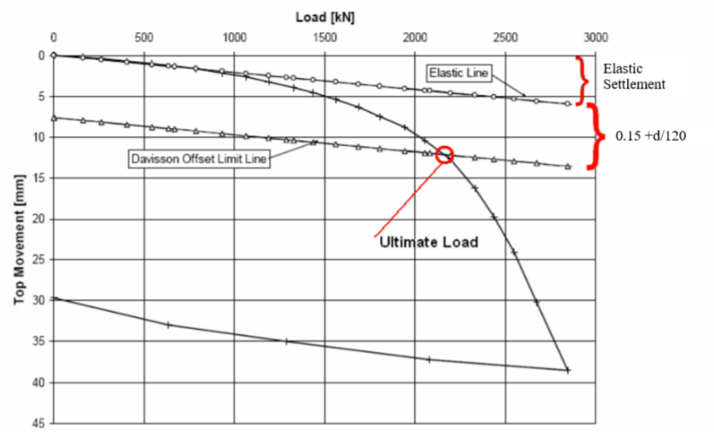


Figure 2

The load to use as the pile design capacity is the ultimate load with a factor of safety of 2.0 applied to it. This means you take one half of the ultimate load ($Q_{ultimate}$) to be equal to the design capacity of a single pile (Q_{design}).

$$Q_{design} = \frac{Q_{ultimate}}{2} \qquad \text{(Eq. 4)}$$

The Geotechnical Engineer provided 3 test result plots for 3 different pile diameters and lengths. The Davisson Method was used to get an approximate capacity for each pile types. These results can be found in *Appendix 1*. For the 14" pile, the Davisson Offset curve does not intersect the load versus settlement plot at any point. When this happens, the maximum test load can be taken as the failure load (McCarthy, 2008).

For this project, the loads were given in the provided construction documents as dead, live, and lateral for each pile group. These loads were then factored using ASD load combinations that can be found in *ASCE 7-16*. Of the ten load combinations, the governing combinations were checked to find the maximum load on each pile group. The governing combinations are as follows:

$$8.\, D + 0.7E_v + 0.7E_h$$

$$9.\, D + 0.525E_v + 0.525E_h + 0.75L$$

$$10.\; 0.6D - 0.7E_v + 0.7E_h$$

The term (D) refers to dead load and (L) refers to live load. The terms (E_v) and (E_h) are the vertical and horizontal seismic load effects. E_v can be combined with the dead load using the relation in ASCE 7-16 of $E_v = 0.2S_{DS}D$, with (S_{DS}) being the design spectral response parameter at short periods. (E_h) is also defined in *ASCE 7-16* as $E_h = \rho Q_E$, with (ρ) being the redundancy factor and (Q_E) being the horizontal seismic forces. For Building 1, $S_{DS} = 1.0g$ and $\rho = 1.3$. Although $\rho = 1.3$, it was assumed that this was already factored into the lateral loads, (E),

given on the plan. This simplifies the load combinations above to the combinations used in excel:

$$8.\ \ 1.14D + 0.7E$$

$$9.\ \ 1.105D + 0.525E + 0.75L$$

$$10.\ \ 0.46D + 0.7E$$

From these combinations, the maximum tension on compression loads were calculated for each pile group individually. The groups were checking individually because there were load variations from group to group. The max compression load was used to find the number of required piled with Eq. 5 for each size pile.

$$N_{req} = \frac{C_{max}}{Q_{design}} \qquad \text{(Eq. 5)}$$

Once the number of required timber piles was found for each size, the piles were regrouped to minimize the required designs. The 16" pile was not used because the length from the test of the 16" pile was significantly longer at 80'. By using the 12" and 14" piles, the length of the piles was like that of the original auger cast pile design. The maximum forces from each new pile group were then used to design the pile caps.

From the maximum loads, the cap was sized based on the *ACI 318-19*. The dimensions were designed to be proportional to that of the auger cast pile caps used in the original design. The minimum center to center spacing of the piles was taken as:

$$s = 3D \qquad \text{(Eq. 6)}$$

With (*s*) being the center-to-center spacing and (*d*) referring to the pile diameter in inches. The edge center-to-edge of the pile cap distance used was the pile spacing with an additional 3 inches. This is the distance between the center of the pile and the edge of rebar and is equal to the center-to-center spacing of the piles. Further information on calculating pile spacing can be found in *ACI-18-19 13.4.1.1*, but the reason for using Eq. 6 is to size the pile caps proportional to the auger cast design. The minimum thickness of each pile cap in feet was calculated as:

$$h = \frac{D}{12} + 2 \qquad \text{(Eq. 7)}$$

This was used in the initial calculation of the pile size. The pile cap was then checked for one-way and two-way shear. Both shear checks are to satisfy Eq. 8 and both use $\varphi = 0.75$:

$$V_u \le \varphi V_c \qquad \text{(Eq. 8)}$$

The one-way shear check calculates (V_c) according to the *ACI 318-19 Table 22.5.5.1* The axial load is assumed to be negligible and Option (a) from the table is simplified to:

$$V_c = \left[2\lambda\sqrt{f'_c} + 0\right]b_w d \qquad \text{(Eq. 9)}$$

The modification factor (λ) is assumed to be 1.0. (f'_c) is the concrete compressive strength (psi). The erm (b_w) refers to the width of the pile cap and the last term (*d*) refers to the pile cap thickness minus the concrete cover which is 3".

The two-way shear check calculated (V_c) according to the ACI 318-19 Table 22.6.5.2. Each the smallest resulting value is used.

a) $V_c = 4\lambda_s\lambda\sqrt{f'_c}$ (Eq. 10a)

b) $V_c = (2 + \frac{4}{\beta})\,\lambda_s\lambda\sqrt{f'_c}$ (Eq. 10b)

c) $V_c = (2 + \frac{\alpha_s d}{b_o})\,\lambda_s\lambda\sqrt{f'_c}$ (Eq. 10c)

In Eq.'s 10a-c the size modification factor is $\lambda_s = \sqrt{\frac{2}{1+\frac{D}{10}}} \leq 1$ (*ACI 318-19 22.5.5.1.3*). The term (β) is the ratio of long to short sides of the reaction area. Eq. 10b will not govern so it is omitted from the design calculations. The term (α_s) as defined in ACI 18 22.6.5.3 is 40 is for interior columns, 30 for edge columns and 20 for corner columns. Lastly, (b_o) is the perimeter of the critical section. For two-way shear, the critical section is *D/2* from the center of the column. Therefore, the perimeter can be found with $b_o = (b_{col} + d)4$.

The shear occurring in the pile cap is calculated by finding the axial force in a single pile and multiplying it by the piles in the effective area. For one way-shear the effective area is located a distance (D) from the column and only looks at one side of the pile cap centerline. For two-way shear the effective area is located outside of the critical section, or *D/2* from the column on all sides. The pile axial force is taken as the total load divided by the number of piles.

Next, the pile cap bottom or tension reinforcement is calculated according to the maximum moment, (M_u), about each axis. This is found by taking the sum of each pile moment on one side of the centerline of the pile cap, which is found by multiplying the single pile axial load by the distance for the column. The calculation of the required rebar in each direction is calculated according to *ACI 318-19 22.2*. The required steel area is calculated with:

$$A_{s,req'd} = \frac{M_u}{\varphi(0.95 f_y d)} \quad \text{(Eq. 11)}$$

In Eq. 11, $\varphi = 0.9$ for bending and (f_y) refers the yield strength of the rebar (psi). This is then checked with the minimum required steel area, ($A_{s,min}$) by the larger of:

$$a)\ A_{s,min} = \frac{3\sqrt{f'_c}}{f_y}(b_w d) \quad \text{(Eq. 12a)}$$

$$b)\ A_{s,min} = 0.0018 A_g \quad \text{(Eq. 12b)}$$

In Eq. 12b (A_g) refers to the cross cross-sectional area of the pile cap which can be found by $b_w h$. All the other variables as previously defined. The largest steel area found in Eq. 11 and Eq.'s 12a-b is then used to choose an appropriate size and number of bars for each pile cap.

There are a few pile groups that require rebar on the top or compression face of the pile cap along with the bottom layer. This calculation is to ensure the section of the pile cap is in equilibrium to maintain the required strain $\varepsilon = 0.003$, as stated in *ACI 318-19 22.2.2.1*. This steel area, (A'_s), is calculated to satisfy the following equation:

$$C_s = C_c + T_s \qquad \text{(Eq. 18)}$$

In Eq. 18, $C_s = A'_s f_y$, and is the steel component of the compression force in the section. The concrete component of this compression force is $C_c = 0.85 f'_c a_b w$. The term in this equation $a_b = \beta_1(h - (c + 3))$, with $\beta_1 = 0.8$ and c referring to the distance from the neutral axis to the center of the bottom rebar. The force resulting from the tension steel is $T_s = A_s f_y$.

<u>Results</u>

The pile caps were designed using Excel and can be referenced in *Appendix 2*. The related drawings can be found at the end of the report in Appendix 7. The new foundation plan and details are updated and are S2.03 and S2.04. This new layout can be compared to the original layout on 1S2.01 and 1S4.01 which were provided by IMEG.

Part II: Life Cycle Assessments and Comparison

Abstract

This portion of the project entails a life cycle analysis with OneClick LCA Software on the original Coleman Highline Building 1 and the redesigned Building 1. The results will be analyzed and compared to see if the timber piles had an impact of the environmental effect of the building.

Background Information

A life cycle analysis or assessment is a method of evaluating the environmental impact of a product over the course of its life (Nemerow et al., 2005). What this means is assessing the environmental impact from when it is created until it is disposed of. This takes into consideration the transportation and operational environmental impacts as well. A life cycle assessment can be done during a products' life, but it can also be completed during design.

In this report, the life cycle analysis is going to be evaluating all the structural components in each design of Building 1. The operational component of the analysis is minimally included, and the analysis is focused on the structural components only. This means that the architectural components have also been excluded. A life cycle analysis is an excellent tool for the construction industry because it provides a better understanding of what is harmful so the negative impact of a product or project can be mitigated. This is not only beneficial to the environment, but also beneficial to many businesses, especially in the construction industry. Using a life cycle analysis has the potential to help businesses manage cost as well as environmental impact (About One Click LCA, 2021). This enables more people and businesses to design and build responsibly.

A life cycle analysis categorizes periods of a product or project's life into various stages. They are the Product Stage, The Construction Process Stage, the Use Stage, the End-of-Life Stage and Benefits and Loads Outside the Systems Boundary. Each stage is broken down further and can be summarized in the figure below from OneClick's *Life Cycle Assessment Software FAQ* page:

Product Stage			Construction Process Stage		Use Stage							End-of-Life Stage				Benefits and loads beyond the system boundary		
Raw material supply	Transport	Manufacturing	Transport to building site	Installation into building	Use/application	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Deconstruction/demolition	Transport	Waste processing	Disposal	Reuse	Recovery	Recycling
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D	D	D

Figure 3

These categories are used to organize the life cycle assessment's results. The results also can be organized by material or assembly. This way the most detrimental items can be identified and replaced with other choices if possible.

Procedure

The goal of these life cycle assessments is to quantify the impact each design has over the building's life and see if the new foundation system is successful in reducing the global warming potential. To begin, a take-off of the entire structural system of Building 1 first with concrete piles and then with timber piles must be completed. This is then input into the LCA software. For this project, the only difference between the two take-offs are the foundation systems. The values in the take-offs were calculated with the original Revit model provided by IMEG. Refer to *Appendix 3* for concrete pile takeoff and *Appendix 4* for the timber pile take off.

These takeoff values are used as inputs for the LCA and OneClick is then able to return the results. The results of each life cycle assessment tell us the amount of embodied carbon in each building and where it is coming from. Embodied carbon is the total amount of greenhouse gas emissions released over the building's life in terms of a carbon dioxide molecule. It is given in GWP, or global warming potential, and is a measurement relative to the impact a single carbon molecule has over a time frame, often 100 years (*SE2050*). The unit used is $t\ CO_2$, or tons of carbon dioxide. Carbon dioxide is often released by burning fossil fuels, a common form of energy, and other waste.

Other results from the life cycle analysis are given in $t\ CO_{2e}$, or tons of carbon dioxide equivalent. This means other greenhouse gases besides carbon dioxide are also included in the tons of emissions. Other common greenhouse gases as defined by the EPA include methane, nitrous oxide, and fluorinated gases. Methane is emitted during the production or extraction of fossil fuels such as oil, coal, and natural gas. It can also come from various agricultural practices. Nitrous oxide is typically the result of soil management practices, such as the use of fertilizers. A

much smaller portion of nitrous oxide emissions is also due to the use of fossil fuels and waste management. Fluorinated gases include hydrofluorocarbons and other synthetic greenhouse gases. They are emitted in smaller quantities than the other common greenhouse gases but are very detrimental the Earth's ozone layer, which protects the planet from ultraviolet radiation.

Results

The results of each life cycle assessment can be found in *Appendix 5* for the concrete foundation and in *Appendix 6* for the timber foundation.

The total embodied carbon of Building 1 with a concrete pile system is 3038.06 t CO_2 and the total for Building 1 with a timber pile system is 2913.38 CO_2. As shown in *Table 1A and 1B,* the timber pile system reduces the contribution of embodied carbon from the concrete by 13%. As shown in *Figure 8A and 8B* the timber pile design reduced the contribution of the foundation system to total embodied carbon by 4%.

Tables 3A and 3B break down the contribution of the foundation system by stage and material. The first two columns are categorized by stage. The Transportation Stage embodied carbon dropped by 12.9 t CO_2, from 12.9 t CO_2 in the original design to 73.3 t CO_2 in the timber pile design. But the Construction Stage increased by 4.1 t CO_2, with only 33.3 t CO_2 in the original design and 37.4 t CO_2 in the timber pile design. The third through fifth columns are categorized by material. The concrete in the foundation system is reduced by 115.0 t CO_2, from 572.0 t CO_2 to 457.0 t CO_2, with the use of timber piles. The steel contribution in the foundation system is reduced by 65.7 t CO_2, from 143.2 t CO_2 to 77.5 t CO_2. This is because the timber piles eliminate the need for rebar used to reinforce the concrete piles. Although the use of timber added 66.2 t CO_2 to the foundation system, the net reduction of embodied carbon or global warming potential is 123.3 t CO_2.

Tables 2A and 2B show results in terms of kg CO_{2e}, or overall greenhouse gas emissions, by material type and their cradle-to-gate percent contribution to the total. Cradle-to-gate refers to the early stages in the life cycle of a product with "cradle" meaning the source and extraction of raw materials and "gate" meaning factory doors prior to transportation to the consumer (Castro-Molinare et al., 2014). It lists the largest contributors in descending order.

Figures 4A and 4B break down the embodied carbon of the entire building by life-cycle stages as percentages. *Figures 5A and 5B* divide the embodied carbon of the entire building by material type.

Figure 6A and 6B take a closer look at embodied carbon by displaying each assembly in the structure as a bar which is divided again by color to show the percent contribution by stage. This reduction of concrete in the foundation system is also shown numerically in *Tables 3A and 3B*.

Combined Analysis of Parts I and II

As shown in the Part II results in *Appendix 4 and 5,* the timber pile design reduces the total embodied carbon. This is because concrete as a material is known to reduce large amounts of carbon dioxide due to the production and use of cement (Ramsden, 2020). This can clearly be seen in below in *Figure 9*:

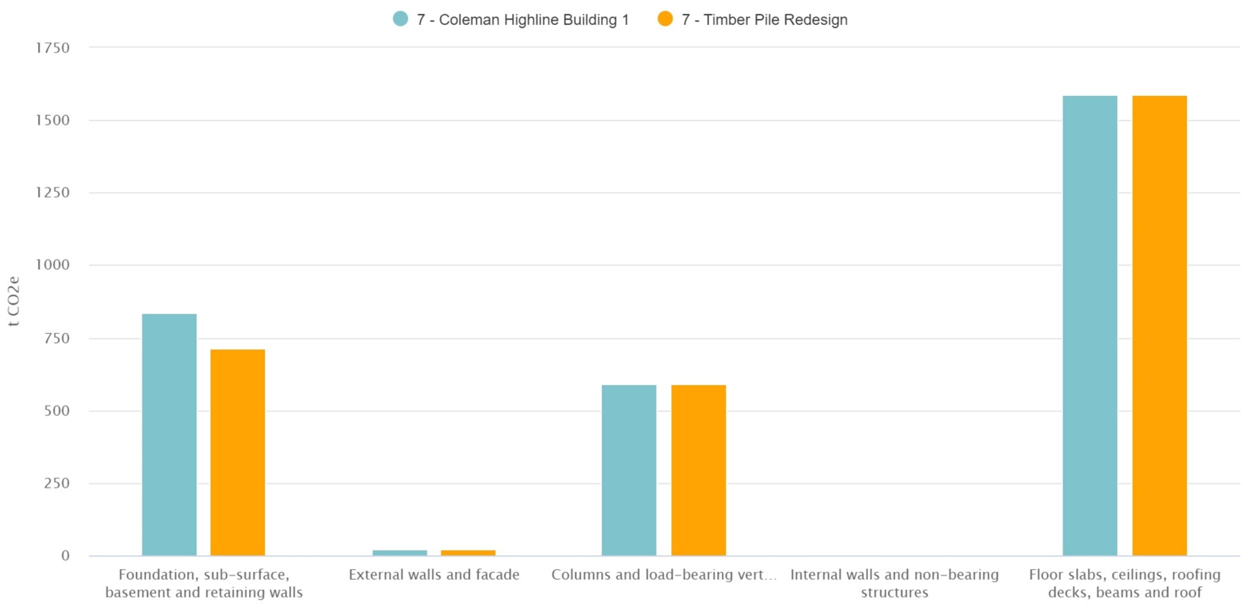


Figure 9

These results prove that the use of timber piles has the potential to mitigate embodied carbon in buildings such as Coleman Highline Building 1. Although more of the embodied carbon comes from the building's horizontal superstructure, the foundation system has a large contribution and should not be disregarded. The use of timber piles can not only reduce the emissions due to concrete, but also eliminates the rebar contribution from the piles.

During the design process, the number of piles per group was greatly increased. This caused an increase in pile cap dimensions as well. For extremely large loads it would not be reasonable to use timber piles because it would require many more piles. In those situations, choices such as auger cast piles used in the original design are more practical to use. Timber piles can efficiently manage relatively small loads, making them a sustainable option to consider for designs of a smaller scale.

Conclusion

Timber piles have specific site requirements to be efficient and long-lasting. This includes being submerged to prevent damage or treated for protection. In this project the timber is assumed to be treated to prevent damage. The alternative would be to use a different material, such as reinforced concrete, for the unsubmerged portion of the pile or move the pile cap lower and extend the column below ground surface. The results proved treated timber piles to be a more sustainable choice than auger cast piles for Coleman Highline Building 1. If one of the alternatives mentioned previously is used, there is potential for the amount of concrete necessary to increase. This would make the use of timber piles less sensible.

It is also important to consider the availability of timber piles depending on the desired length. The 12" diameter pile was 50 ft. in length and the 14" diameter pile was 60 ft. in length. This is approximately the length of the auger cast pile originally used, of 55 ft. minimum. The 16" diameter pile test results were for a pile 80 ft in length. This would be an unreasonable length to source due to high limitations discussed earlier. Long length requirements make timber piles a poor choice. Additionally, more pile testing would likely be required to confirm capacities of each timber piles.

Life cycle assessments are growing in popularity in the construction industry. They are an excellent tool to monitor embodied carbon in buildings and minimize negative environmental impacts. Sustainable construction is the responsibility of structural engineers, geotechnical engineers, architects, general contractors, and building owners. To improve the global warming situation of today, everyone must make an effort to be environmentally conscientious regarding their role in the construction process. Minimizing embodied carbon in buildings is vital to reducing total greenhouse gas emissions. The construction industry has the ability to help mitigate this problem, the responsibility to do so should not be ignored.

This report shows that timber piles reduce the total embodied carbon in Coleman Highline Building 1. The change in building design for this report was purely in the foundation system. The superstructure has a far greater contribution to the embodied carbon total, which explains why that is often the first choice when altering design to be more sustainable. However, the foundation system should not be ignored and excluded from sustainable building design. When the foundation system is designed sustainably along with the building superstructure, there is an excellent opportunity to greatly reduce the embodied carbon total.

Sources:

About one click LCA. One Click LCA® software. (2021, November 17). Retrieved December 6, 2021, from https://www.oneclicklca.com/about-one-click-lca/.

American Concrete Institute. (2019). *ACI 318-19: Building code requirements for structural concrete: Commentary on building code requirements for structural concrete (ACI 318R-19)*.

American Society of Civil Engineers. (2017). *Minimum design loads and associated criteria for buildings and other structures: ASCE/SEI 7-16 Provisions* (pp. 8–9,99).

Castro-Molinare, J., Korre, A., & Durucan, S. (2014). A Case Study in the North of Chile. In *Sustainability Analysis of Copper Extraction and Processing using Life Cycle Analysis Methods* (24th , Vol. 33, Ser. European symposium on Computer Aided Process Engineering, pp. 1861–1866). essay, Elsevier Science.

Collin, J. G. (2002). *Timber Pile Design and Construction Manual*. Timber Piling Council, American Wood Preservers Institute.

Environmental Protection Agency. (n.d.). *Overview of Greenhouse Gases*. EPA. Retrieved December 6, 2021, from https://www.epa.gov/ghgemissions/overview-greenhouse-gases.

Gallagher, M., & Fritzges, M. (n.d.). *Foundation Design and Construction for our Structural Brethren Deep Foundation Design Basic Cookbook*. Retrieved November 11, 2021, from http://www.dvase.org/docs/Breakfast%20Seminar/Breakfast%20Seminar%2006FEB15.pdf

Infratech Energy. (n.d.). *Estimation of Ultimate Load from Pile Load Test by Davisson Method*. Retrieved December 5, 2021, from http://www.infratechenergy.com/wp-content/uploads/2020/05/1-AcceptanceOfCompresion.pdf.

Life Cycle Assessment Software FAQ: One click LCA explained. One Click LCA® software. (2021, June 29). Retrieved December 6, 2021, from https://www.oneclicklca.com/support/faq/.

Liu, C., & Evett, J. B. (2014). *Soils and foundations*. Pearson.

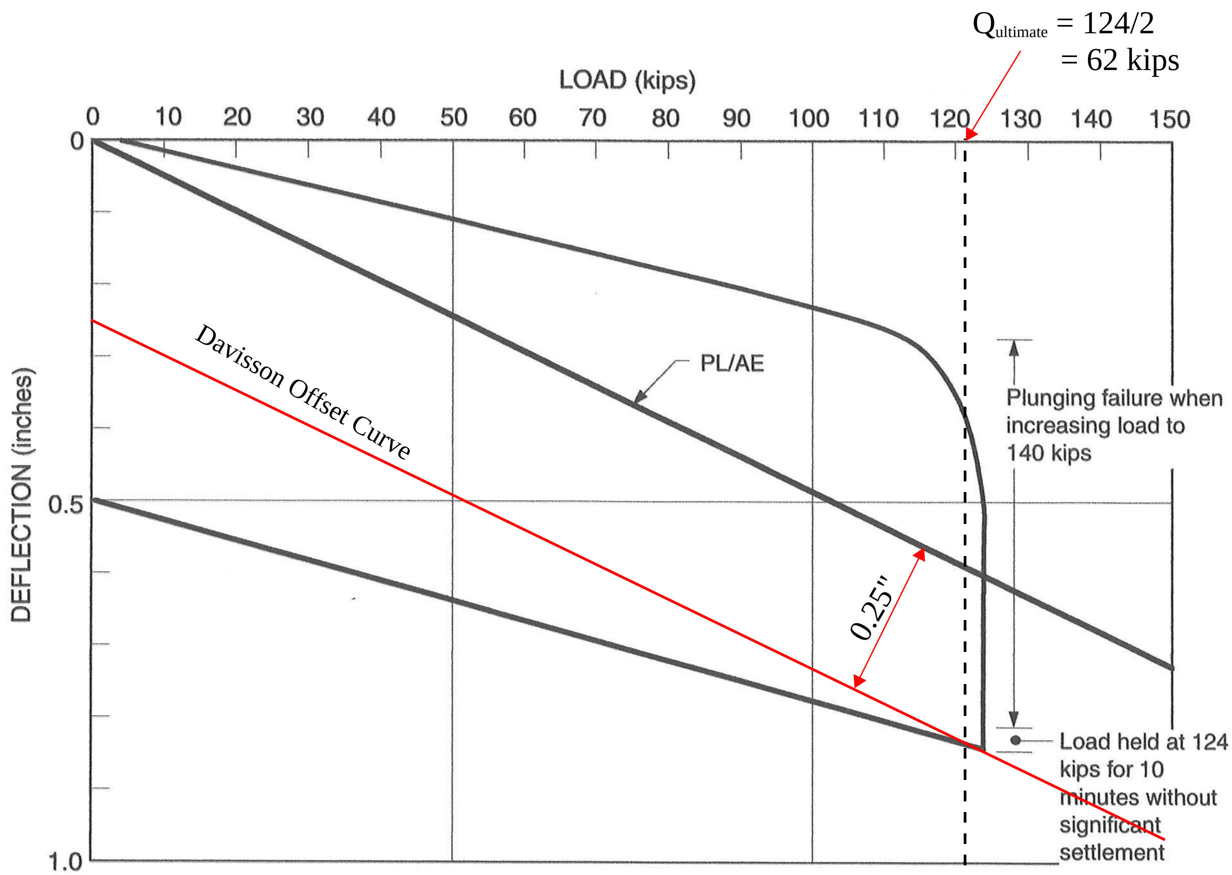
McCarthy, D. (2008). *Empirical Relationships Betweenload Test Data And Predicted Compression Capacity Of Augered Cast-in-place Piles In Predominantly* . Electronic Theses and Dissertations,2004-2019. Retrieved November 3, 2021, from https://stars.library.ucf.edu/etd/3476.

Nemerow, N. L., Agardy, F. J., & El Haggar, S. M. (2005). CHAPTER 13 - Rural and Developing Country Solutions. In *Environmental solutions: A comprehensive guide to environmental problems, and the technology, regulatory, and resource issues to solve them*. story, Elsevier.

Ramsden, K. (2020, November 3). *Cement and concrete: The environmental impact - PSCI*. Princeton University. Retrieved December 6, 2021, from https://psci.princeton.edu/tips/2020/11/3/cement-and-concrete-the-environmental-impact.

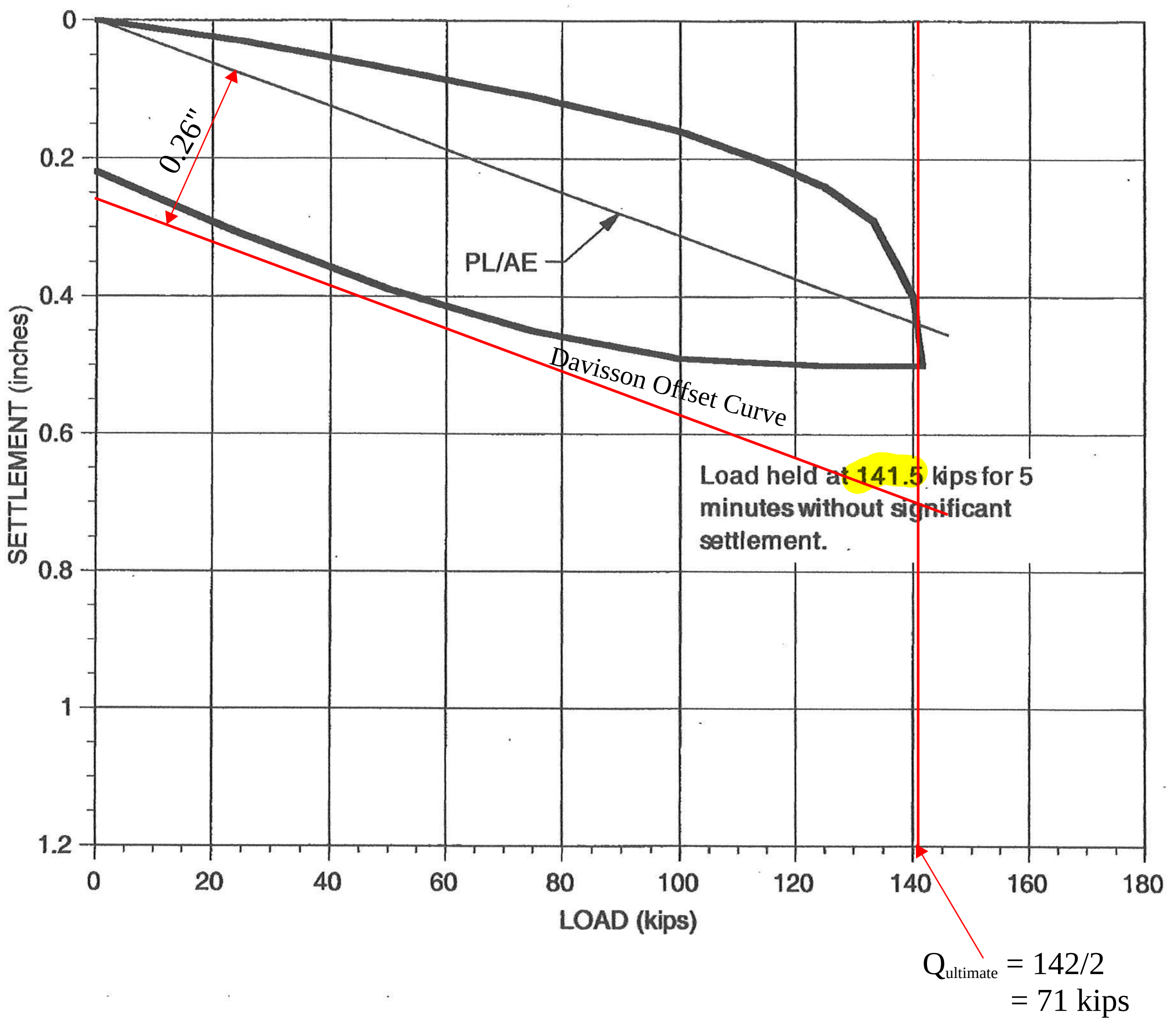
Structural Engineering Institute . (n.d.). *What is embodied carbon?* SE2050. Retrieved December 6, 2021, from https://se2050.org/resources-overview/embodied-carbon/what-is-embodied-carbon/.

Walker, S. A., & Rogers, R. D. (2014). (rep.). *Geotechnical Investigation for Coleman Highline Development- Phase I*. San Jose, CA: Langan Treadwell Rollo.



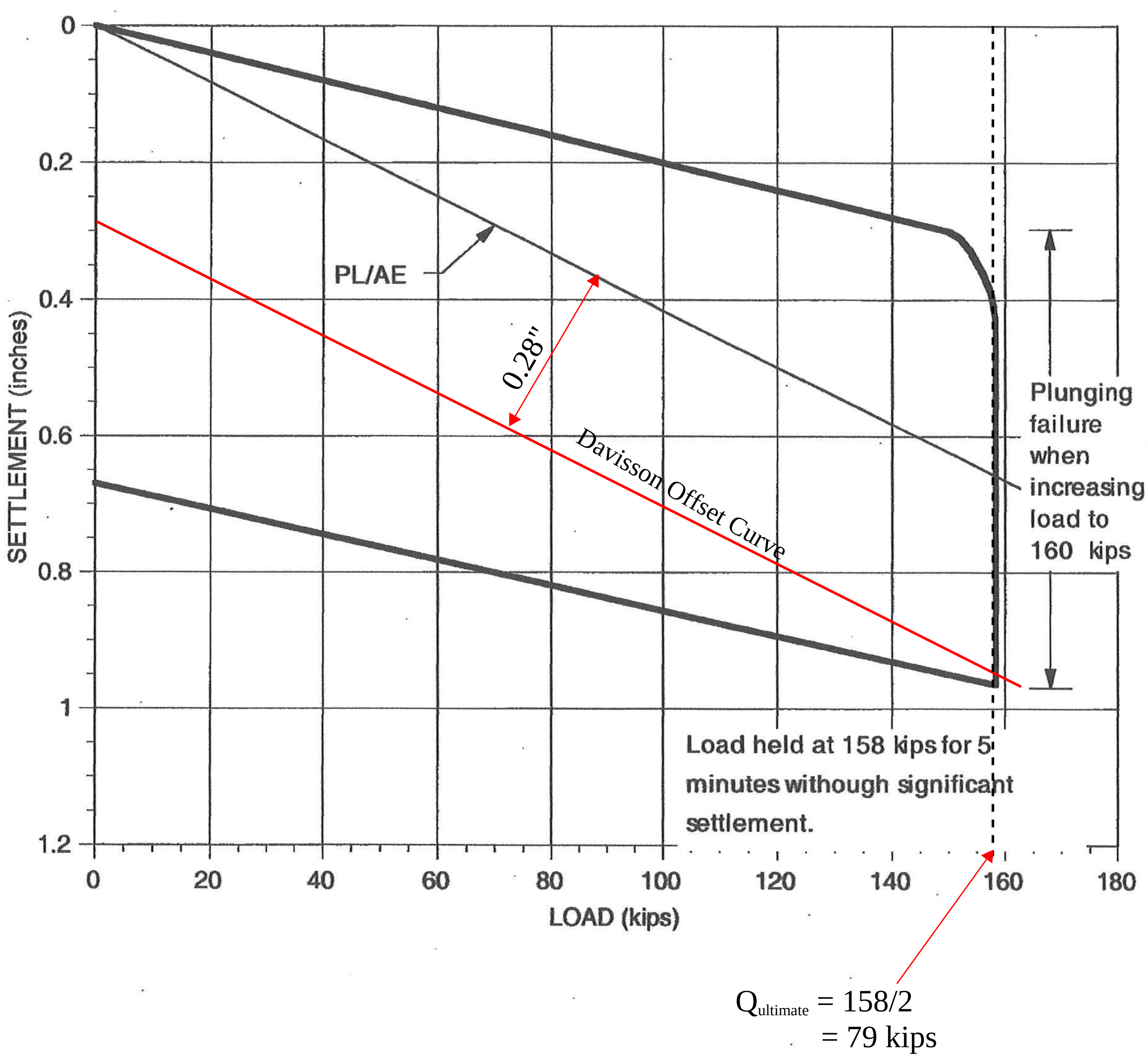
Notes: 1. Load test performed on a 12-inch-diameter timber pile located in test pit TP-2.
2. Pile loaded using the ASTM test method D1143 "Quick Load Test" procedure.
3. Length of pile is assumed to be 50 feet.
4. Modulus of elasticity is assumed to be 1,500 kips per square inch.

110 THE EMBARCADERO San Francisco, California	**PILE LOAD TEST RESULTS FOR 12 - INCH TIMBER PILE**
Treadwell&Rollo	Date: 01/14/08 — Project No. 4591.01 — Figure D-7



Notes: 1. Load test performed on a 14-inch diameter timber pile at column line E-7.5.
2. Pile loaded using the ASTM test method D1143 "Quick Load Test" procedure.
3. Length of pile assumed to be 60 feet.
4. Modulus of Elasticity is assumed to be 1,500 kips per square inch.

110 THE EMBARCADERO San Francisco, California	PILE LOAD TEST RESULTS FOR 14-INCH TIMBER PILE		
Treadwell&Rollo	Date 01/14/08	Project No. 4591.01	Figure D-8



Notes: 1. Load test performed on a 16-inch diameter timber pile at column line A-7.5.
2. Pile loaded using the ASTM test method D1143 "Quick Load Test" procedure.
3. Length of pile assumed to be 80 feet.
4. Modulus of Elasticity is assumed to be 1,500 kips per square inch.

110 THE EMBARCADERO San Francisco, California	**PILE LOAD TEST RESULTS FOR 16-INCH TIMBER PILE**
Treadwell&Rollo	Date 01/14/08 | Project No. 4591.01 | Fiugre D-9

Appendix 2

Pile Re-Grouping

										min						
									12" ø, 50' Long		14" ø, 60' Long		16" ø, 80' Long			
	LOADS:			COMBO:			MAX FORCE:		62 KIPS		71 KIPS		79 KIPS			
PILE GROUP	DEAD	LIVE	LATERAL	2) D+L	8) 1.14D+0.7E	10) 0.46D+0.7E	C	T	No.	Volume	No.	Volume	No.	Volume	Group Selection	Mark
1	242	99	122	341	361.28	-25.92	361.28	0	5.8	228.83	5.1	271.98	4.6	319.27	8- 14"	PC8
2	189	72	80	261	271.46	-30.94	271.46	0	4.4	171.94	3.8	204.36	3.4	239.89	5- 12"	TPC5
3	216	112	80	328	302.24	-43.36	328	0	5.3	207.75	4.6	246.93	4.2	289.86	8-14"	PC8
4	242	112	80	354	331.88	-55.32	354	0	5.7	224.22	5.0	266.50	4.5	312.83	8- 14"	PC8
5	142	39	80	181	217.88	-9.32	217.88	0	3.5	138.00	3.1	164.03	2.8	192.54	5-12"	TPC5
6	175	72	122	247	284.9	4.9	284.9	4.9	4.6	180.45	4.0	214.48	3.6	251.77	5-12"	TPC5
7	296	141	0	437	337.44	-136.16	437	0	7.0	276.79	6.2	328.99	5.5	386.18	8-14"	PC8
8	426	240	0	666	485.64	-195.96	666	0	10.7	421.83	9.4	501.38	8.4	588.55	12- 14"	PC12
9	429	240	0	669	489.06	-197.34	669	0	10.8	423.73	9.4	503.64	8.5	591.20	12- 14"	PC12
10	309	141	0	450	352.26	-142.14	450	0	7.3	285.02	6.3	338.77	5.7	397.67	8-14"	PC8
11	324	149	0	473	369.36	-149.04	473	0	7.6	299.59	6.7	356.09	6.0	418.00	9-14"	PC9
12	429	240	0	669	489.06	-197.34	669	0	10.8	423.73	9.4	503.64	8.5	591.20	12- 14"	PC12
13	429	240	0	669	489.06	-197.34	669	0	10.8	423.73	9.4	503.64	8.5	591.20	12- 14"	PC12
14	309	141	0	450	352.26	-142.14	450	0	7.3	285.02	6.3	338.77	5.7	397.67	8-14"	PC8
15	26	7	0	33	29.64	-11.96	33	0	0.5	20.90	0.5	24.84	0.4	29.16	1- 12"	PC1
16	58	23	0	81	66.12	-26.68	81	0	1.3	51.30	1.1	60.98	1.0	71.58	2- 14"	PC2
17	341	161	0	502	388.74	-156.86	502	0	8.1	317.96	7.1	377.92	6.4	443.62	9-14"	PC9
18	477	245	0	722	543.78	-219.42	722	0	11.6	457.30	10.2	543.54	9.1	638.04	12- 14"	PC12
19	477	245	0	722	543.78	-219.42	722	0	11.6	457.30	10.2	543.54	9.1	638.04	12- 14"	PC12
20	322	143	0	465	367.08	-148.12	465	0	7.5	294.52	6.5	350.06	5.9	410.93	9-14"	PC9
21	92	44	0	136	104.88	-42.32	136	0	2.2	86.14	1.9	102.38	1.7	120.18	3-12"	PC3
22	366	177	0	543	417.24	-168.36	543	0	8.8	343.93	7.6	408.78	6.9	479.86	9-12"	PC9
23	391	193	896	584	1072.94	447.34	1072.94	447.34	17.3	679.58	15.1	807.74	13.6	948.17	17-14"	TPC17
24	389	196	896	585	1070.66	448.26	1070.66	448.26	17.3	678.14	15.1	806.02	13.6	946.15	17-14"	TPC17
25	334	145	0	479	380.76	-153.64	479	0	7.7	303.39	6.7	360.60	6.1	423.30	9-14"	PC9
26	90	46	0	136	102.6	-41.4	136	0	2.2	86.14	1.9	102.38	1.7	120.18	3-12"	PC3
27	363	179	0	542	413.82	-166.98	542	0	8.7	343.30	7.6	408.03	6.9	478.97	9-14"	PC9
28	334	150	849	484	975.06	440.66	975.06	440.66	15.7	617.59	13.7	734.05	12.3	861.67	17-14"	TPC17
29	383	175	892	558	1061.02	448.22	1061.02	448.22	17.1	672.03	14.9	798.76	13.4	937.64	17-14"	TPC17
30	46	44	0	90	52.44	-21.16	90	0	1.5	57.00	1.3	67.75	1.1	79.53	2-12"	PC2
31	46	44	0	90	52.44	-21.16	90	0	1.5	57.00	1.3	67.75	1.1	79.53	2-12"	PC2
32	335	145	0	480	381.9	-154.1	480	0	7.7	304.03	6.8	361.36	6.1	424.18	9-14"	PC9
33	90	46	0	136	102.6	-41.4	136	0	2.2	86.14	1.9	102.38	1.7	120.18	3-12"	PC3
34	351	177	0	528	400.14	-161.46	528	0	8.5	334.43	7.4	397.49	6.7	466.60	9-14"	PC9
35	330	149	853	479	973.3	445.3	973.3	445.3	15.7	616.47	13.7	732.73	12.3	860.12	17-14"	TPC17
36	380	173	892	553	1057.6	449.6	1057.6	449.6	17.1	669.87	14.9	796.19	13.4	934.61	17-14"	TPC17
37	297	164	1046	461	1070.78	595.58	1070.78	595.58	17.3	678.22	15.1	806.11	13.6	946.26	17-14"	TPC17
38	307	175	1046	482	1082.18	590.98	1082.18	590.98	17.5	685.44	15.2	814.69	13.7	956.33	17-14"	TPC17
39	384	167	0	551	437.76	-176.64	551	0	8.9	349.00	7.8	414.81	7.0	486.92	12- 14"	PC12
40	88	45	0	133	100.32	-40.48	133	0	2.1	84.24	1.9	100.13	1.7	117.53	3-12"	PC3
41	330	171	0	501	376.2	-151.8	501	0	8.1	317.33	7.1	377.17	6.3	442.74	9-14"	PC9
42	375	207	0	582	427.5	-172.5	582	0	9.4	368.63	8.2	438.15	7.4	514.32	12- 14"	PC12
43	377	215	0	592	429.78	-173.42	592	0	9.5	374.96	8.3	445.67	7.5	523.16	12- 14"	PC12
44	387	183	0	570	441.18	-178.02	570	0	9.2	361.03	8.0	429.11	7.2	503.72	12- 14"	PC12
45	82	51	0	133	93.48	-37.72	133	0	2.1	84.24	1.9	100.13	1.7	117.53	3-12"	PC3
46	244	127	0	371	278.16	-112.24	371	0	6.0	234.99	5.2	279.30	4.7	327.86	8-14"	PC8
47	330	164	0	494	376.2	-151.8	494	0	8.0	312.89	7.0	371.90	6.3	436.55	9-14"	PC9
48	321	163	0	484	365.94	-147.66	484	0	7.8	306.56	6.8	364.37	6.1	427.72	9-14"	PC9
49	268	114	0	382	305.52	-123.28	382	0	6.2	241.95	5.4	287.58	4.8	337.58	8-14"	PC8
50	87	48	0	135	99.18	-40.02	135	0	2.2	85.51	1.9	101.63	1.7	119.30	3-12"	PC3
51	100	46	0	146	114	-46	146	0	2.4	92.47	2.1	109.91	1.8	129.02	3-12"	PC3
52	103	50	0	153	117.42	-47.38	153	0	2.5	96.91	2.2	115.18	1.9	135.21	3-12"	PC3
53	90	44	0	134	102.6	-41.4	134	0	2.2	84.87	1.9	100.88	1.7	118.42	3-12"	PC3
54	34	5	0	39	38.76	-15.64	39	0	0.6	24.70	0.5	29.36	0.5	34.46	1-12"	PC1
55	9	4	0	13	10.26	-4.14	13	0	0.2	8.23	0.2	9.79	0.2	11.49	1-12"	PC1

SUMMARY				
PILE CAP	count	PILES	Pu (kips)	Tu (kips)
PC1	3	1-12"	39	0
PC2	3	2-12"	90	0
PC3	9	3-12"	153	0
TPC5	3	5-12"	284.9	4.9
PC8	9	8-14"	465	0
PC9	10	9-14"	543	0
PC12	10	12-14"	722	0
TPC17	8	17-14"	1082.2	595.6

PC1 DESIGN

# of Piles:	1	
size =	12	inches
length =	50	ft
f'_c =	3000	psi
f_y =	60	ksi
λ =	1	

$\mathrm{sqrt}(f'_c)$ = 0.054772256 KSI

DIMENSIONS:

	3	x	3	min = 3
	3	ft thick	MIN	
use:	3	ft thick		

SIZE: **3'-0" x 3'-0" x 3'-0"**

d = 33 inches

LOADING:

SELF WEIGHT = 4.05 kips

factored load:

P_u =	43.05	kips
P_u/ pile =	43.05	kips
CHECK:	**OK**	

1- WAY SHEAR **(beam shear)** **(d from edge)**

ϕ =	0.75	
b_w*d =	1188.0000	in^2
ϕV_c =	97.60	kips
# eff.cols =	0	
V_u =	0	kips
$V_u < V_c$	OK	

2- WAY SHEAR **(punching shear)** **(d/2 from col)**

d/2 =	16.5	in	
b_o =	12	in	1
λ_s =	0.6820	<	1
check:		OK	

v_c =	a)	0.1494	ksi
	c)	4.1837	ksi
	MIN =	0.1494	ksi

shear area =	396.0000	in^2
ϕV_c =	44.38	kips
# eff.cols =	0	

V_u =		0 kips			
$V_u < V_c$	OK				

BENDING

X DIRECTION:		
# piles =	0	
y =	0	ft
M_u =	0	kip- ft
Y DIRECTION:		
# piles =	0	
x =	0	ft
M_u =	0	kip- ft

REINF:

X DIRECTION:					
ϕ =		0.9			
β =		0.85			
A_{sREQ} =		0 in2			
find A_{smin}	max of:		3.2535 in^2		
			2.3328 in^2		
A_{smin} =		3.253471992 in^2			
Check A_s >A_{smin}	use Asmin				
a =		0.0021 in	< d?		**OK**
c =		0.0025 in			
ε_t =		39.5700 >		0.005	
			OK		
SPACING:	s_{max} =	lesser of:		108 in	
				18 in	
	AsREQ =		3.253471992 in^2		
bars used:		**5 #8 bars**			
	A_s =		3.95 in^2		**OK**
	spacing =		7.2000 in		
Y DIRECTION:					
ϕ =		0.9			
β =		0.85			

As =		0	in^2			
find Asmin	max of:			3.2535	in^2	
				2.3328	in^2	
A_{smin} =		3.2535	in^2			
Check $A_s > A_{smin}$	use Asmin					
a =		2.1265	in	< d?		**OK**
c =		2.5017	in			
ε_t =		0.0366	>		0.005	
				OK		
SPACING:	s_{max} =		lesser of:		108	in
					18	in
	As =			3.253471992	in^2	
bars used:		**5**	**#8 bars**			
	A_s =			3.9500	in^2	OK
	spacing =			7.2000	in	

PC2 DESIGN

# of Piles:	2				
size =	12	inches			
length =	50	ft			
f'_c =	3000	psi	sqrt(f'_c) =	0.054772256	
f_y =	60	ksi			
λ =	1				

DIMENSIONS:

	7.5	x	3	min =	3
	3	ft thick	MIN		
use:	3	ft thick			
SIZE:	**7'-6" x 3'-0" x 3'-0"**				
d =	33	inches			

LOADING:

SELF WEIGHT =	10.125	kips
factored load:		
P_u =	100.125	kips
P_u/ pile =	50.0625	kips
CHECK:	**OK**	

1- WAY SHEAR (beam shear) (d from edge)

ϕ =	0.75	
b_w*d =	1188	in^2
ϕV_c =	97.60	kips
# eff.cols =	2	
V_u =	100.13	kips
$V_u < V_c$	NG	

2- WAY SHEAR (punching shear) (d/2 from col)

d/2 =		16.5	in	
b_o =		120	in	
λ_s =		0.6820	<	1
	check:		OK	
v_c =		a)	0.1494	ksi
		c)	0.4856	ksi
		MIN =	0.1494	ksi
shear area =		3960	in^2	
ϕV_c =		443.77	kips	
# eff.cols =		2		

V_u = 100.125 kips

$V_u < V_c$ OK

BENDING

X DIRECTION:

# piles =		0			
y =		0	ft		
M_u =		0	kip- ft		

Y DIRECTION:

# piles =		1			
x =		1	ft		
M_u =		50.06	kip- ft		

REINF:

X DIRECTION:

ϕ =		0.9				
β =		0.85				`
A_s =		0	in2			
find A_{smin}	max of:			3.5492	in^2	
				2.3328	in^2	
A_{smin} =		3.549242173	in^2			
Check A_s >A_{smin}	use Asmin					
a =		0.9279	in	< d?		**OK**
c =		1.0917	in			
ε_t =		0.0877	>		0.005	
				OK		
SPACING:	s_{max} =		lesser of:		108	in
					18	in
	As =			3.5492	in^2	
bars used:		**5**	**#8 bars**			
	A_s =			3.9500	in^2	**OK**
	spacing =			7.2000	in	< s_{max} OK

Y DIRECTION:

ϕ =		0.9
β =		0.85

As =		3.9035 in^2			
find Asmin	max of:		3.2535 in^2		
			5.8320 in^2		
A_{smin} =		5.8320 in^2			
Check $A_s > A_{smin}$	use Asmin				
a =		3.8118 in	< d?	**OK**	
c =		4.4844 in			
ε_t =		0.0191 >	0.005		
			OK		
SPACING:	s_{max} =	lesser of:	108 in		
			18 in		
	As =		5.8320 in^2		
bars used:	**8 #8 bars**				
	A_s =		6.3200 in^2	OK	
	spacing =		4.5000 in	< s_{max}	OK

PC3 DESIGN

# of Piles:	3					
size =		12	inches			
length =		50	ft			
f'_c =		3000	psi	$sqrt(f'_c)$ =	0.054772256	
f_y =		60	ksi			
λ =		1				

DIMENSIONS:		6	x	6	min dimension:	6	ft
		3	ft thick	MIN			
	SIZE:			**SEE DETAIL**			
d =		33	inches				

LOADING:

SELF WEIGHT =	6.6375	kips
factored load:		
P_u =	159.6375	kips
P_u/ pile =	53.2125	kips
CHECK:	**OK**	

1- WAY SHEAR	**(beam shear)**	**(d from edge)**
ϕ =	0.75	
b_w*d =	2376	in^2
ϕV_c =	195.21	kips
# eff.cols =	3	
V_u =	159.64	kips
$V_u < V_c$	OK	

2- WAY SHEAR	**(punching shear)**	**(d/2 from col)**		
d/2 =		16.5	in	
b_o =		117	in	
λ_s =		0.6820	<	1
	check:		OK	
v_c =		a)	0.1494	ksi
		c)	0.4961	ksi
		MIN =	0.1494	ksi
shear area =		3861	in^2	
ϕV_c =		432.68	kips	
# eff.cols =		3		
V_u =		159.6375	kips	

$V_u < V_c$	OK				

BENDING

X DIRECTION:					
# piles =	2				
y =	2 ft				
M_u =	212.85 kip- ft				
Y DIRECTION:					
# piles =	1				
x =	2 ft				
M_u =	106.43 kip- ft				

REINF:

X DIRECTION:					
ϕ =		0.9			
β =		0.85			
A_s =		1.5088 in2			
find A_{smin}	max of:		6.5069 in^2		
			4.87296 in^2		
A_{smin} =		6.506943983 in^2			
Check A_s >A_{smin}	use Asmin				
a =		2.1265 in	< d?		**OK**
c =		2.5017 in			
ε_t =		0.0366 >		0.005	
			OK		
SPACING:	s_{max} =	lesser of:		108 in	
				18 in	
	As =		6.5069 in^2		
bars used:		**9 #8 bars**			
	A_s =		7.1100 in^2		**OK**
Y DIRECTION:					
ϕ =		0.9			
β =		0.85			
As =		8.2982 in^2			
find Asmin	max of:		6.506943983 in^2		

			4.6656 in^2		
A_{smin} =		6.506943983 in^2			
Check A_s >A_{smin}	use As				
a =		2.1265 in		< d?	**OK**
c =		2.5017 in			
ε_t =		0.0366 >		0.005	
			OK		
SPACING:	s_{max} =	lesser of:		108 in	
				18 in	
	As =		6.506943983 in^2		
bars used:	**9 #8bars**				
	A_s =		7.11 in^2		OK

USE DIAGONAL BARS- 3 #8 EACH WAY

TPC5 DESIGN

# of Piles:	5				
size =	14	inches			
length =	60	ft			
f'_c =	3000	psi	$sqrt(f'_c)$ =	0.054772256	
f_y =	60	ksi			
λ =	1				
DIMENSIONS:	6.5	x	6.5	min =	6.5
	3.167	ft thick			
use:	3.5	ft thick			
SIZE:		**6'-6" x 6'-6" x 3'-6"**			
d =	39	inches			
LOADING:					
SELF WEIGHT =	22.1813	kips			
factored load:					
P_u =	307.0813	kips			
P_u/ pile =	61.4163	kips			
CHECK:	**OK**				
factored load:					
T_u =	27.0813	kips			
T_u/ pile =	5.4163	kips			
CHECK:	**OK**				
1- WAY SHEAR	**(beam shear)**	**(d from edge)**			
ϕ =	0.75				
b_w*d =	3042.00	in^2			
ϕV_c =	249.93	kips			
# eff.cols =	2				
V_u =	122.83	kips			
$V_u < V_c$	OK				
2- WAY SHEAR	**(punching shear)**	**(d/2 from col)**			
d/2 =	19.5	in			
b_o =	156.0000	in			
λ_s =	0.6389	<	1		
	check:	OK			
v_c =	a)	0.1400	ksi		
	c)	0.4199	ksi		

		MIN =	0.1400 ksi		
shear area =		6084.00 in^2			
ϕV_c =		638.69 kips			
# eff.cols =		4			
V_u =		245.67 kips			
$V_u < V_c$	OK				

BENDING

X DIRECTION:		
# piles =	2	
y =	2.167	ft
M_u =	266.18	kip- ft
Y DIRECTION:		
# piles =	2	
x =	2.167	ft
M_u =	266.18	kip- ft

REINF:

X DIRECTION:					
$\phi =$		0.9			
$\beta =$		0.85			
$A_{s\ c.}$ =		1.59651 in2			
find A_{smin}	max of:		8.3309 in^2		
			5.8968 in^2		
A_{smin} =		8.3309 in^2			
Check $A_s > A_{smin}$	use Asmin				
a =		2.5131 in		< d?	**OK**
c =		2.9566 in			
ε_t =		0.0366 >		0.005	
				OK	
SPACING:	s_{max} =	lesser of:		126 in	
				18 in	
	As c. =		8.3309 in^2		

bars used:	**7 #10 bars**				
		8.8900 in^2	**OK**		
	spacing =	11.1429 in	$< s_{max}$	OK	

Y DIRECTION:					
$\phi =$		0.9			
$\beta =$		0.85			
As =		1.5965 in^2			
find Asmin	max of:		8.3309 in^2		
			5.4756 in^2		
A_{smin} =		8.3309 in^2			
Check $A_s > A_{smin}$	use Asmin				
a =		2.5131 in	< d?	**OK**	
c =		2.9566 in			
ε_t =		0.0366 >		0.005	
			OK		
SPACING:	s_{max} =	lesser of:		126 in	
				18 in	
	As =		8.3309 in^2		
bars used:	**7 #10 bars**				
	A_s =		8.8900 in^2	OK	
	spacing =		11.1429 in	$< s_{max}$	OK

NEGATIVE BENDING

X DIRECTION:	
# piles =	2
y =	2.167 ft
M_u =	23.47 kip- ft
Y DIRECTION:	
# piles =	2
x =	2.167 ft
M_u =	23.47 kip- ft

REINF:

X DIRECTION:	
$\phi =$	0.9

β =	0.8				
c	18				
c' =	21.5000	in			
a' =	17.2000	in			
C_c=	2736.86	kips			
f's =	74.8605				
T_s =	665.51	kips			
A'_s =	8.091825581	in^2			

bars used:		7	#10 bars			
	A_s =	8.8900	in^2	**OK**		
	spacing =	11.1429	in	$< s_{max}$	OK	
	REQ'D BARS=	4.33	BARS			
bars used:		**7**	**#10 bars**			
	A_s =	8.8900	in^2	**OK**		

Y DIRECTION: SAME IN BOTH

PC8 DESIGN

# of Piles:	8			
size =	14	inches		
length =	60	ft		
f'_c =	3000	psi	$\mathrm{sqrt}(f'_c)$ =	0.054772256
f_y =	60	ksi		
λ =	1			

DIMENSIONS:

	9.5	x	9.5	min =	9.5
	3.166666667	ft thick	MIN		
use:	3.5	ft thick			
SIZE:	**9'-6" x 9'-6" x 3'-6"**				
d =	35	inches			

LOADING:

SELF WEIGHT =	47.38125	kips
factored load:		
P_u =	512.38125	kips
P_u/ pile =	64.04765625	kips
CHECK:	**OK**	

1- WAY SHEAR **(beam shear)** **(d from edge)**

ϕ =	0.75	
b_w*d =	3990	in^2
ϕV_c =	327.81	kips
# eff.cols =	3	
V_u =	192.14	kips
$V_u < V_c$	OK	

2- WAY SHEAR **(punching shear)** **(d/2 from col)**

d/2 =		17.5	in	
b_o =		316	in	
λ_s =		0.6667	<	1
	check:		OK	
v_c =		a)	0.1461	ksi
		c)	0.2348	ksi
		MIN =	0.1461	ksi
shear area =		11060	in^2	
ϕV_c =		1211.56	kips	
# eff.cols =		6		

V_u =		384.2859 kips				
$V_u < V_c$	OK					

BENDING

X DIRECTION:		
# piles =	3	
y =	4	ft
M_u =	768.57	kip- ft
Y DIRECTION:		
# piles =	1	
x =	2	ft
# piles =	2	
x =	4	
M_u =	640.48	kip- ft

REINF:

X DIRECTION:						
ϕ =		0.9				
β =		0.85			`	
A_s =		5.1367 in2				
find A_{smin}	max of:		10.9271 in^2			
			8.6184 in^2			
A_{smin} =		10.92706502 in^2				
Check $A_s > A_{smin}$	use Asmin					
a =		2.2553 in	< d?		OK	
c =		2.6533 in				
ε_t =		0.0366 >		0.005		
			OK			
SPACING:	s_{max} =	lesser of:		126 in		
				18 in		
	As =		10.9271 in^2			
bars used:	**9 #10 bars**					
	A_s =		11.4300 in^2		**OK**	
	spacing =		12.6667 in		$< s_{max}$	OK

Y DIRECTION:

ϕ =		0.9				
β =		0.85				
As =		4.2805 in^2				
find Asmin	max of:		10.9271 in^2			
			8.6184 in^2			
A_{smin} =		10.9271 in^2				
Check $A_s > A_{smin}$	use Asmin					
a =		0.8835 in		< d?	**OK**	
c =		1.0394 in				
ε_t =		0.0980 >		0.005		
				OK		
SPACING:	s_{max} =	lesser of:		126 in		
				18 in		
	As =		10.9271 in^2			
bars used:	**9 #10 bars**					
			11.4300 in^2		OK	
	spacing =		25.3333 in		< s_{max}	NG

PC9 DESIGN

# of Piles:	9				
size =	14	inches			
length =	60	ft			
f'_c =	3000	psi	$sqrt(f'_c)$ =	0.054772256	
f_y =	60	ksi			
λ =	1				

DIMENSIONS:	9.5	x	9.5	min =	9.5
	3.166666667	ft thick	MIN		
use:	3.5	ft thick			
SIZE:	**9'-6" x 9'-6" x 3'-6"**				
d =	35	inches			

LOADING:

SELF WEIGHT =	47.38125	kips
factored load:		
P_u =	590.38125	kips
P_u/ pile =	65.59791667	kips
CHECK:	**OK**	

1- WAY SHEAR **(beam shear)** **(d from edge)**

ϕ =	0.75	
b_w*d =	3990	in^2
ϕV_c =	327.81	kips
# eff.cols =	3	
V_u =	196.79	kips
$V_u < V_c$	OK	

2- WAY SHEAR **(punching shear)** **(d/2 from col)**

d/2 =		17.5	in	
b_o =		316	in	
λ_s =		0.6667	<	1
	check:		OK	
v_c =	a)	0.1461	ksi	
	c)	0.2348	ksi	
	MIN =	0.1461	ksi	
shear area =		11060	in^2	
ϕV_c =		1211.56	kips	
# eff.cols =		8		

V_u = 524.7833 kips

$V_u < V_c$ OK

BENDING

X DIRECTION:

piles = 3

y = 4 ft

M_u = 787.18 kip- ft

Y DIRECTION:

piles = 3

x = 4 ft

M_u = 787.18 kip- ft

REINF:

X DIRECTION:

ϕ = 0.9

β = 0.85

A_s = 5.2610 in2

find A_{smin} max of: 10.9271 in^2

8.6184 in^2

A_{smin} = 10.92706502 in^2

Check $A_s > A_{smin}$ use Asmin

a = 2.2553 in < d? **OK**

c = 2.6533 in

ε_t = 0.0366 > 0.005

OK

SPACING: s_{max} = lesser of: 126 in

18 in

As = 10.9271 in^2

bars used: **9 #10 bars**

A_s = 11.4300 in^2 **OK**

spacing = 12.6667 in < s_{max} OK

Y DIRECTION:

ϕ = 0.9

β = 0.85

As =		5.2610 in^2			
find Asmin	max of:		10.9271 in^2		
			8.6184 in^2		
A_{smin} =		10.9271 in^2			
Check A_s >A_{smin}	use Asmin				
a =		1.0859 in	< d?	**OK**	
c =		1.2775 in			
ε_t =		0.0792 >		0.005	
			OK		
SPACING:	s_{max} =	lesser of:		126 in	
				18 in	
	As =		10.9271 in^2		
bars used:	**9 #10 bars**				
	A_s =		11.4300 in^2	OK	
	spacing =		12.6667 in	< s_{max}	OK

PC12 DESIGN

# of Piles:	12				
size =		14	inches		
length =		60	ft		
f'_c =		3000	psi	$sqrt(f'_c)$ =	0.054772256
f_y =		60	ksi		
λ =		1			

DIMENSIONS:		12.5	x	9.5	min =	9.5
		3.166666667	ft thick	MIN		
use:		3.5	ft thick			
	SIZE:		**12'-6" x 9'-6" x 3'-6"**			
d =		39	inches			

LOADING:

SELF WEIGHT =	62.34375	kips
factored load:		
P_u =	784.34375	kips
P_u/ pile =	65.36197917	kips
CHECK:	**OK**	

1- WAY SHEAR	**(beam shear)**		**(d from edge)**
ϕ =		0.75	
b_w*d =		4446	in^2
ϕV_c =		365.28	kips
# eff.cols =		5.5	
V_u =		359.49	kips
$V_u < V_c$	OK		

2- WAY SHEAR	**(punching shear)**		**(d/2 from col)**			
d/2 =		19.5	in			
b_o =		372	in			
λ_s =		0.6389	<			1
	check:		OK			
v_c =		a)		0.1400	ksi	
		c)		0.2167	ksi	
		MIN =		0.1400	ksi	
shear area =		14508	in^2			
ϕV_c =		1523.02	kips			
# eff.cols =		10				

V_u =		653.6198 kips			
$V_u < V_c$	OK				

BENDING

X DIRECTION:

# piles =	4	
y =	4	ft
M_u =	1045.79	kip- ft

Y DIRECTION:

# piles =	3	
x =	2	ft
# piles =	3	
x =	6	ft
M_u =	1568.69	kip- ft

REINF:

X DIRECTION:

ϕ =		0.9			
β =		0.85		`	
A_s =		6.2726 in2			
find A_{smin}	max of:		12.1759 in^2		
			8.6184 in^2		
A_{smin} =		12.17587245 in^2			
Check $A_s > A_{smin}$	use Asmin				
a =		1.9099 in	< d?	**OK**	
c =		2.2470 in			
ε_t =		0.0491 >		0.005	
			OK		
SPACING:	s_{max} =	lesser of:		126 in	
				18 in	
	As =		12.1759 in^2		
bars used:	**10 #10 bars**				
	A_s =		12.7000 in^2	**OK**	
	spacing =		11.4000 in	< s_{max}	OK

Y DIRECTION:

ϕ =		0.9			
β =		0.85			
As =		9.4088 in^2			
find Asmin	max of:		16.0209 in^2		
			11.3400 in^2		
A_{smin} =		16.0209 in^2			
Check A_s >A_{smin}	use Asmin				
a =		1.9420 in		< d?	**OK**
c =		2.2847 in			
ε_t =		0.0482 >		0.005	
			OK		
SPACING:	s_{max} =	lesser of:		126 in	
				18 in	
	As =		16.0209 in^2		
bars used:		**13 #10 bars**			
	A_s =		16.5100 in^2	OK	
	spacing =		8.7692 in	< s_{max}	OK

TPC17 DESIGN

# of Piles:	17			
size =	14	inches		
length =	60	ft		
f'_c =	3000	psi	$\sqrt{f'_c}$ =	0.054772256
f_y =	60	ksi		
λ =	1			

DIMENSIONS:	6.5	x	18.5	min =	6.5
	3.167	ft thick			
use:	4.0	ft thick			
SIZE:	**6'-6" x18'-6" x 4'-0"**				
d =	45	inches			

LOADING:

SELF WEIGHT =	72.1500	kips
factored load:		
P_u =	1154.3300	kips
P_u/ pile =	67.9018	kips
CHECK:	**OK**	
factored load:		
T_u =	667.7300	kips
T_u/ pile =	39.2782	kips
CHECK:	**OK**	

1- WAY SHEAR **(beam shear)** **(d from edge)**

ϕ =	0.75	
b_w*d =	3510.00	in^2
ϕV_c =	288.38	kips
# eff.cols =	4	
V_u =	271.61	kips
$V_u < V_c$	OK	

2- WAY SHEAR **(punching shear)** **(d/2 from col)**

d/2 =		22.5	in	
b_o =		420.0000	in	
λ_s =		0.6030	<	1
	check:		OK	
v_c =	a)	0.1321	ksi	
	c)	0.2076	ksi	

	MIN =		0.1321	ksi
shear area =		18900.00	in^2	
ϕV_c =		1872.74	kips	
# eff.cols =		16		
V_u =		1086.43	kips	
$V_u < V_c$	OK			

POSITIVE BENDING

X DIRECTION:		
# piles =	2	
y =	2	ft
# piles =	1	
y =	4	ft
# piles =	2	
y =	6	ft
# piles =	1	
y =	8	ft
# piles =	2	
y =	10	ft
M_u =	3259.28	kip- ft
Y DIRECTION:		
# piles =	6	
x =	2	ft
# piles =	0	
x =	0	ft
M_u =	814.82	kip- ft

REINF:

X DIRECTION:							
$\phi =$		0.9					
$\beta =$		0.85					
$A_{s\,c.}$ =		16.94235	in2				
find A_{smin}	max of:			27.3587	in^2		
				19.1808	in^2		
A_{smin} =		27.3587	in^2				
Check $A_s > A_{smin}$	use Asmin						
a =		8.2530	in		< d?		**OK**
c =		9.7094	in				

ε_t =		0.0109 >		0.005	
			OK		
SPACING:	s_{max} =	lesser of:		144 in	
				18 in	
	As c. =		27.3587 in^2		
bars used:	**22 #10 bars**				
	A_s =		27.9400 in^2	**OK**	
	spacing =		10.0909 in	< s_{max}	OK

Y DIRECTION:

ϕ =		0.9			
β =		0.85			
As =		4.2356 in^2			
find Asmin	max of:		9.6125 in^2		
			6.3180 in^2		
A_{smin} =		9.6125 in^2			
Check A_s >A_{smin}	use Asmin				
a =		1.0188 in	< d?	**OK**	
c =		1.1986 in			
ε_t =		0.1096 >		0.005	
			OK		
SPACING:	s_{max} =	lesser of:		144 in	
				18 in	
	As =		9.6125 in^2		
bars used:	**8 #10 bars**				
	A_s =		10.1600 in^2	OK	
	spacing =		9.7500 in	< s_{max}	OK

NEGATIVE BENDING

X DIRECTION:

# piles =	2
y =	2 ft
# piles =	1
y =	4 ft
# piles =	2

y =	6	ft
# piles =	1	
y =	8	ft
# piles =	2	
y =	10	ft
M_u =	1885.36	kip- ft

Y DIRECTION:

# piles =	6	
x =	2	ft
# piles =	0	
x =	4	ft
M_u =	471.34	kip- ft

REINF:

X DIRECTION:

ϕ =	0.9	
β =	0.8	
c	20.76923077	
c' =	24.7308	in
a' =	19.7846	in
C_c=	8960.06	kips
f's =	76.4463	
T_s =	2135.91	kips
A'_s =	32.59851477	in^2

bars used:		21 #11 bars				
	A_s =		32.7600	in^2	**OK**	
	spacing =		10.5714	in	< s_{max}	OK
	REQ'D BARS=		4.33	BARS		
bars used:		**21 #11 bars**				
	A_s =		32.7600	in^2	**OK**	

REINF:

Y DIRECTION:

ϕ =	0.9	
β =	0.8	
c	20.76923077	
c' =	24.7308	in
a' =	19.7846	in
C_c=	3148.13	kips
f's =	76.4463	
T_s =	776.69	kips
A'_s =	9.944914463	in^2

bars used:		8 #10 bars			
	A_s =	10.1600	in^2	**OK**	
	spacing =	27.7500	in	< s_{max}	NG
	REQ'D BARS=	4.33	BARS		
bars used:		**8 #10 bars**			
		10.1600	in^2	**OK**	

Appendix 3

Project:	Coleman Highline Building 1	**Story Height:**	14.5 ft	**Total Area:**	34316 ft^2
Location:	San Jose,California	**No. Stories:**	5		205896 ft^2
		Height (Roof)	74 ft		19128.38284 m^2
		Height (Mech)	87 ft		

Foundation System:

Extras:

5000 ksi grout
150 pcf Conc.
60 ksi steel
490 pcf steel

pile caps, grade beams and pilasters (and all other) = 4000psi
slab/fill = 3000 psi
A99S STEEL = 0.2836 #/in3
490.0608

Pile:

Type	Piles per	Count	Length (ft)	Diameter (ft)	Area (ft^2)	Volume Per (ft^3)	Total (ft^3)
PC1	1	19	60	1.333333333	1.396263402	83.7758041	1591.740278
PC2	2	2	60	1.333333333	1.396263402	167.5516082	335.1032164
PC3	3	10	60	1.333333333	1.396263402	251.3274123	2513.274123
PC4	4	13	60	1.333333333	1.396263402	335.1032164	4356.341813
PC5	5	6	60	1.333333333	1.396263402	418.8790205	2513.274123
TPC6	6	8	60	1.333333333	1.396263402	502.6548246	4021.238597
		58					

Piles Total Concrete:
Sum = 15330.97 ft^3
2299646 #

Pile Reinforcement:

				Longitudinal				Ties				
	Pile Cap	Count	Size	Area (ft^2)	Bar Count	total (ft^3)	Size	Pile Dia.(in)	Pitch (in)	lenth (ft)	Area (ft^2)	Total (ft^3)
type 1	PC1	19	#9	0.006944444	1	7.9167	#3	0.833333333	4	98.17477042	0.000763889	1.42489771
			#6	0.003055556	6	20.9000						
type 1	PC2	2	#9	0.006944444	1	1.6667	#3	0.833333333	4	98.17477042	0.000763889	0.29997847
			#6	0.003055556	6	4.4000						
type 1	PC3	10	#9	0.006944444	1	12.5000	#3	0.833333333	4	98.17477042	0.000763889	2.24983849
			#6	0.003055556	6	33.0000						
type 1	PC4	13	#9	0.006944444	1	21.6667	#3	0.833333333	4	98.17477042	0.000763889	3.89972005
			#6	0.003055556	6	57.2000						
type 1	PC5	6	#9	0.006944444	1	12.5000	#3	0.833333333	4	98.17477042	0.000763889	2.24983849
			#6	0.003055556	6	33.0000						
type 3	TPC6	8	#14	0.015625	1	45.0000	#3	0.833333333	4	98.17477042	0.000763889	3.59974158
			#6	0.003055556	6	52.8000						

Pile Total Steel:
Sum = 316.2740 ft^3
154974.3 #

Pile Cap:

Type	Count	Area (ft^2)	Thickness(ft)	Volume (ft^3)	Total (ft^3)
PC1	19	20.25	3	60.75	1154.25
PC2	2	38.25	4	153	306
PC3	10	61.66	4	246.64	2466.4
PC4	13	72.25	4	289	3757
PC5	6	103.3617889	4	413.4471556	2480.682933
TPC6	8	106.25	4.5	478.125	3825

Sum = 13989.33 ft^3
2098400 #

Pile Cap Reinforcement:

			Bottom				Top		
Pile Cap	Count	Size	Area (ft^2)	Bar Count	total (ft^3)	Size	Area (ft^2)	Bar Count	total (ft^3)
PC1	19	#7	0.004166667	14	4.9875				
PC2	2	#7	0.004166667	8	0.566666667				
		#8	0.005486111	7	0.345625				
PC3	10	#9	0.006944444	10	6.25				
PC4	13	#9	0.006944444	20	15.34722222				
PC5	6	#10	0.008819444	20	10.58333333				
TPC6	8	#10	0.008819444	20	14.25222222	#10	0.008819444	20	14.25222222

Pile Total Steel:
Sum = 66.58479 ft^3
32626.55 #

Grade Beam:

Type	length(ft)	Count	Size	Area (ft^2)	Volume (ft^3)	Total (ft^3)
GB1	20.5	2	2' x 2'	4	82	164
	21.5	21	2' x 2'	4	86	1806
	18	11	2' x 2'	4	72	792
	12	7	2' x 2'	4	48	336
	25.5	6	2' x 2'	4	102	612
	35	16	2' x 2'	4	140	2240
GB2	16	3	3' x 3'	9	144	432
	10	1	3' x 3'	9	90	90
	22.5	1	3' x 3'	9	202.5	202.5

Grade Beam Total Concrete:
Sum = 6674.5 ft^3
1001175 #

Grade Beam Reinforcement:

				Longitudinal				Ties		
Type	length(ft)	Count	Size	Area (ft^2)	Bar Count	Total (ft^3)	Size	Area (in^2)	Bar Count	Total (ft^3)
GB1	20.5	2	#8	0.005486111	6	1.349583333	#4	0.001388889	34	0.285
	21.5	21	#8	0.005486111	6	14.861875	#4	0.001388889	35	0.295
	18	11	#8	0.005486111	6	6.5175	#4	0.001388889	31	0.26
	12	7	#8	0.005486111	6	2.765	#4	0.001388889	24	0.2
	25.5	6	#8	0.005486111	6	5.03625	#4	0.001388889	40	0.335
	35	16	#8	0.005486111	6	18.43333333	#4	0.001388889	52	0.43
GB2	16	3	#9	0.006944444	4	1.333333333	#4	0.001388889	29	0.4
	10	1	#9	0.006944444	4	0.277777778	#4	0.001388889	22	0.18
	22.5	1	#9	0.006944444	4	0.625	#4	0.001388889	37	0.305

Pile Total Steel:
Sum = 53.88965 ft^3
26405.93 #

Slab:

Type	Count	Area (ft^2)	Thickness (ft)	Volume (ft^3)	Total (ft^3)
SOG	1	31100	0.416666667	12958.33333	12958.33333

Depressed Slab	1	3318	0.25	829.5	829.5

Slab Total Concrete:
Sum = 13787.83 ft^3
2068175 #

Slab Reinforcement:

Type	Count	Size	N/S Area (ft^2)	Bar Count	total	Size	E/W Area (in^2)	Bar Count	total
SOG	1	#4	0.001388889	160	53.3333	#4	0.001388889	85	15.1704
Depressed Slab	1	#4	0.001388889	7	0.1095	#4	0.001388889	30	1.8750
				40	3.3333			23	1

Slab Total Steel:
Sum = 75 ft^3
36569.54 #

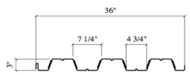
4000 psi Total Concrete:
Sum = 35994.81 ft^3
5399220.76 #

3000 psi Total Concrete:
Sum = 13787.83 ft^3
2068175.00 #

FND Total Steel:
Sum = 511.38 ft^3
250576.28 #

Framing System:

Decking:	2nd floor Area (ft^2)	Volume(ft^2)	3rd floor Area (ft^2)	Volume(ft^2)	4th floor Area (ft^2)	Volume(ft^2)	5th Floor Area (ft^2)	Volume(ft^2)	Roof Area (ft^2)	Volume(ft^2)
2-1/2" NW Conc. Over		6970.3125		6338.583333		6390.625		6430.625		6453.291667
3" Comp. Metal Deck	33457.5	15334.66	30425.2	13945	30675	14096	30867	14147	30975.8	14197.2
2" Weathered Steel Canopy	427.5	71.25	4259.6	709.9333333	0	0			0	0
12" Concrete Slab									2971.4	2917.4
1-1/2" Metal Deck									842.19	105.26



3" Composite Floor Deck

for 36" strip 61.5 inches
ratio: 1.708333333

total conc: 28530.525 ft^3
total sheet 276630.0579 ft^2

Beams:	2nd Floor Count	Avg Length	3rd Floor Count	Avg Length	4th Floor Count	Avg Length	5th Floor Count	Avg Length	Roof Count	Avg Length	Penthouse Count	Avg Length	CSA (ft^2)	Volume (ft^3)
W10 x 15	3	6	4	6	4	6	4	6	2	6			0.030625	3.12375
W12 x 19	56	10	69	12	37	10	37	10	80	10			0.038680556	113.2567
W14 x 22	6	18.5	10	16	10	16	10	16	7	11			0.045069444	30.10639
W16 x 26	16	17.5	17	17.5	10	17.5	10	17.5	14	13.5			0.053333333	59.54667
W16 x 36	1	16	0	0	0	0	0	0	0	0			0.073611111	1.177778
W18 x 35	27	34	25	34	16	34	16	34	41	13.5			0.071527778	243.874
W18 x 40	2	35	0	0	0	0	0	0	0	0			0.081944444	5.736111
W 18 x 46	1	35	8	30	1	35	1	35	1	35			0.09375	35.625
W21 x 50	40	45	40	45	40	45	40	45	20	45			0.102083333	826.875
W21 x 62	3	45	3	45	3	45	3	45	0	0			0.127083333	68.625
W21 x 73	1	45	2	36.5	0	0	0	0	0	0			0.149305556	17.61806
W21 x 83	2	52	5	45	1	51.5	1	51.5	1	51.5			0.169444444	81.92639
W24 x 55	20	30	20	30	18	30	18	30	41	35			0.1125	417.9375
W24x 62	1	37	1	37	1	37	1	37	0	0			0.126388889	18.70556
W24 x 68	12	30	4	30	5	30	5	30	10	30			0.139583333	150.75
W24 x 76	1	52	0	0	1	52	1	52	3	41			0.139583333	38.94375
W24 x 103	5	25	5	25	4	25	4	25					0.210416667	94.6875
W18x68					8	25	8	25					0.145138889	58.05556
W18 x 60			2	37	1	37	1	37	0	0			0.122222222	18.08889
W18 x 97			2	14	0	0	0	0	0	0			0.197916667	5.541667
W21 x 57			2	45	0	0	0	0	0	0			0.115972222	10.4375
W27 x 94			1	52	0	0	0	0	0	0			0.191666667	9.966667
W18x71					2	14	2	14					0.145138889	8.127778
W24x 84									10	25			0.171527778	42.88194
HSS6X4X3/8	1	10	1	10	1	10	1	10	1	10			0.042916667	2.145833
HSS8X8X3/8	3	9.5	0	0	0	0	0	0	0	0			0.072222222	2.058333
HSS12X6X3/8	1	13.5	1	13	1	13	1	13	0	0			0.081944444	4.302083
HSS14X10X3/8	2	15	0	0	0	0	0	0	0	0			0.111111111	3.333333
HSS20X8X1/2	2	12.5	0	0	0	0	0	0	0	0			0.170833333	4.270833
HSS20x8x5/8			1	35	0	0	0	0	0	0			0.210416667	7.364583
HSS10x10x3/8			1	13	0	0	0	0	0	0			0.091666667	1.191667
Horizontal Bracing:														
L6X6X3/8	6	10	6	10	8	10	8	10	6	10			0.030416667	10.34167
	8	10.7	8	10.7	6	10.7	6	10.7	0	0			0.030416667	9.112833
	18	8	18	8	8	10	8	10	0	0			0.030416667	13.62667
HSS4x4x3/16			5	19.25	0	0	0	0	0	0			0.017916667	1.724479
L4x4x3/8			16	10	16	10	16	10	16	10			0.019861111	12.71111
W12x19									58	5.5			0.038680556	12.3391
W8x35											6	9	0.071527778	3.8625
HSS4x4x3/8											3	9.7	0.033194444	0.965958
HSS10x4x1/4											52	10	0.042847222	22.28056
1000S162-43											18	10.5	0.004354167	0.822938

Plates:
15%

W-Flange Total:	2377.816667 ft^3	356.6725 ft^3
	1165130.167 #	174769.525 #
HSS/other Total:	96.252875 ft^3	14.43793125 ft^3
	47163.90875 #	7074.586313 #

Plate total: 371.1104313 ft3

Columns:	2nd-3rd Floor Count	Avg Length	3rd-4th Floor Count	Avg Length	4th-5th Floor Count	Avg Length	5th Floor - Roof Count	Avg Length	Roof- Penthouse Count	Avg Length	area (ft^2)	Volume (ft^3)
W27x194	6	18	6	14							0.396527778	76.1333333
12C2-W14x82	7	18									0.166666667	21
1C1-W14x99	8	17									0.202083333	27.4833333
1C3-W14x90	9	18									0.184027778	29.8125
W14x193	2	16									0.394444444	12.6222222
W14x311	2	17									0.634722222	21.5805556
W14x283	2	16									0.578472222	18.5111111
W14x342	2	17									0.701388889	23.8472222
W14x61			14	14	14	14	14	14			0.124305556	73.0916667

W14x53			1	14	1	14	1	14			0.108333333	4.55
W14x68			8	14	8	14	8	13			0.138888889	45.5555556
W14x132			4	14	4	14	4	14			0.269444444	45.2666667
W14x48			2	14	2	14	2	12			0.097916667	7.83333333
W27x146					6	14	6	14			0.3	50.4
HSS14x10x5/8	3	18									0.178472222	9.6375
HSsS10x10x1/2	7	18									0.119444444	15.05
HSS8x8x3/8	9	13.5									0.072222222	8.775
HSS10x10x5/8	2	16									0.098611111	3.15555556
HSS6x4x3/8	10	16	10	16	10	16	10	16	13	15	0.042916667	35.8354167
HSS10x10x3/8									54	15	0.091666667	74.25

			Plates: 15%	
Total =	457.6875	(ft^3)	68.653125	(ft^3)
	224266.9	lbs	33640.03125	lbs
Total =	146.7035	(ft^3)	22.00552083	(ft^3)
	71884.7	lbs	10782.70521	lbs
		plate total:	90.65864583	(ft^3)

Walls:	Length(ft)	Height (ft)	thickness (ft)	volume
Mech. Stud Wall	60.8	5.5	0.5	167.2
	110	5.5	0.5	302.5
	104	10	0.5	520
		total =		989.7 ft^3

Vertical Bracing:

brace name:	members:	count	length ft	width ft	steel area ft2		conc ft^3
1BF-1	BRB 15	2	23.5	0.322748612	60.67673909		4.895833333
	BRB 14	2	22.5	0.311804782	56.1248608		4.375
	BRB 12	2	22.5	0.288675135	51.96152423		3.75
	BRB 8	2	22.5	0.23570226	42.42640687		2.5
	BRB 4	2	22.5	0.166666667	30		1.25
1BF-2	BRB 17	2	23.5	0.343592135	64.59532147		5.548611111
	BRB 13.5	2	22.5	0.306186218	57.56300896		4.21875
	BRB 11.5	2	22.5	0.282597083	50.86747487		3.59375
	BRB 9.5	2	22.5	0.256850583	46.23310502		2.96875
	BRB 7	2	22.5	0.220479276	39.68626967		2.1875
1BF-3	BRB 14.5	2	23.5	0.317323879	59.65688933		4.732638889
	BRB 11.5	2	22.5	0.282597083	50.86747487		3.59375
	BRB 9	2	22.5	0.25	45		2.8125
	BRB 8	2	22.5	0.23570226	42.42640687		2.5
	BRB 5.5	2	22.5	0.19543399	35.1781182		1.71875
1BF-4	BRB 14.5	2	23.5	0.317323879	59.65688933		4.732638889
	BRB 12	2	22.5	0.288675135	51.96152423		3.75
	BRB 11	2	22.5	0.276385399	49.74937186		3.4375
	BRB 8.5	2	22.5	0.242956329	43.73213921		2.65625
	BRB 6	2	22.5	0.204124145	36.74234614		1.875
				total:	975.105871	ft2	67.09722222 ft^3
					477801.8768		10064.58333 lbs
							77.16180556

Stiffeners/plates: assume plate size to be 2 ft^2 for eccen.

use 15% total steel for connections

Connections:		plates (ft^2)	
1BF-1	roof	0.416666667	
	5th	0.416666667	
	4th	0.333333333	
	3rd	0.291666667	
	2nd	0.208333333	
	base	10.2037037	
1BF-2	roof	0.416666667	
	5th	0.333333333	
	4th	0.333333333	
	3rd	0.291666667	
	2nd	0.291666667	
	base	10.74074074	
1BF-3	roof	0.416666667	
	5th	0.333333333	
	4th	0.291666667	
	3rd	0.291666667	
	2nd	0.25	
	base	7.653935185	
1BF-4	roof	0.416666667	.
	5th	0.333333333	
	4th	0.333333333	
	3rd	0.291666667	
	2nd	0.25	
	base	7.653935185	
	total:	42.79398148 ft^3	49.2130787
		20969.05093 #	
		71670.28152 # (15%)	
	vol (ft3)		
MF	7.333333333	3593.333333	
		56.54641204	
	total =	96232.66578 #	

Bolts/Anchor Bolts:

1BF-1	(20)- 2" DIA
1BF-2	(20)- 2.25" DIA
1BF-3	(22)- 2" DIA
1BF-4	(22)- 2" DIA
MF	(36) 1.5" DIA

Appendix 4

Project:	UPDATED Coleman Highline Building 1	**Story Height:**	14.5 ft	**Total Area:**	34316 ft^2
Location:	San Jose,California	**No. Stories:**	5		205896 ft^2
		Height (Roof)	74 ft		19128.38284 m^2
		Height (Mech)	87 ft		

Foundation System:

Pile:

Type	Piles per	Count	Length (ft)	Diameter (ft)	Area (ft^2)	Volume Per (ft^3)	Total (ft^3)
PC1	1	3	50	1	0.785398163	39.26990817	117.8097245
PC2	2	3	50	1	0.785398163	78.53981634	235.619449
PC3	3	9	50	1	0.785398163	117.8097245	1060.287521
TPC5	5	3	60	1.166666667	1.069014167	320.7042501	962.1127502
PC8	8	14	60	1.166666667	1.069014167	513.1268001	7183.775201
PC9	9	6	60	1.166666667	1.069014167	577.2676501	3463.605901
PC12	12	9	60	1.166666667	1.069014167	769.6902001	6927.211801
TPC17	17	8	60	1.166666667	1.069014167	1090.39445	8723.155601
		55					

Extras:

5000 ksi grout		pile caps, grade beams and pilasters (and all other) = 4000psi	
150 pcf Conc.		slab/fill = 3000 psi	
60 ksi steel		A995 STEEL =	0.2836 #/in3
490 pcf steel			490.0608
G=	0.5 (DF-L)		
	31.2018		
use:	35 pcf (DF-L)		

Piles Total TIMBER DF-L:
Sum = 13023.21 ft^3
455812.4 #

Pile Cap:

Type	Count	Area (ft^2)	Thickness(ft)	Volume (ft^3)	Total (ft^3)
PC1	1	9	3	27	27
PC2	2	22.5	3	67.5	135
PC3	3	33.75	3	101.25	303.75
TPC5	5	42.25	3.5	147.875	739.375
PC8	8	90.25	3.5	315.875	2527
PC9	9	90.25	3.5	315.875	2842.875
PC12	12	118.75	3.5	415.625	4987.5
TPC17	17	120.25	4	481	8177

Sum = 19739.5 ft^3
2960925 #

Pile Cap Reinforcement:

		Bottom				Top			
Pile Cap	Count	Size	Area (ft^2)	Bar Count	total (ft^3)	Size	Area (ft^2)	Bar Count	total (ft^3)
PC1	1	#8	0.005486111	10	0.164583333				
PC2	2	#8	0.005486111	13	0.674791667				
PC3	3	#8	0.005486111	9	0.9875				
TPC5	5	#10	0.008819444	14	4.012847222	#10	0.008819444	14	6.276710417
PC8	8	#10	0.008819444	18	12.065				
PC9	9	#10	0.008819444	18	13.573125				
PC12	12	#10	0.008819444	20	27.25208333				
TPC17	17	#10	0.008819444	30	43.62979167	#10	0.008819444	29	42.65524306

Sum = 151.2917 ft^3
74132.92 #

Grade Beam:

Type	length(ft)	Count	Size	Area (ft^2)	Volume (ft^3)	Total (ft^3)
GB1	20.5	2	2' x 2'	4	82	164
	21.5	21	2' x 2'	4	86	1806
	18	11	2' x 2'	4	72	792
	12	7	2' x 2'	4	48	336
	25.5	6	2' x 2'	4	102	612
	30	20	2' x 2'	4	120	2400
GB2	14	3	3' x 3'	9	126	378
	10	1	3' x 3'	9	90	90
	19	1	3' x 3'	9	171	171

Grade Beam Total Concrete:
Sum = 6749 ft^3
1012350 #

Grade Beam Reinforcement:

			Longitudinal				Ties			
Type	length(ft)	Count	Size	Area (ft^2)	Bar Count	Total (ft^3)	Size	Area (in^2)	Bar Count	Total (ft^3)
GB1	20.5	2	#8	0.005486111	6	1.349583333	#4	0.001388889	34	0.285
	21.5	21	#8	0.005486111	6	14.861875	#4	0.001388889	35	0.295
	18	11	#8	0.005486111	6	6.5175	#4	0.001388889	31	0.26
	12	7	#8	0.005486111	6	2.765	#4	0.001388889	24	0.2
	25.5	6	#8	0.005486111	6	5.03625	#4	0.001388889	40	0.335
	30	16	#8	0.005486111	6	15.8	#4	0.001388889	46	0.38
GB2	14	3	#9	0.006944444	4	1.166666667	#4	0.001388889	26	0.366666667
	10	1	#9	0.006944444	4	0.277777778	#4	0.001388889	22	0.18
	19	1	#9	0.006944444	4	0.527777778	#4	0.001388889	32	0.27

Pile Total Steel:
Sum = 50.8741 ft^3
24928.31 #

Slab:

Type	Count	Area (ft^2)	Thickness (ft)	Volume (ft^3)	Total (ft^3)
SOG	1	31100	0.416666667	12958.33333	12958.33333
Depressed Slab	1	3318	0.25	829.5	829.5

Slab Total Concrete:
Sum = 13787.83 ft^3
2068175 #

Slab Reinforcement:

		N/S				E/W			
Type	Count	Size	Area (ft^2)	Bar Count	total	Size	Area (in^2)	Bar Count	total
SOG	1	#4	0.001388889	160	53.3333	#4	0.001388889	85	15.1704
Depressed Slab	1	#4	0.001388889	7	0.1095	#4	0.001388889	30	1.8750
				40	3.3333			23	1

Slab Total Steel:
Sum = 75 ft^3
36569.54 #

4000 psi Total Concrete:
Sum = 26488.50 ft^3
3973275.00 #

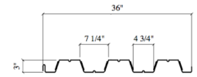
3000 psi Total Concrete:
Sum = 13787.83 ft^3
2068175.00 #

FND Total Steel:
Sum = 276.80 ft^3
135630.77 #

Timber Total e:
Sum = 13023.21 ft^3
455812.37 #

Framing System:

Decking:	2nd floor Area (ft^2)	Volume(ft^2)	3rd floor Area (ft^2)	Volume(ft^2)	4th floor Area (ft^2)	Volume(ft^2)	5th Floor Area (ft^2)	Volume(ft^2)	Roof Area (ft^2)	Volume(ft^2)
2-1/2" NW Conc. Over		6970.3125		6338.583333		6390.625		6430.625		6453.291667
3" Comp. Metal Deck	33457.5	15334.66	30425.2	13945	30675	14096	30867	14147	30975.8	14197.2
2" Weathered Steel Canopy	427.5	71.25	4259.6	709.9333333	0	0			0	0
12" Concrete Slab									2971.4	2917.4
1-1/2" Metal Deck									842.19	105.26



3" Composite Floor Deck

total conc: 28530.525 ft^3
total sheet 276630.0579 ft^2

for 36" strip 61.5 inches
ratio: 1.708333333

	2nd Floor		3rd Floor		4th Floor		5th Floor		Roof		Penthouse			
Beams:	Count	Avg Length	Count	Avg Length	Count	Avg Length	Count	Avg Length	Count	Avg Length	Count	Avg Length	CSA (ft^2)	Volume (ft^3)
W10 x 15	3	6	4	6	4	6	4	6	2	6			0.030625	3.12375
W12 x 19	56	10	69	12	37	10	37	10	80	10			0.038680556	113.2567
W14 x 22	6	18.5	10	16	10	16	10	16	7	11			0.045069444	30.10639
W16 x 26	16	17.5	17	17.5	10	17.5	10	17.5	14	13.5			0.053333333	59.54667
W16 x 36	1	16	0	0	0	0	0	0	0	0			0.073611111	1.177778
W18 x 35	27	34	25	34	16	34	16	34	41	13.5			0.071527778	243.874
W18 x 40	2	35	0	0	0	0	0	0	0	0			0.081944444	5.736111
W 18 x 46	1	35	8	30	1	35	1	35	1	35			0.09375	35.625
W21 x 50	40	45	40	45	40	45	40	45	20	45			0.102083333	826.875
W21 x 62	3	45	3	45	3	45	3	45	0	0			0.127083333	68.625
W21 x 73	1	45	2	36.5	0	0	0	0	0	0			0.149305556	17.61806
W21 x 83	2	52	5	45	1	51.5	1	51.5	1	51.5			0.169444444	81.92639
W24 x 55	20	30	20	30	18	30	18	30	41	35			0.1125	417.9375
W24x 62	1	37	1	37	1	37	1	37	0	0			0.126388889	18.70556
W24 x 68	12	30	4	30	5	30	5	30	10	30			0.139583333	150.75
W24 x 76	1	52	0	0	1	52	1	52	3	41			0.139583333	38.94375
W24 x 103	5	25	5	25	4	25	4	25					0.210416667	94.6875
W18x68					8	25	8	25					0.145138889	58.05556
W18 x 60			2	37	1	37	1	37	0	0			0.122222222	18.08889
W18 x 97			2	14	0	0	0	0	0	0			0.197916667	5.541667
W21 x 57			2	45	0	0	0	0	0	0			0.115972222	10.4375
W27 x 94			1	52	0	0	0	0	0	0			0.191666667	9.966667
W18x71					2	14	2	14					0.145138889	8.127778
W24x 84									10	25			0.171527778	42.88194
HSS6X4X3/8	1	10	1	10	1	10	1	10	1	10			0.042916667	2.145833
HSS8X8X3/8	3	9.5	0	0	0	0	0	0	0	0			0.072222222	2.058333
HSS12X6X3/8	1	13.5	1	13	1	13	1	13	0	0			0.081944444	4.302083
HSS14X10X3/8	2	15	0	0	0	0	0	0	0	0			0.111111111	3.333333
HSS20X8X1/2	2	12.5	0	0	0	0	0	0	0	0			0.170833333	4.270833
HSS20x8x5/8			1	35	0	0	0	0	0	0			0.210416667	7.364583
HSS10x10x3/8			1	13	0	0	0	0	0	0			0.091666667	1.191667
Horizontal Bracing:														
L6X6X3/8	6	10	6	10	8	10	8	10	6	10			0.030416667	10.34167
	8	10.7	8	10.7	6	10.7	6	10.7	0	0			0.030416667	9.112833
	18	8	18	8	8	10	8	10	0	0			0.030416667	13.62667
HSS4x4x3/16			5	19.25	0	0	0	0	0	0			0.017916667	1.724479
L4x4x3/8			16	10	16	10	16	10	16	10			0.019861111	12.71111
W12x19									58	5.5			0.038680556	12.3391
W8x35											6	9	0.071527778	3.8625
HSS4x4x3/8											3	9.7	0.033194444	0.965958
HSS10x4x1/4											52	10	0.042847222	22.28056
1000S162-43											18	10.5	0.004354167	0.822938

		Plates: 15%
W-Flange Total:	2377.816667 ft^3	356.6725 ft^3
	1165130.167 #	174769.525 #
HSS/other Total:	96.252875 ft^3	14.43793125 ft^3
	47163.90875 #	7074.586313 #
	Plate total:	371.1104313 ft3

	2nd-3rd Floor		3rd-4th Floor		4th-5th Floor		5th Floor - Roof		Roof- Penthouse			
Columns:	Count	Avg Length	Count	Avg Length	Count	Avg Length	Count	Avg Length	Count	Avg Length	area (ft^2)	Volume (ft^3)
W27x194	6	18	6	14							0.396527778	76.1333333
12C2-W14x82	7	18									0.166666667	21
1C1-W14x99	8	17									0.202083333	27.4833333
1C3-W14x90	9	18									0.184027778	29.8125
W14x193	2	16									0.394444444	12.6222222
W14x311	2	17									0.634722222	21.5805556
W14x283	2	16									0.578472222	18.5111111
W14x342	2	17									0.701388889	23.8472222
W14x61			14	14	14	14	14	14			0.124305556	73.0916667
W14x53			1	14	1	14	1	14			0.108333333	4.55
W14x68			8	14	8	14	8	13			0.138888889	45.5555556
W14x132			4	14	4	14	4	14			0.269444444	45.2666667
W14x48			2	14	2	14	2	12			0.097916667	7.83333333
W27x146					6	14	6	14			0.3	50.4
HSS14x10x5/8	3	18									0.178472222	9.6375
HSsS10x10x1/2	7	18									0.119444444	15.05
HSS8x8x3/8	9	13.5									0.072222222	8.775
HSS10x10x5/8	2	16									0.098611111	3.15555556
HSS6x4x3/8	10	16	10	16	10	16	10	16	13	15	0.042916667	35.8354167
HSS10x10x3/8									54	15	0.091666667	74.25

			Plates: 15%
Total =	457.6875	(ft^3)	68.653125 (ft^3)
	224266.9	lbs	33640.03125 lbs
Total =	146.7035	(ft^3)	22.00552083 (ft^3)
	71884.7	lbs	10782.70521 lbs
		plate total:	90.65864583 (ft^3)

Walls:	Length(ft)	Height (ft)	thickness (ft)	volume
Mech. Stud Wall	60.8	5.5	0.5	167.2
	110	5.5	0.5	302.5
	104	10	0.5	520
			total =	989.7 ft^3

Vertical Bracing:

brace name:	members:	count	length ft	width ft	steel area ft2		conc ft^3
1BF-1	BRB 15	2	23.5	0.322748612	60.67673909		4.895833333
	BRB 14	2	22.5	0.311804782	56.1248608		4.375
	BRB 12	2	22.5	0.288675135	51.96152423		3.75
	BRB 8	2	22.5	0.23570226	42.42640687		2.5
	BRB 4	2	22.5	0.166666667	30		1.25
1BF-2	BRB 17	2	23.5	0.343592135	64.59532147		5.548611111
	BRB 13.5	2	22.5	0.306186218	57.56300896		4.21875
	BRB 11.5	2	22.5	0.282597083	50.86747487		3.59375
	BRB 9.5	2	22.5	0.256850583	46.23310502		2.96875
	BRB 7	2	22.5	0.220479276	39.68626967		2.1875
1BF-3	BRB 14.5	2	23.5	0.317323879	59.65688933		4.732638889
	BRB 11.5	2	22.5	0.282597083	50.86747487		3.59375
	BRB 9	2	22.5	0.25	45		2.8125
	BRB 8	2	22.5	0.23570226	42.42640687		2.5
	BRB 5.5	2	22.5	0.19543399	35.1781182		1.71875
1BF-4	BRB 14.5	2	23.5	0.317323879	59.65688933		4.732638889
	BRB 12	2	22.5	0.288675135	51.96152423		3.75
	BRB 11	2	22.5	0.276385399	49.74937186		3.4375
	BRB 8.5	2	22.5	0.242956329	43.73213921		2.65625
	BRB 6	2	22.5	0.204124145	36.74234614		1.875
				total:	975.105871	ft2	67.09722222 ft^3
					477801.8768		10064.58333 lbs
							77.16180556

Stiffeners/plates:		assume plate size to be 2 ft^2 for eccen.	
Connections:		plates (ft^2)	
1BF-1	roof	0.416666667	
	5th	0.416666667	
	4th	0.333333333	
	3rd	0.291666667	
	2nd	0.208333333	
	base	10.2037037	
1BF-2	roof	0.416666667	
	5th	0.333333333	
	4th	0.333333333	
	3rd	0.291666667	
	2nd	0.291666667	
	base	10.74074074	
1BF-3	roof	0.416666667	
	5th	0.333333333	
	4th	0.291666667	
	3rd	0.291666667	
	2nd	0.25	
	base	7.653935185	
1BF-4	roof	0.416666667	
	5th	0.333333333	
	4th	0.333333333	
	3rd	0.291666667	
	2nd	0.25	
	base	7.653935185	
	total:	42.79398148 ft^3	49.2130787
		20969.05093 #	
		71670.28152 # (15%)	
	vol (ft3)		
MF	7.333333333	3593.333333	
		56.54641204	
	total =	96232.66578 #	

use 15% total steel for connections

Bolts/Anchor Bolts:	
1BF-1	(20)- 2" DIA
1BF-2	(20)- 2.25" DIA
1BF-3	(22)- 2" DIA
1BF-4	(22)- 2" DIA
MF	(36) 1.5" DIA

Appendix 5

Concrete Pile Coleman Highline Building 1 Results:

Table 1A: Summary Report

One Click LCA

Main > Coleman Highline Building 1 > Coleman Highline Building 1 > One Click LCA Planetary United States > Detailed report

One Click LCA Planetary United States

Download Excel Close

Section	Result category	Global warming t CO_2e	Global warming kg CO_2e/m^2	Mass of raw materials t	Mass of raw materials kg/m²
1	Ready mix concrete (A1-A3)	852.13	4.14	5,341.52	25.94
2	Precast concrete (A1-A3)				
3	Cement (A1-A3)				
4	Steel (A1-A3)	1,903.09	9.24	1,244.7	6.05
5	Aluminium (A1-A3)				
6	Bricks (A1-A3)	18.69	0.09	53.87	0.26
7	Glass (A1-A3)				
8	Insulation (A1-A3)				
9	Wood (A1-A3)				
10	Gypsum (A1-A3)				
11	Other materials (A1-A3)				
A1-A3	Construction Materials	2,773.92	13.47	6,640.09	32.25
A4	Transportation to site	157.92	0.77		
A5	Construction/installation process	106.22	0.52	259.19	1.26
A5a	Site operations & site waste handling	0	0	0	0
A5b	Site waste transportation				
A5c	Construction site - material wastage - materials	100.04	0.49	259.19	1.26
A5d	Construction site - material wastage - transport	6.18	0.03		

Table 2A

Most contributing materials (Global warming)

No.	Resource	Cradle to gate impacts (A1-A3)	Of cradle to gate (A1-A3)	Sustainable alternatives
1.	Concrete, ready mix ?	71 kg CO_2e	45.2 %	Show sustainable alternatives
2.	Concrete, ready mix ?	60 kg CO_2e	38.2 %	Show sustainable alternatives
3.	Fabricated hot-rolled structural sections ?	13 kg CO_2e	8.2 %	Show sustainable alternatives
4.	Primary structural steel frame components ?	4.5 kg CO_2e	2.8 %	Show sustainable alternatives
5.	Steel sheet profiles, roll-formed ?	2.5 kg CO_2e	1.6 %	Show sustainable alternatives
6.	Rebar ?	2.3 kg CO_2e	1.5 %	Show sustainable alternatives
7.	Steel plate ?	2.4 kg CO_2e	1.5 %	Show sustainable alternatives
8.	Hollow structural steel sections ?	1.1 kg CO_2e	0.7 %	Show sustainable alternatives
9.	Thin facing bricks ?	0.39 kg CO_2e	0.2 %	Show sustainable alternatives
10.	Concrete, ready mix ?	0.11 kg CO_2e	0.1 %	Show sustainable alternatives
11.	Steel stud framing for drywall/gypsum plasterboard per sq. meter of wall area (incl. air gaps per m3) ?	0.05 kg CO_2e	0.0 %	Show sustainable alternatives

Figure 4A

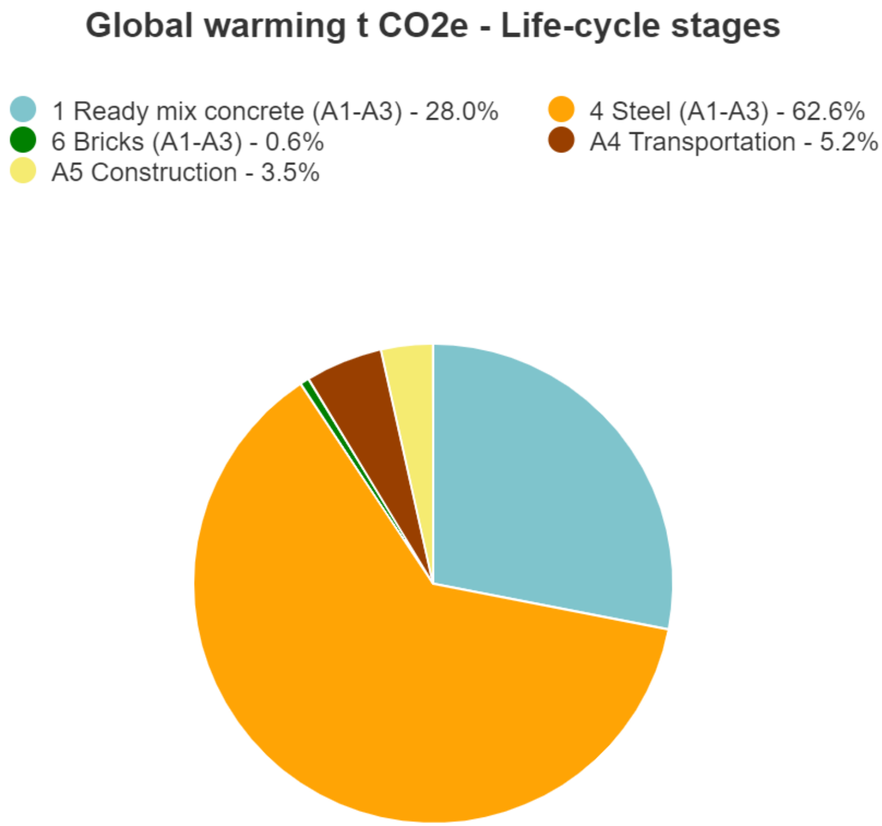


Figure 5A

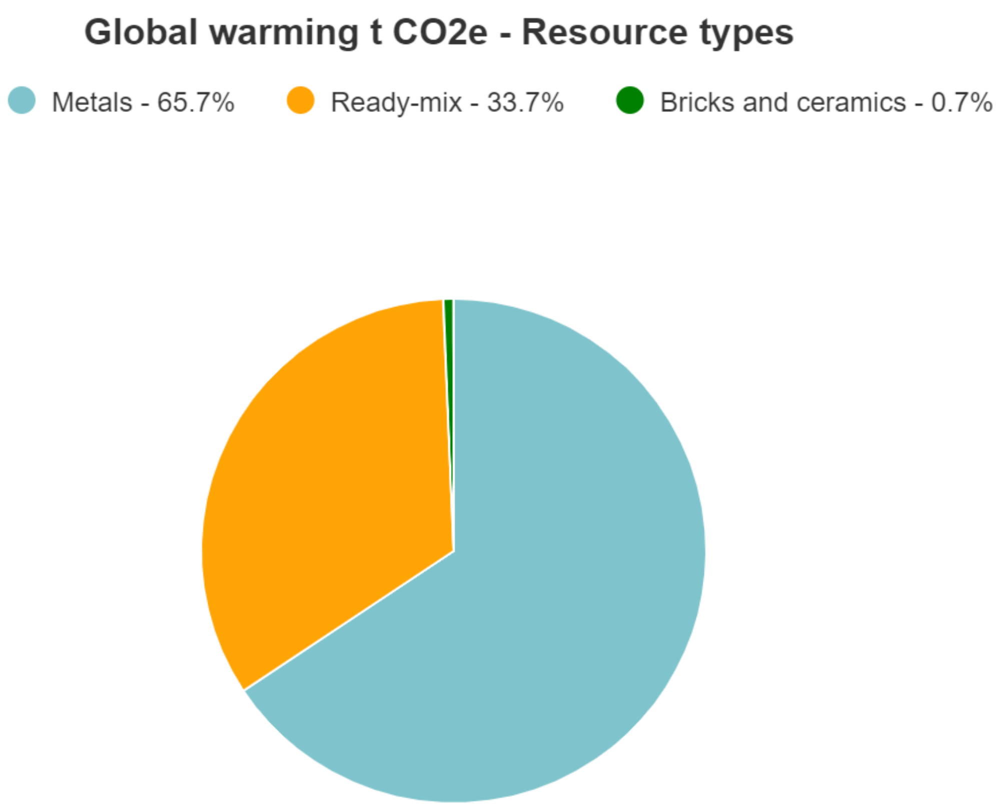


Figure 6A

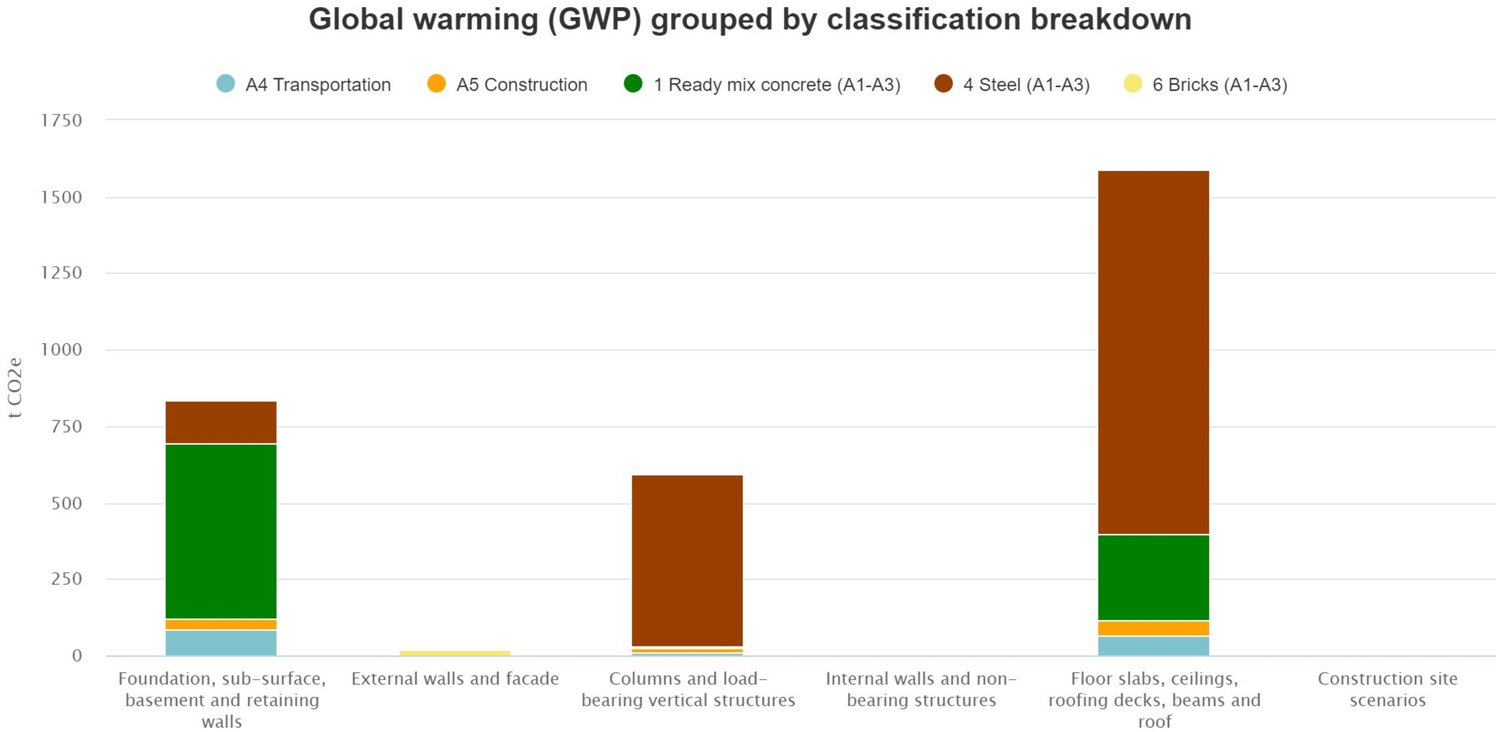
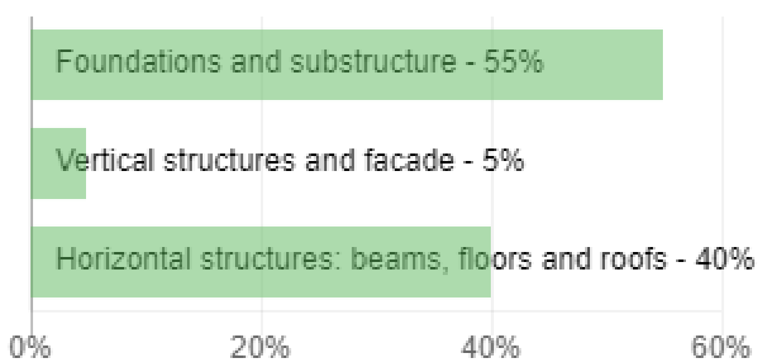


Table 3A

Global warming (GWP) grouped by classification breakdown

Category	A4 Transportation	A5 Construction	1 Ready mix concrete (A1-A3)	4 Steel (A1-A3)	6 Bricks (A1-A3)
Foundation, sub-surface, basement and retaining walls	86.19258896930583	33.29357888293702	572.004265678524	143.21095590212977	0
External walls and facade	0.3913083876409795	0.9542052751007162	0	0	18.69279711437334
Columns and load-bearing vertical structures	7.98392443188301	18.94146267974401	0.9916624808067181	564.7739463314709	0
Internal walls and non-bearing structures	0.04737045023331802	0.11395413036473151	0	3.4057850153646063	0
Floor slabs, ceilings, roofing decks, beams and roof	63.30572511503834	52.91563720701988	279.1353840467284	1191.704308983852	0
Construction site scenarios	0	0	0	0	0

Figure 7A: Embodied Carbon by Structure



Appendix 6

Timber Pile Coleman Highline Building 1 Results :

Table 1B: Summary Report

One Click LCA Planetary results

Download Results Summary

One Click LCA Planetary reports the product cradle to gate (A1-A3) carbon impacts as well as material efficiency for your project. Biogenic carbon is not deducted from totals. You can compare number of designs to identify the most environmentally sustainable design, material and/or supplier. Results are also displayed per m2 Gross Internal Floor Area, if you have inputted area.

	Result category	Global warming t CO_2e	Global warming kg CO_2e/m^2	Mass of raw materials t	Mass of raw materials kg/m^2
1	Ready mix concrete (A1-A3)	737.2 | -13 %	3.58 | -13 %	4,695.15 | -12 %	22.8 | -12 %
2	Precast concrete (A1-A3)				
3	Cement (A1-A3)				
4	Steel (A1-A3)	1,836.01 | -3.5 %	8.92 | -3.5 %	1,191.62 | -4.3 %	5.79 | -4.3 %
5	Aluminium (A1-A3)				
6	Bricks (A1-A3)	18.69 | 0 %	0.09 | 0 %	53.87 | 0 %	0.26 | 0 %
7	Glass (A1-A3)				
8	Insulation (A1-A3)				
9	Wood (A1-A3)	66.16 | +100%	0.32 | +100%	206.75 | +100%	1 | +100%
10	Gypsum (A1-A3)				
11	Other materials (A1-A3)				
A1-A3	Construction Materials	2,658.06 | -4.2 %	12.91 | -4.2 %	6,147.39 | -7.4 %	29.86 | -7.4 %
A4	Transportation to site	145.03 | -8.2 %	0.7 | -8.2 %		
A5	Construction/installation process	110.29 | +3.8 %	0.54 | +3.8 %	267.79 | +3.3 %	1.3 | +3.3 %

The percentages given in red denote the percent change from the concrete foundation option.

Table 2B

Most contributing materials (Global warming)

No.	Resource	Cradle to gate impacts (A1-A3)	Of cradle to gate (A1-A3)	Sustainable alternatives
1.	Concrete, ready mix ?	71 kg CO_2e	49.2 %	Show sustainable alternatives
2.	Concrete, ready mix ?	44 kg CO_2e	30.6 %	Show sustainable alternatives
3.	Fabricated hot-rolled structural sections ?	13 kg CO_2e	8.9 %	Show sustainable alternatives
4.	Primary structural steel frame components ?	4.5 kg CO_2e	3.1 %	Show sustainable alternatives
5.	Softwood lumber ?	4.2 kg CO_2e	2.9 %	Show sustainable alternatives
6.	Steel sheet profiles, roll-formed ?	2.5 kg CO_2e	1.7 %	Show sustainable alternatives
7.	Steel plate ?	2.4 kg CO_2e	1.6 %	Show sustainable alternatives
8.	Rebar ?	1.3 kg CO_2e	0.9 %	Show sustainable alternatives
9.	Hollow structural steel sections ?	1.1 kg CO_2e	0.8 %	Show sustainable alternatives
10.	Thin facing bricks ?	0.39 kg CO_2e	0.3 %	Show sustainable alternatives
11.	Concrete, ready mix ?	0.11 kg CO_2e	0.1 %	Show sustainable alternatives
12.	Steel stud framing for drywall/gypsum plasterboard per sq. meter of wall area (incl. air gaps per m3) ?	0.03 kg CO_2e	0.0 %	Show sustainable alternatives

Figure 4B

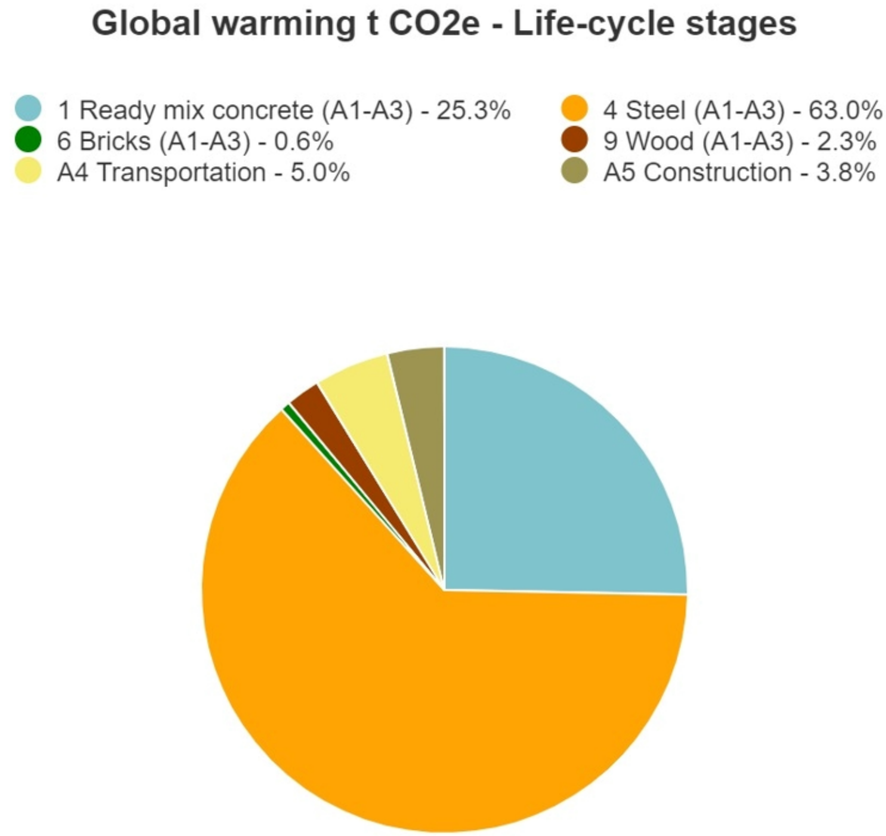


Figure 5B

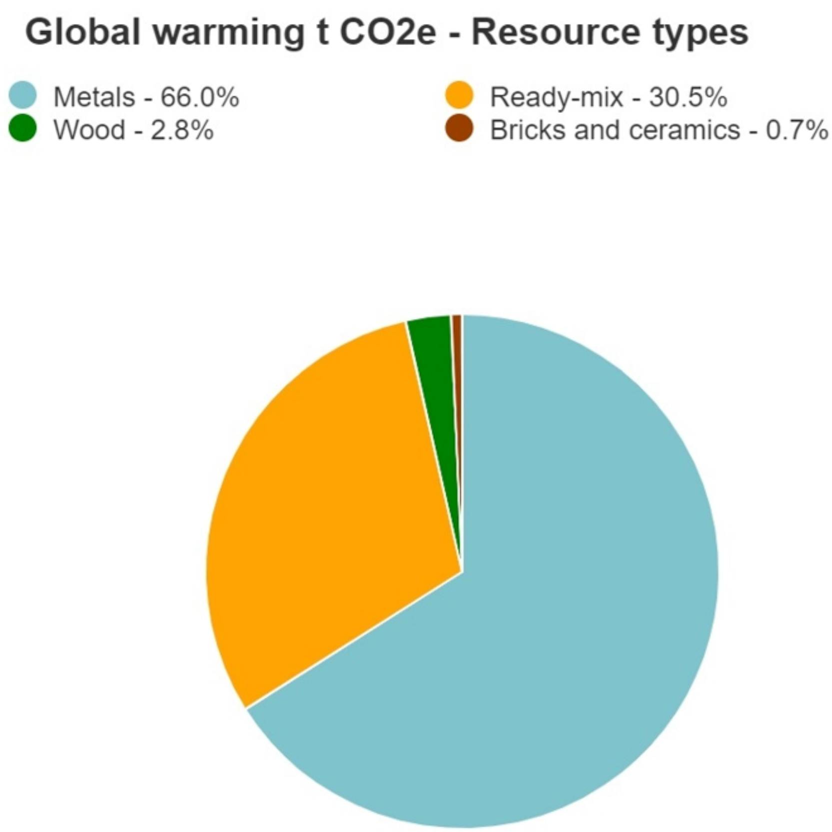


Figure 6B

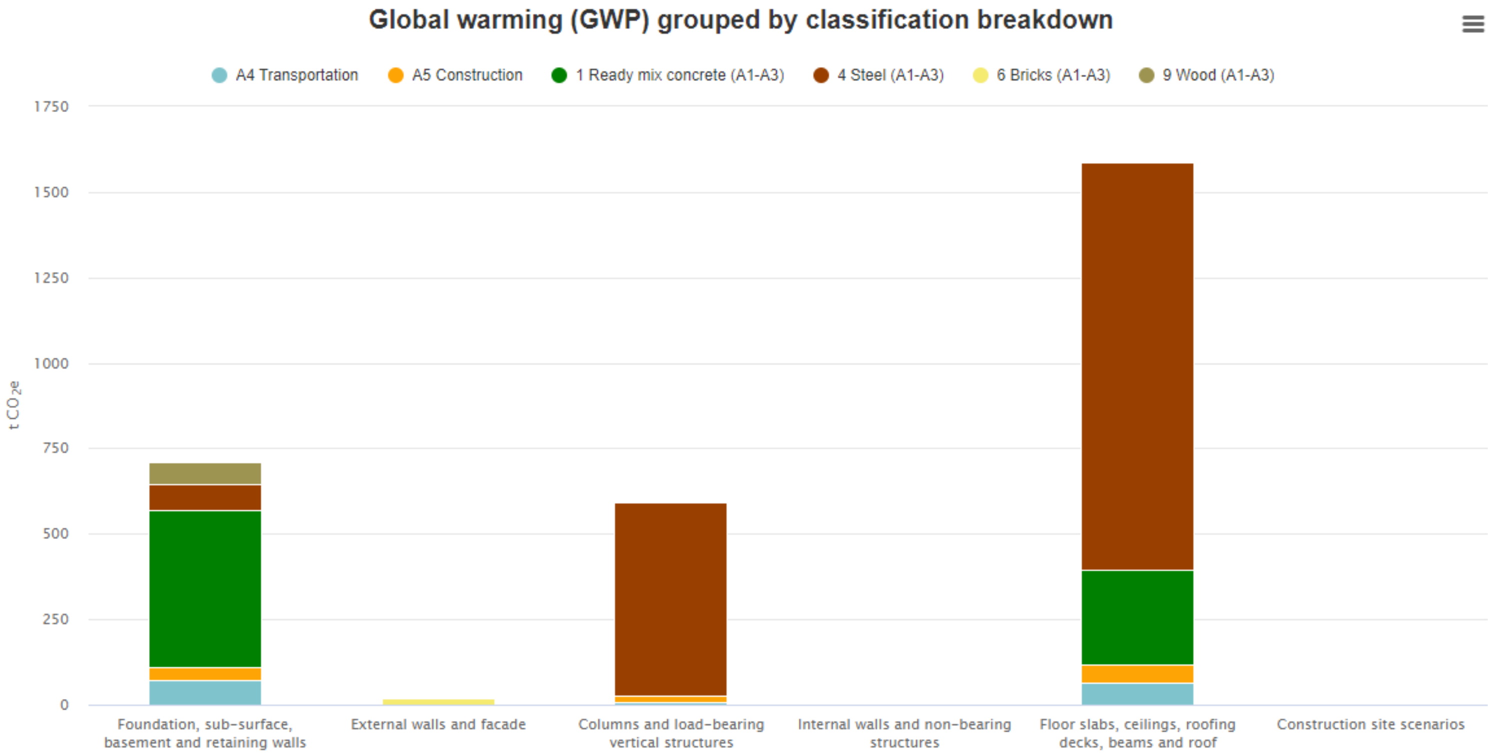
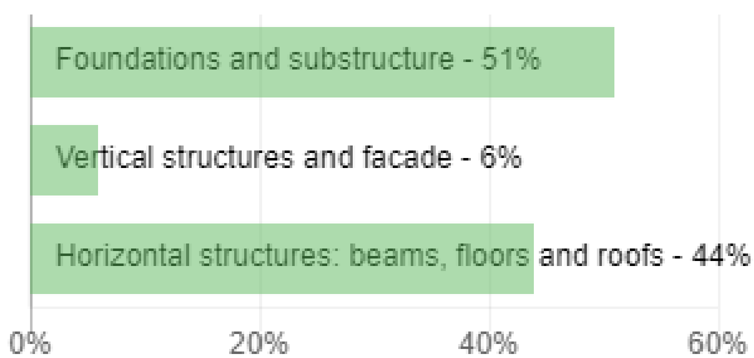


Table 3B

Global warming (GWP) grouped by classification breakdown

Category	A4 Transportation	A5 Construction	1 Ready mix concrete (A1-A3)	4 Steel (A1-A3)	6 Bricks (A1-A3)	9 Wood (A1-A3)
Foundation, sub-surface, basement and retaining walls	73.32500138151073	37.407112807275446	457.071303599147	77.51669535505022	0	66.16091057176473
External walls and facade	0.3913083876409795	0.9542052751007162	0	0	18.69279711437334	0
Columns and load-bearing vertical structures	7.98392443188301	18.94146267974401	0.9916624808067181	564.7739463314709	0	0
Internal walls and non-bearing structures	0.027966053925865753	0.06727500665834389	0	2.010670511478495	0	0
Floor slabs, ceilings, roofing decks, beams and roof	63.30572511503834	52.91563720701988	279.1353840467284	1191.704308983852	0	0
Construction site scenarios	0	0	0	0	0	0

Figure 7B: Embodied Carbon by Structure



Appendix 7: Drawings

1 LEVEL 1 / FOUNDATION PLAN

3/32" = 1'-0"

FOUNDATION PLAN NOTES

1. SEE SHEET S1.01 TO S1.01A FOR STRUCTURAL NOTES.
   SEE SHEET S1.01A FOR SYMBOL LEGEND.
   SEE SHEETS S1.02 TO S1.02B FOR TYPICAL CONCRETE DETAILS.
   SEE SHEET S1.04 TO S1.04D FOR TYPICAL STEEL DETAILS.
2. TOP OF SLAB ON GRADE = 0'-0" UNO.
3. TOP OF REFERENCE FINISH SLAB ELEVATION = +57.00' CITY OF SAN JOSE DATUM = 0'-0".
4. TOP OF PILECAPS AND GRADE BEAMS SHALL BE -1'-0" BELOW TOP OF SLAB OR FINISH GRADE, UNO. [-X'-X"] INDICATES TOP OF PILECAP ELEVATION RELATIVE TO TOP OF SLAB ON GRADE. TOP OF GRADE BEAM ALIGNS WITH TOP OF PILECAP/PILASTER UNO. SLOPE GRADE BEAMS AT VARYING TOP OF PILECAPS ELEVATIONS. (1)
5. SAD FOR DIMENSIONS, ELEVATIONS, SLOPES, CURBS, STEPS, AND PADS NOTED ON PLAN.
6. COORDINATE LOCATION OF SLAB STEPS AND RECESSED AREAS WITH ARCHITECTURAL DRAWINGS.
7. CONTRACTOR TO FIELD-VERIFY ALL EXISTING DIMENSIONS AND CONDITIONS AND NOTIFY ARCHITECT OF ANY DISCREPANCIES PRIOR TO CONSTRUCTION.
8. ALL FOUNDATION EXCAVATIONS MUST BE INSPECTED AND APPROVED BY THE GEOTECHNICAL ENGINEER PRIOR TO PLACEMENT OF REINFORCING STEEL.
9. PRIOR TO THE CONTRACTOR REQUESTING A BUILDING DEPARTMENT INSPECTION, THE SOILS ENGINEER SHALL ADVISE THE BUILDING OFFICIAL IN WRITING THAT:
   A. THE BUILDING PAD WAS PREPARED IN ACCORDANCE WITH THE SOILS REPORT,
   B. THE UTILITY TRENCHES HAVE BEEN PROPERLY BACKFILLED AND COMPACTED, AND
   C. THE FOUNDATION EXCAVATIONS COMPLY WITH THE INTENT OF THE SOILS REPORT.
10. DIMENSIONS AND GRIDS TO FACE OF WALLS OR CENTERLINE OF COLUMNS UNO.
11. REMOVE (E) SLAB TO INSTALL (N) PILES AND PILECAPS. REMOVE (E) PILECAPS AND PILES 1'-0" BELOW BOTTOM OF (N) PILECAPS,

PILE FOUNDATION LOADING NOTES:

1. D = DEAD LOAD AT ALLOWABLE STRESS LEVEL.
2. L = LIVE LOAD AT ALLOWABLE STRESS LEVEL.
3. E = VERTICAL EARTHQUAKE LOAD AT STRENGTH LEVEL WITH RHO OF 1.3 INCLUDED. LOADS CAN ACT EITHER DOWNWARD OR UPWARD.
4. LIVE LOADS HAVE BEEN REDUCED PER ASCE 7-10.
5. PILE DESIGN LOAD COMBINATIONS SHALL BE IN ACCORDANCE WITH ASCE 7-10.

HUNTER STORM

COLEMAN HIGHLINE
BUILDING 1

DEVCON CONSTRUCTION INCORPORATED
690 Gibraltar Drive
Milpitas, California 95035
(408)942-8200 Lic. #399163

NISHKIAN MENNINGER
CONSULTING AND STRUCTURAL ENGINEERS SINCE 1919
600 Harrison St. Suite110, San Francisco, CA 94107
Tel: (415) 541-9477 Fax: (415) 543-5071

JOB NO.: NM7459

GENERAL NOTES:
CONTRACTOR SHALL FIELD VERIFY ALL JOB CONDITIONS AND DIMENSIONS. VARIATIONS THEREOF FROM THE DRAWINGS MUST BE REPORTED TO THE ARCHITECT.

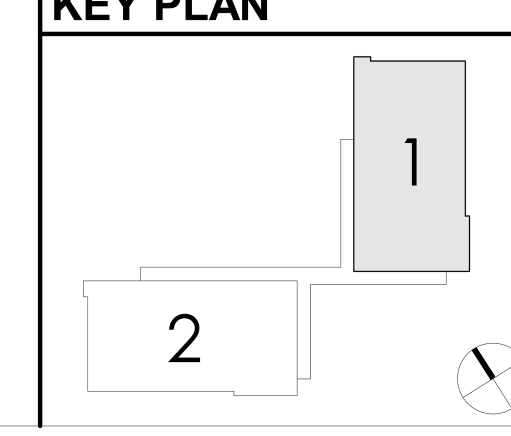
DETAILS INDICATED ON THE DRAWINGS ARE REPRESENTATIVE AND TYPICAL. ALL ATTACHMENTS AND CONNECTIONS SHALL CONFORM TO BEST PRACTICE AND SHALL BE THE CONTRACTOR'S RESPONSIBILITY.

REGISTERED PROFESSIONAL ENGINEER
KEVIN L. MENNINGER
No. S3163
Exp. 3/31/17
STRUCTURAL
STATE OF CALIFORNIA

REVISIONS

NO.	DATE	DESCRIPTION	BY
1	9/26/14	RESPONSE TO CITY COMMENTS	
2	11/21/14	RESPONSE TO CITY COMMENTS	
5	4/25/16	FOR CONSTRUCTION	

KEY PLAN

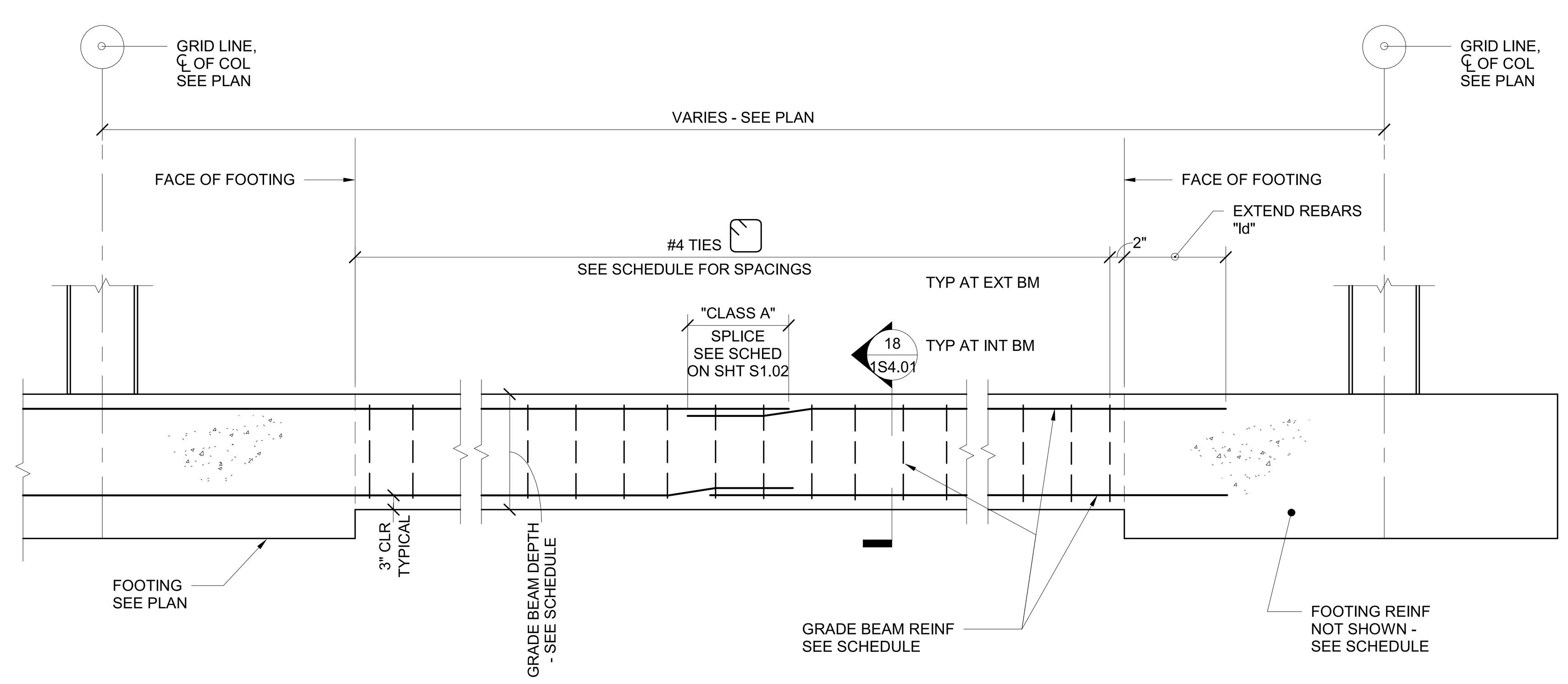


BLDG 1 - LEVEL 1
(FOUNDATION PLAN)

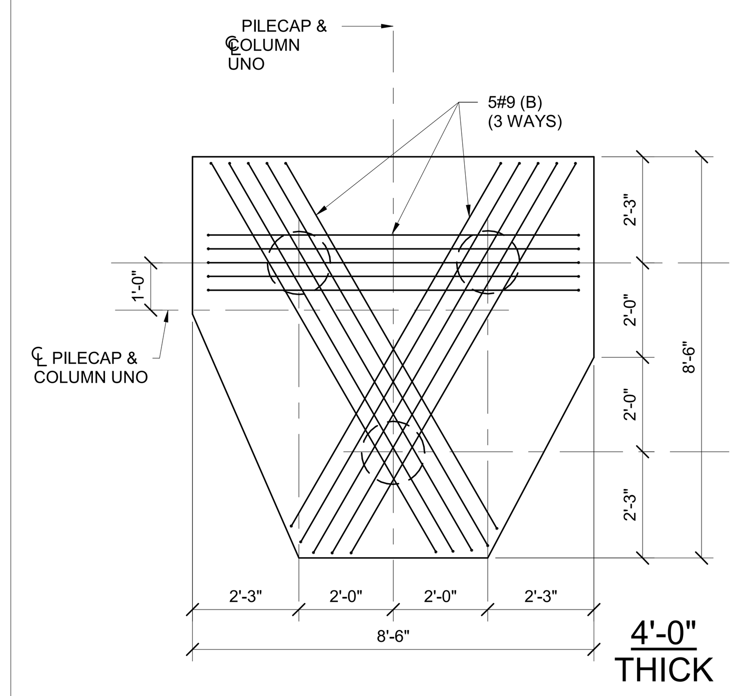
JOB NO. 14-091
DATE 1/8/18
DRAWN: PM
CHECKED: RK
ISSUE: FOR RECORD

SHEET NO.
1S2.01
OF SHEETS

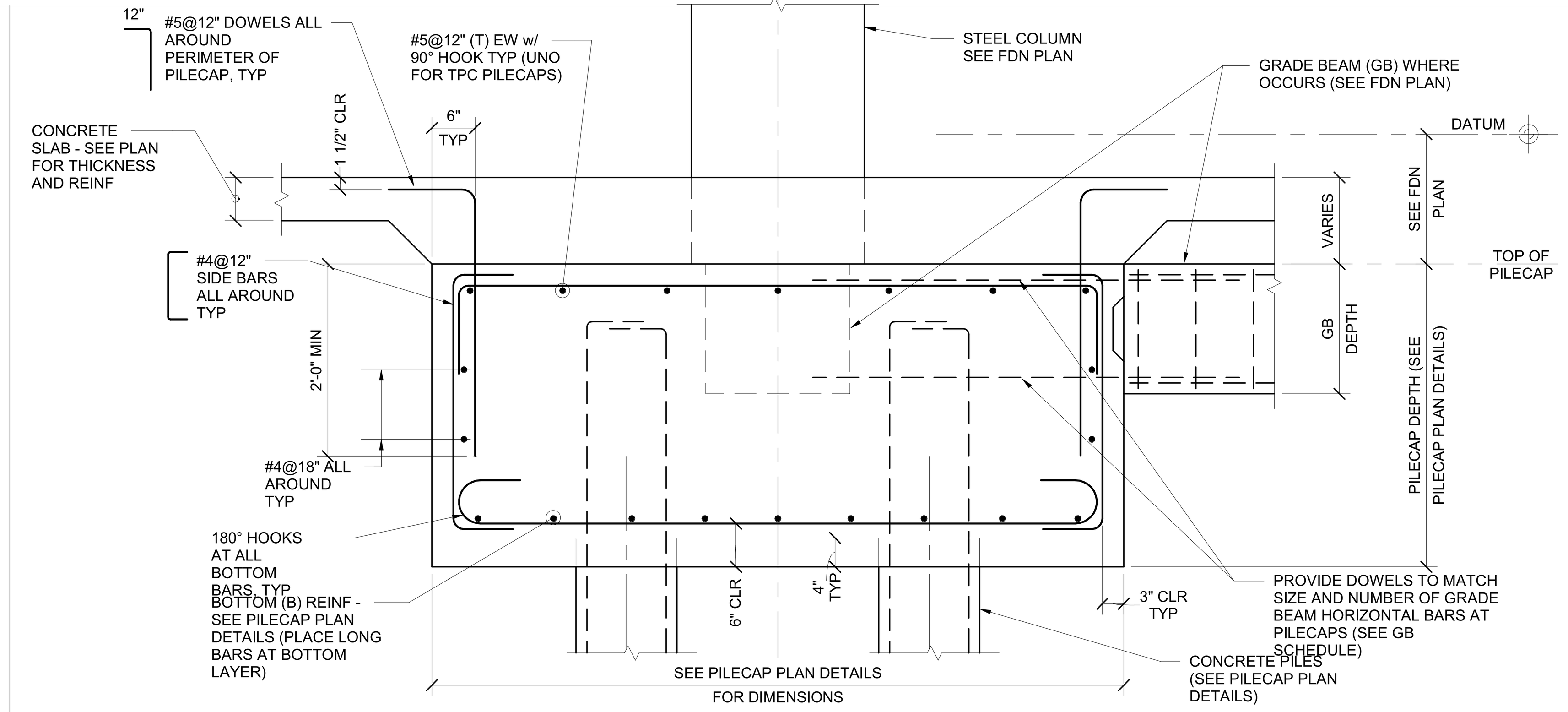
12/5/2021 10:05:18 PM



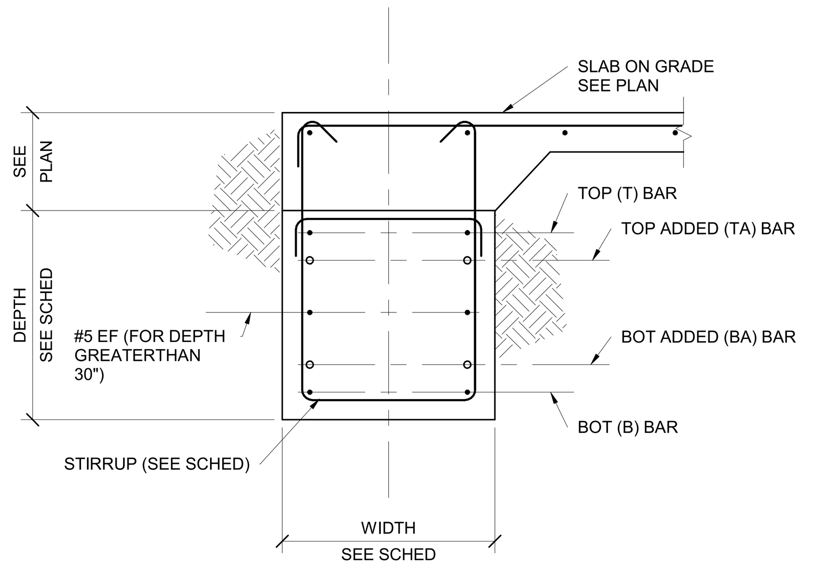
20 TYP GRADE BEAM REINFORCEMENT
NTS



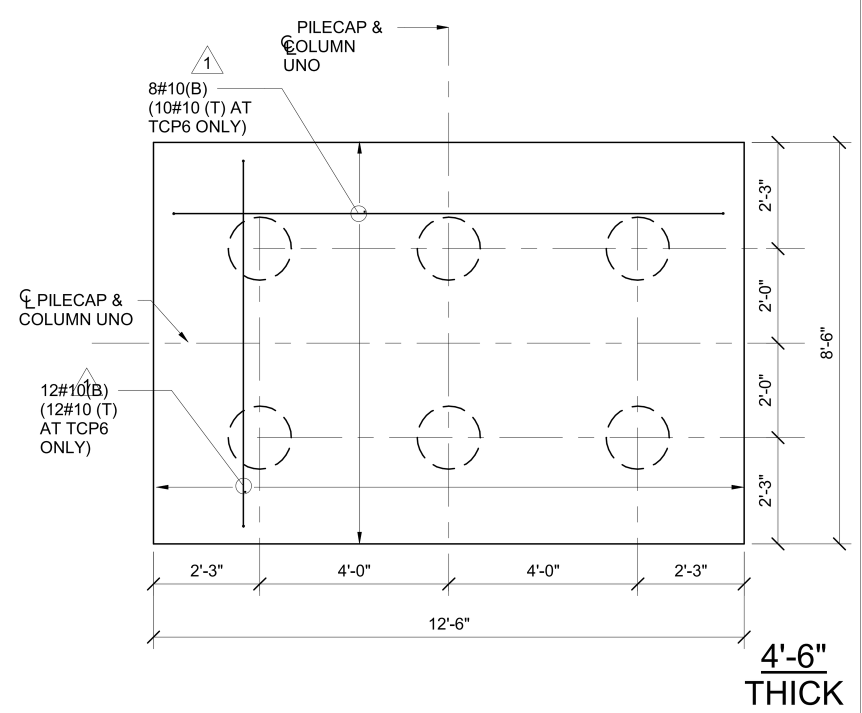
12 PILECAP PC3 PLAN DETAIL
NTS



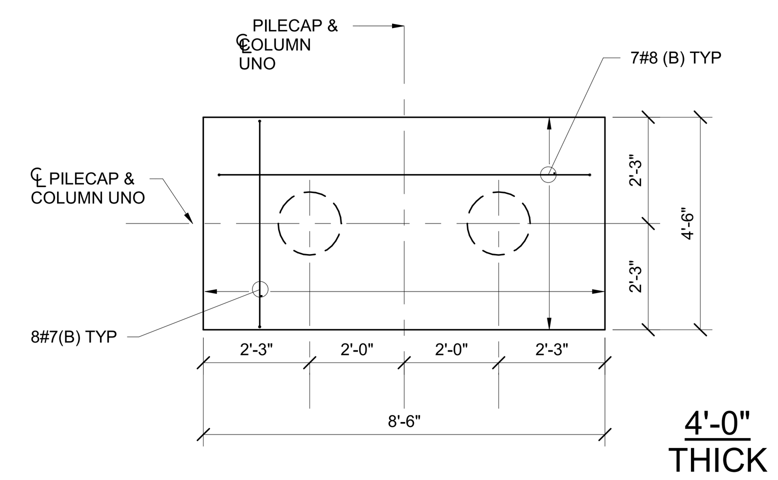
8 TYP PILECAP SECTION (CONCRETE PILES)
NTS



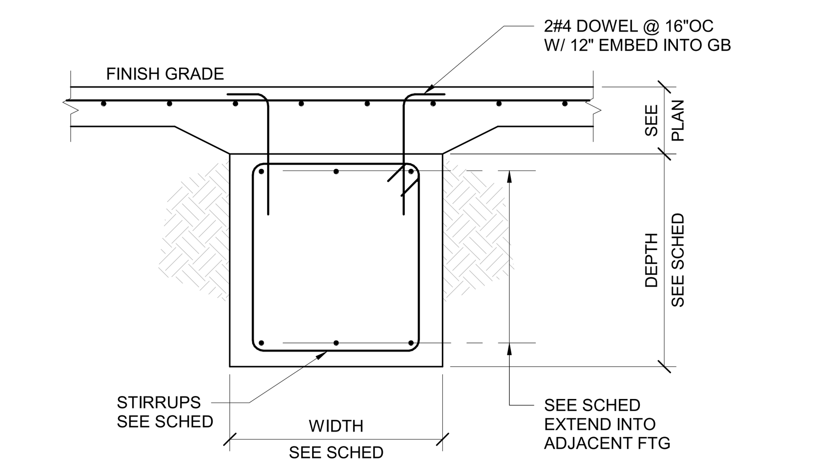
19 TYP PERIMETER GRADE BEAM
NTS



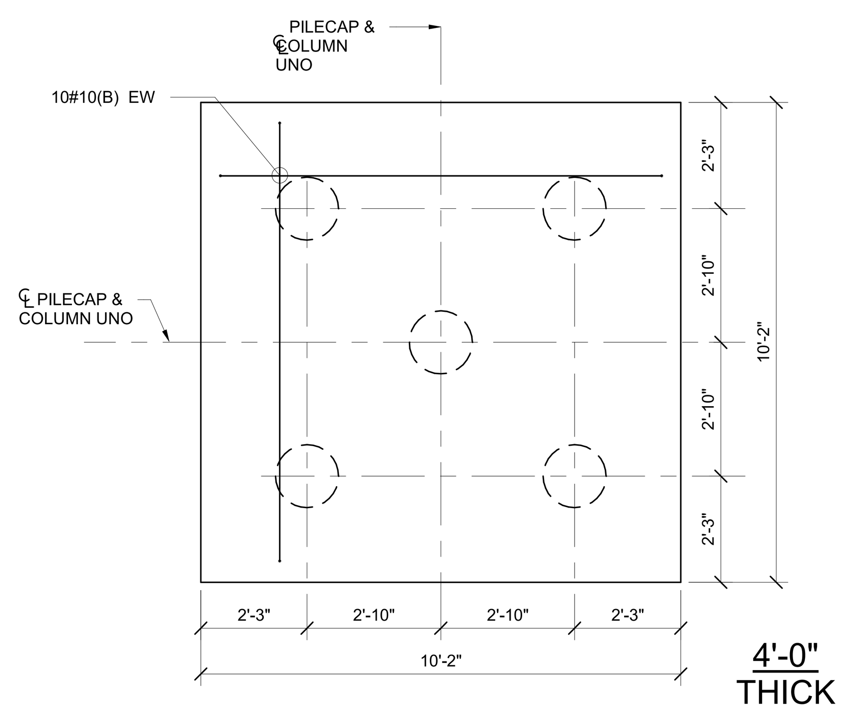
15 PILECAP PC6 PLAN DETAIL (TPC6 AT SIM)
NTS



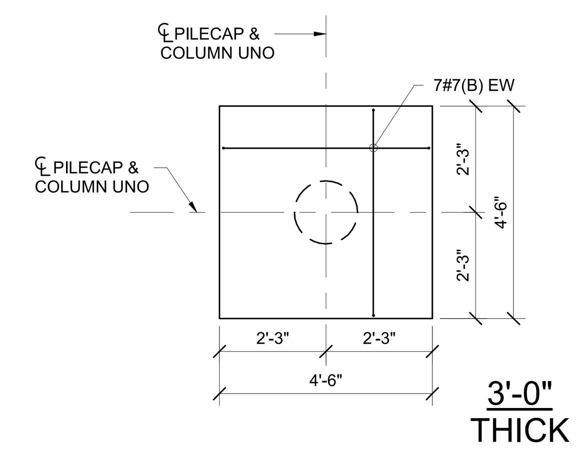
11 PILECAP PC2 PLAN DETAIL
NTS



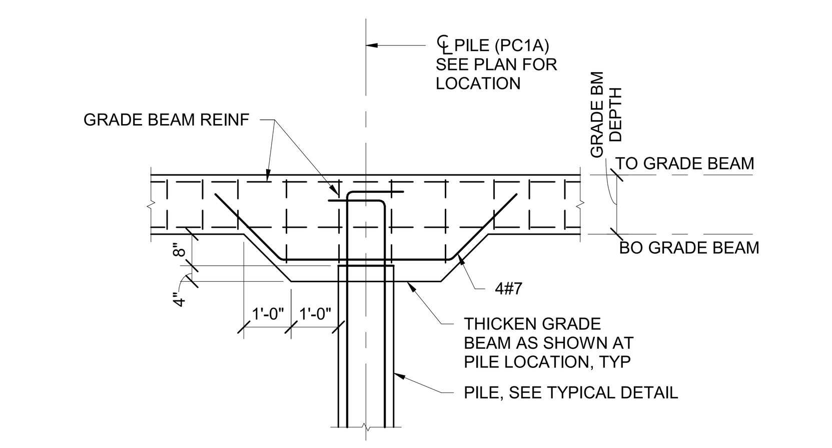
18 TYP INTERIOR GRADE BEAM
NTS



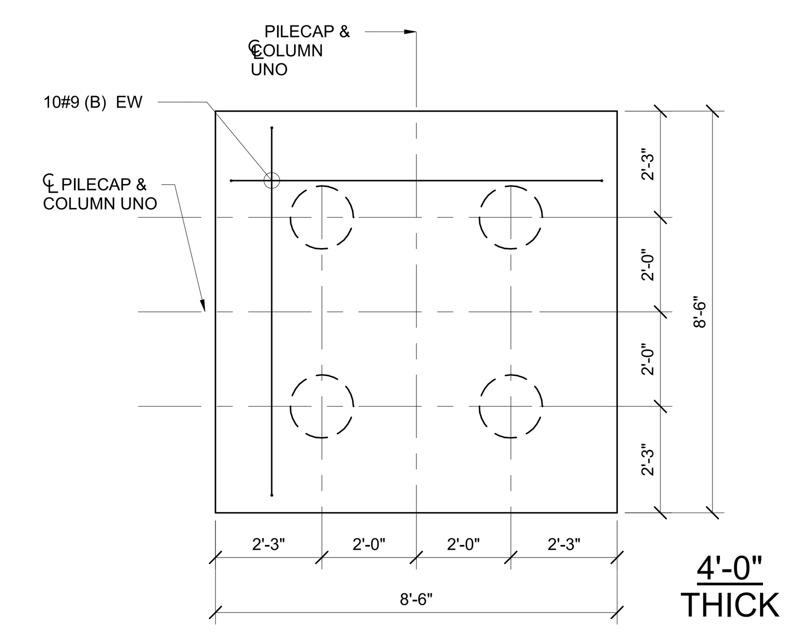
14 PILECAP PC5 PLAN DETAIL
NTS



10 PILECAP PC1 PLAN DETAIL
NTS



17 PC1A SINGLE PILE AT GRADE BEAM
NTS



13 PILECAP PC4 PLAN DETAIL
NTS

PILE DESIGN CRITERIA

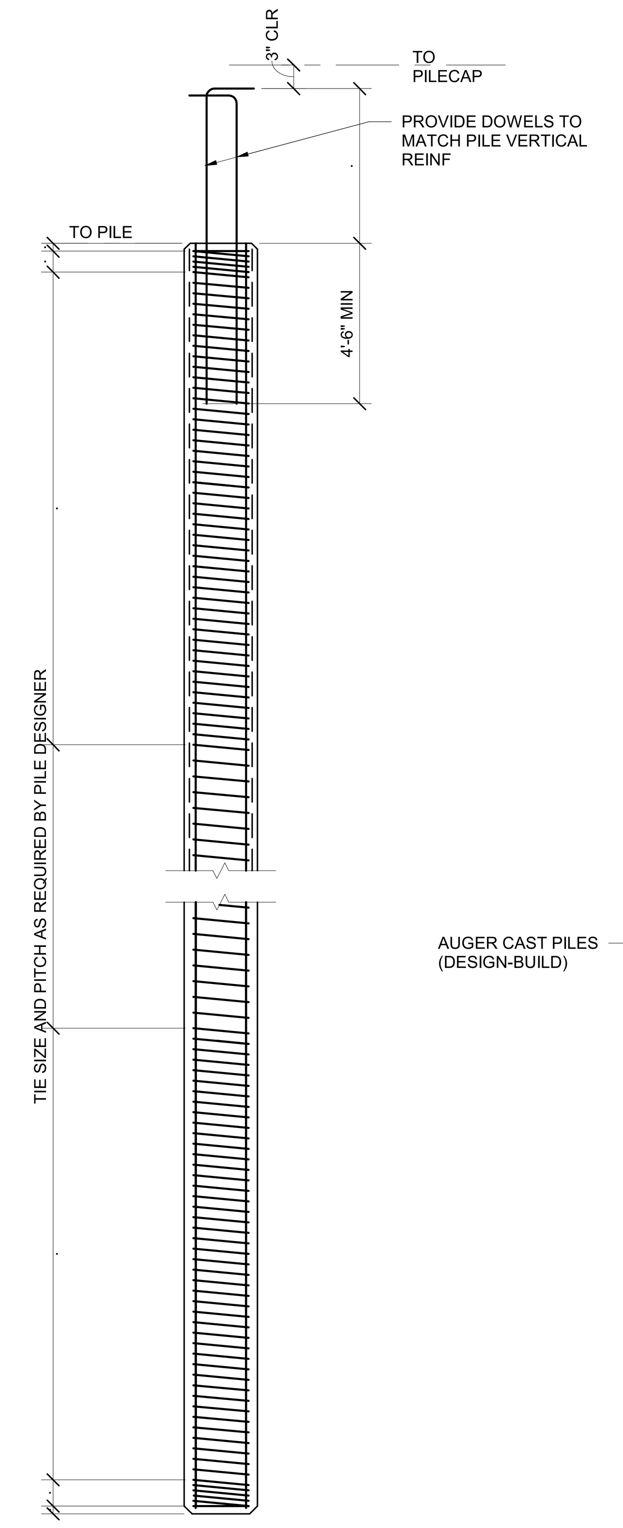
A. PILES TO BE AUGERCAST CONCRETE PILES (SEE FOUNDATION PLANS)

B. ALL PILES TO BE DESIGNED ACCORDING TO THE ***2013 CALIFORNIA BULDING CODE*** TO CARRY LATERAL LOAD COMBINED WITH AXIAL COMPRESSION OR TENSION LOADS AS SHOWN ON PILE CAPACITIES TABLE. PROVIDE MILD STEEL REINFORCING FOR BENDING MOMENTS AS REQUIRED.

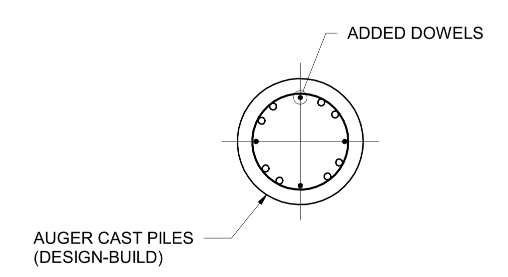
C. TENSION PILES ARE INDICATED ON PLAN THUS: TPC4, TPC5 ("T" INDICATED TENSION)

D. PILE LENGTHS SHOWN ARE ESTIMATED VALUE FOR BIDDING PURPOSES. FINAL LENGTHS SHALL BE DETERMINED THROUGH A LOAD TEST PROGRAM.

E. SEE GEOTECHNICAL REPORT FOR ADDITIONAL INFORMATION.



TYPICAL PILE ELEVATION



PLAN

GRADE BEAM SCHEDULE							
MARK	BEAM SIZE (IN)		REF DETAIL	REINFORCING		#4 STIRRUPS (FROM EACH END)	
	WIDTH	DEPTH		TOP	BOTTOM		
GB1	2'-0"	2'-0"	18&19/-	3#8	3#8	4@3" ; REM @ 10"OC	
GB2	3'-0"	3'-0"	(1) 18&19/-	4#9	4#9	4@3" ; REM @ 10"OC	

9 GRADE BEAM SCHEDULE
NTS

PILE CAPACITIES (WORKING LOAD) SCHEDULE

PILE SIZE	LENGTH	DEAD LOAD + LIVE LOAD	DEAD LOAD + LIVE LOAD + WIND OR SEISMIC	UPLIFT	LATERAL LOAD	MOMENT
16" DIA	60' +/- (VERIFY THRU LOAD TEST PROGRAM)	150 KIPS	200 KIPS	100 KIPS	-	- K-FT

5 TYPICAL AUGERCAST CONCRETE PILE DETAILS
NTS

HUNTER STORM

COLEMAN HIGHLINE
BUILDING 1

DEVCON CONSTRUCTION INCORPORATED
690 Gibraltar Drive
Milpitas, California 95035
(408)942-8200 Lic. #399163

NISHKIAN MENNINGER
CONSULTING AND STRUCTURAL ENGINEERS SINCE 1919
600 Harrison St. Suite110, San Francisco, CA 94107
Tel: (415) 541-9477 Fax: (415) 543-5071
JOB NO.: NM7459

GENERAL NOTES:
CONTRACTOR SHALL FIELD VERIFY ALL JOB CONDITIONS AND DIMENSIONS. VARIATIONS THEREOF FROM THE DRAWINGS MUST BE REPORTED TO THE ARCHITECT.

DETAILS INDICATED ON THE DRAWINGS ARE REPRESENTATIVE AND TYPICAL. ALL ATTACHMENTS AND CONNECTIONS SHALL CONFORM TO BEST PRACTICE AND SHALL BE THE CONTRACTOR'S RESPONSIBILITY.

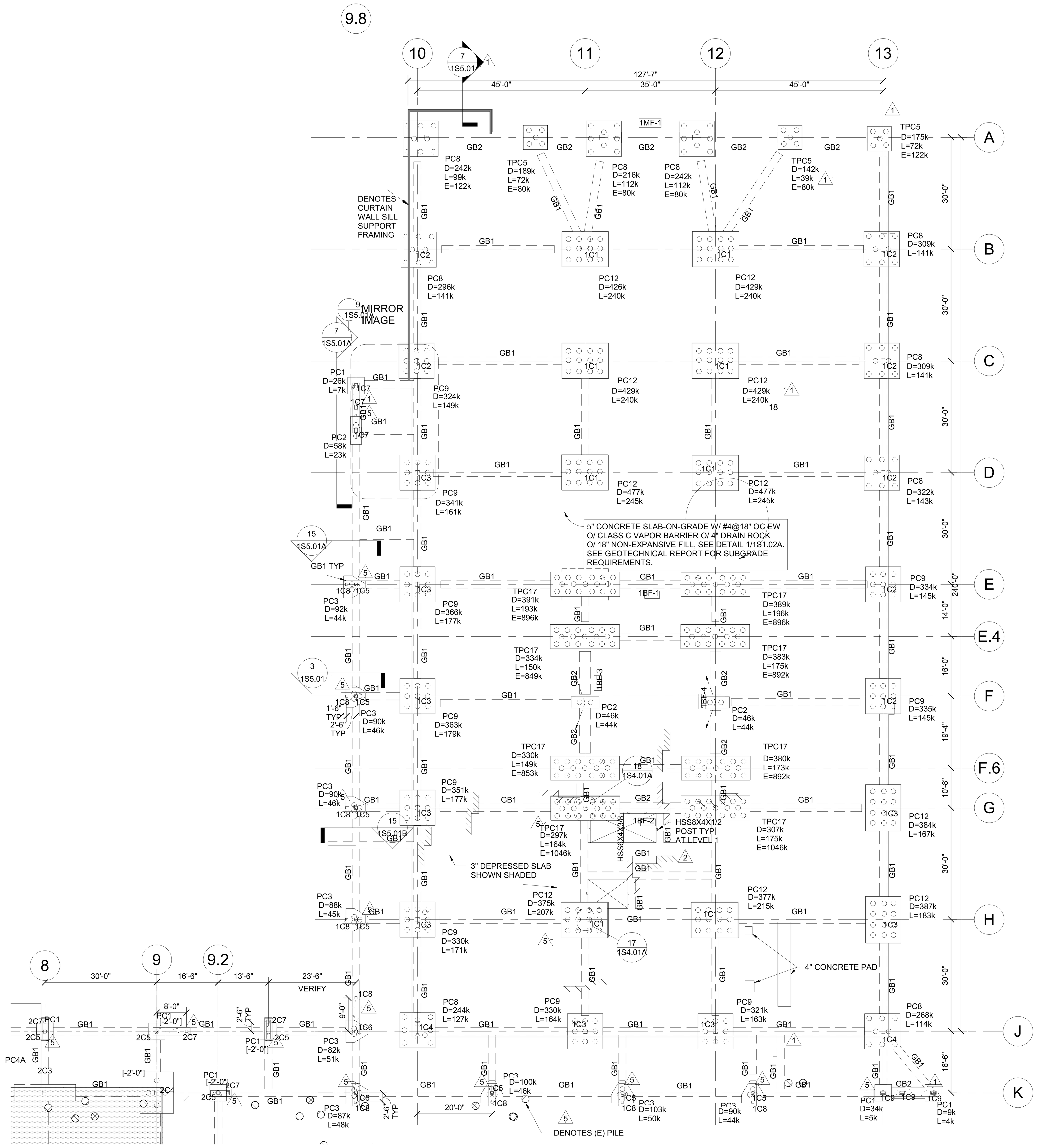
REVISIONS

NO.	DATE	DESCRIPTION	BY
1	9/26/14	RESPONSE TO CITY COMMENTS	

FOUNDATION SECTIONS AND DETAILS

JOB NO. 14-091
DATE 1/8/18
DRAWN: PM
CHECKED:RK
ISSUE: FOR RECORD

SHEET NO.
1S4.01
OF SHEETS



1 LEVEL 1 / FOUNDATION PLAN

1/16" = 1'-0"

SENIOR PROJECT

STAMP:

DATE:

PROJECT: TIMBER PILE DESIGN

SITE: COLEMAN HIGHLINE

REVISIONS:

NO.	DESC.	DATE

DRAWN BY: Author

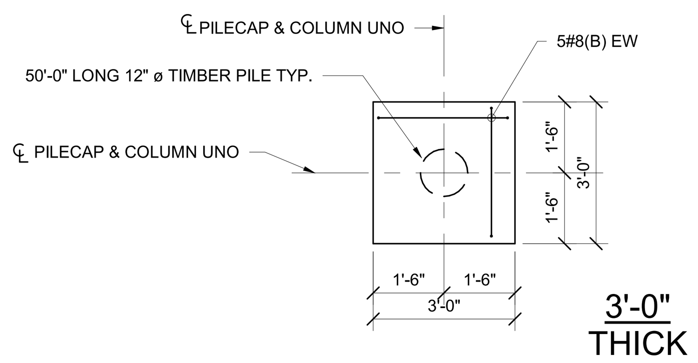
CHECKED BY: Checker

PLOT DATE: 12/7/2021 11:21:37 AM

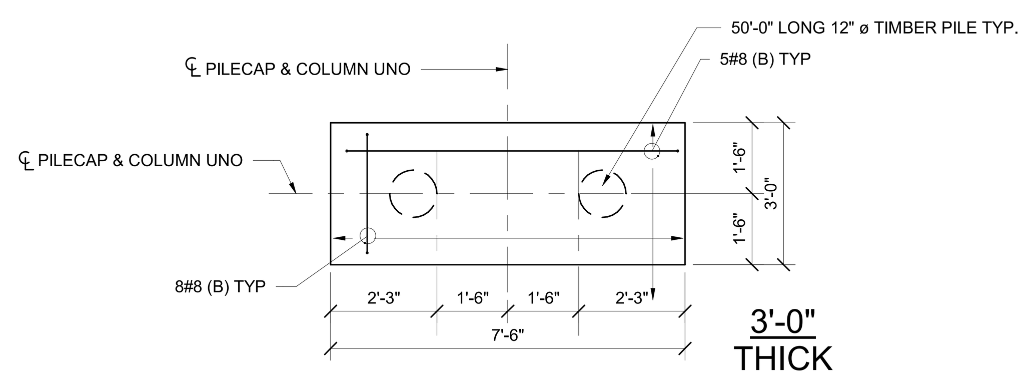
SHEET NAME: UPDATED FOUNDATION PLAN

SCALE: 1/16" = 1'-0"

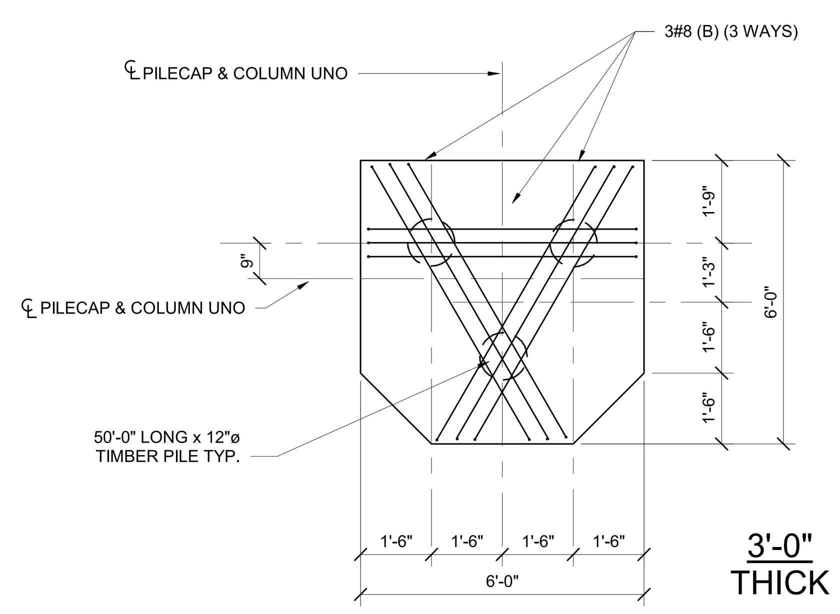
SHEET NO: S2.04



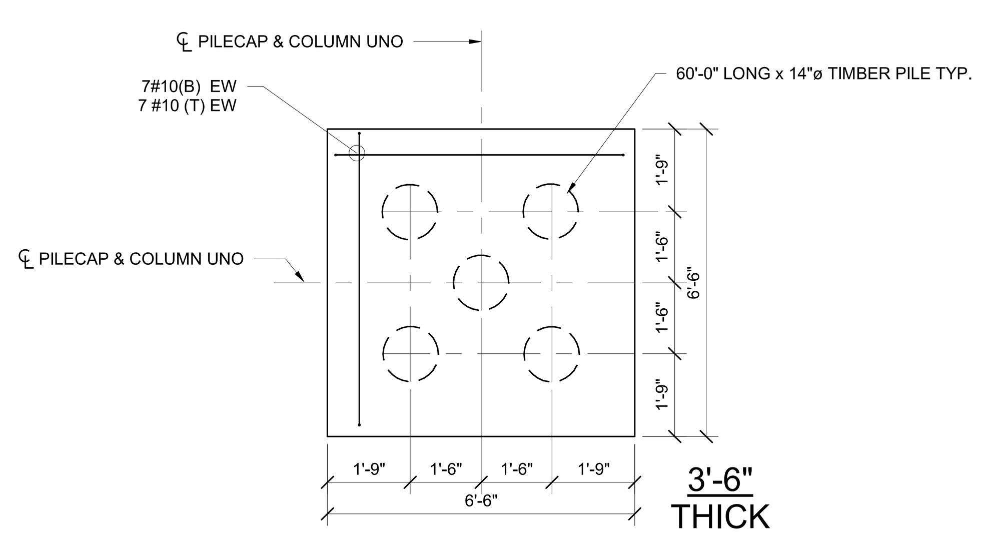
1 PC1 PLAN DETAIL
3/8" = 1'-0"



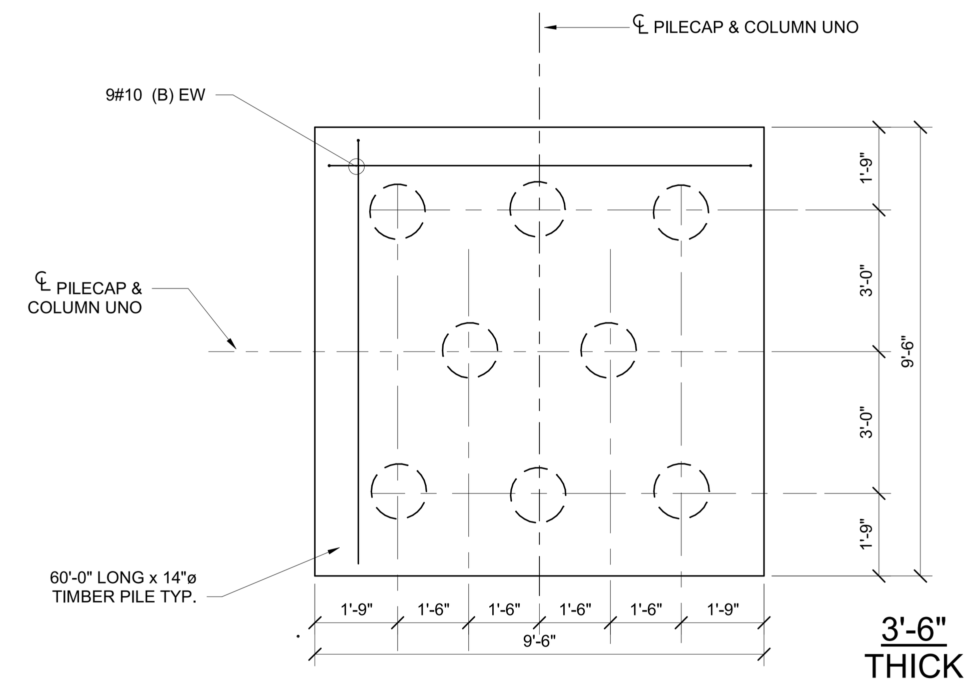
2 PC2 PLAN DETAIL
3/8" = 1'-0"



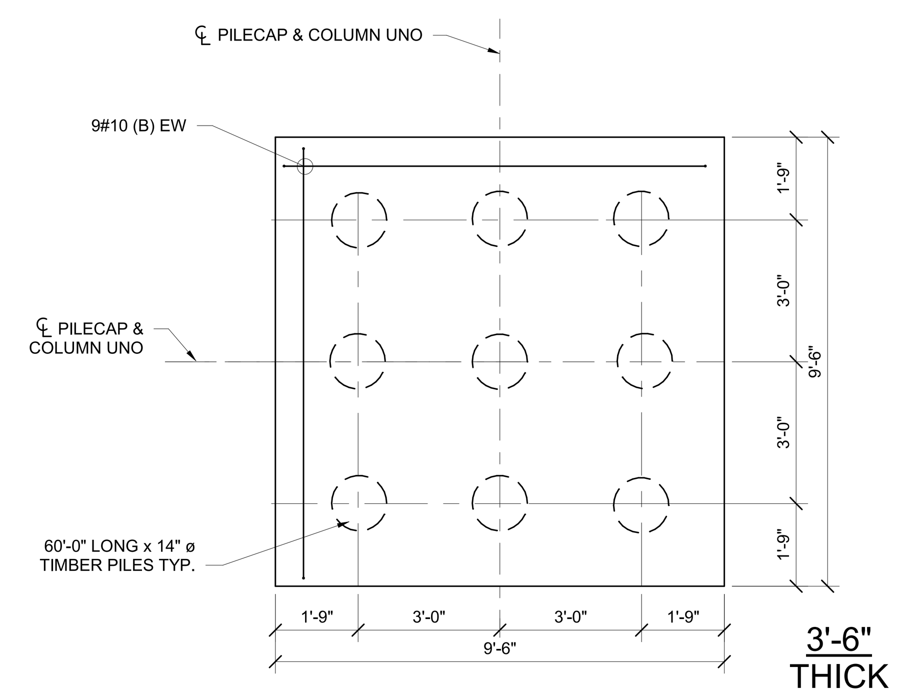
3 PC3 PLAN DETAIL
3/8" = 1'-0"



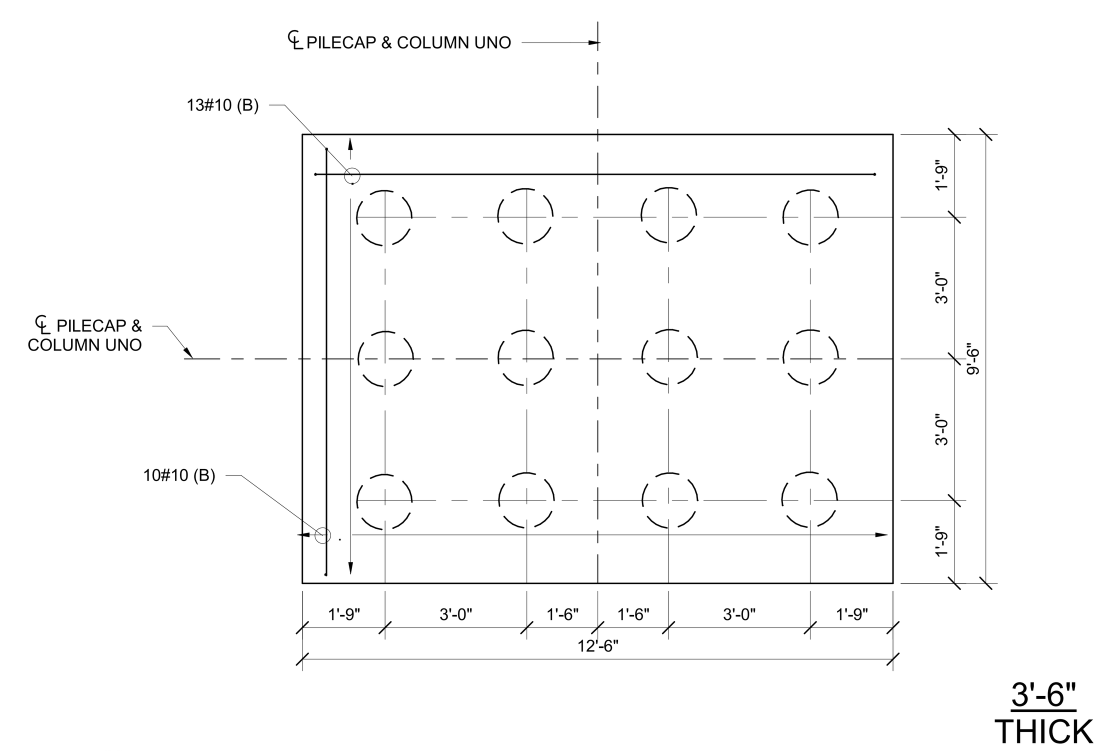
4 TPC5 PLAN DETAIL
3/8" = 1'-0"



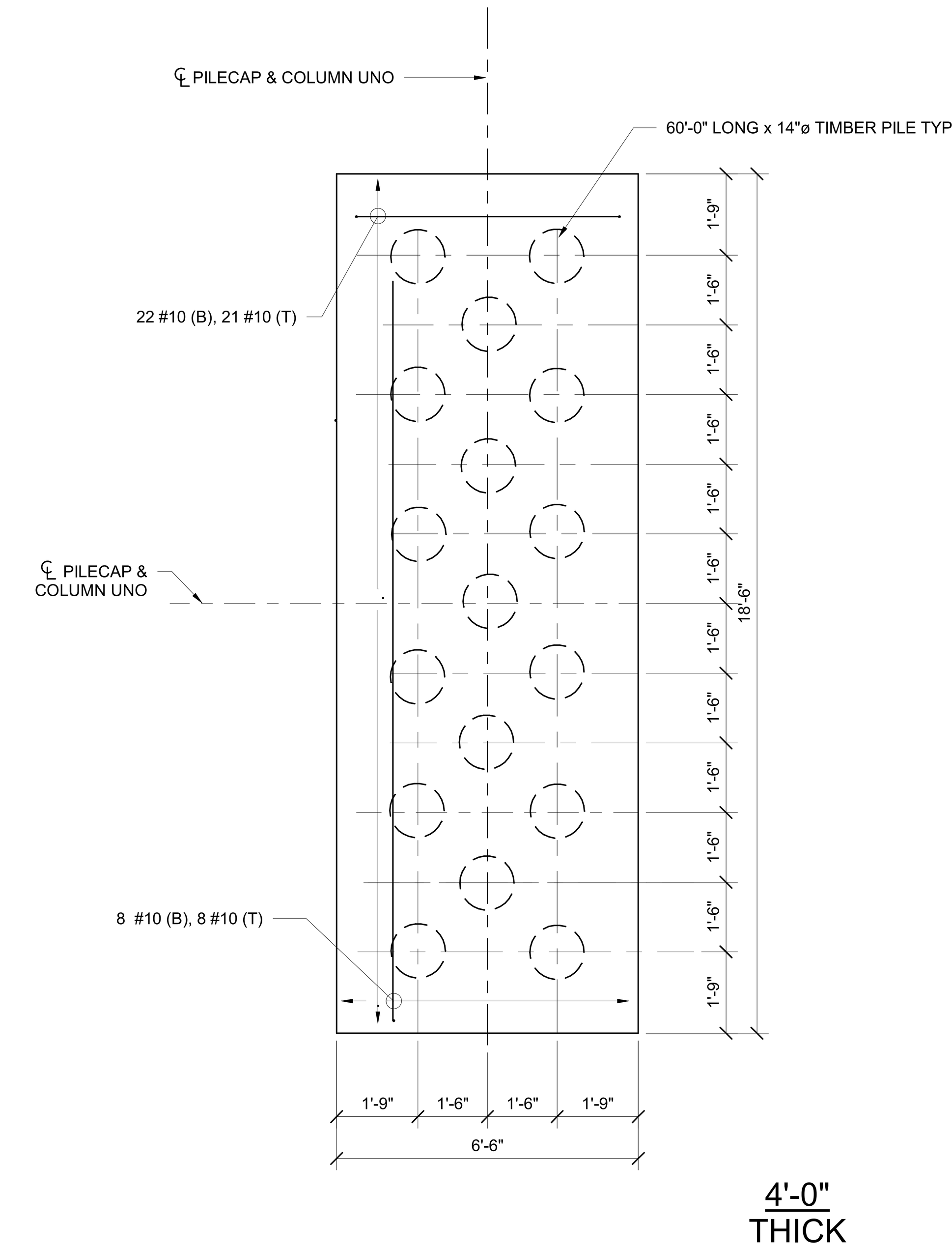
5 PC8 PLAN DETAIL
3/8" = 1'-0"



6 PC9 PLAN DETAIL
3/8" = 1'-0"



7 PC12 PLAN DETAIL
3/8" = 1'-0"



8 TPC17 PLAN DETAIL
3/8" = 1'-0"

SENIOR PROJECT

STAMP:

DATE:

PROJECT: TIMBER PILE DESIGN

SITE: COLEMAN HIGHLINE

REVISIONS:

NO.	DESC.	DATE

DRAWN BY: Author

CHECKED BY: Checker

PLOT DATE: 12/5/2021 10:07:54 PM

SHEET NAME: UPDATED PILE CAP DETAILS

SCALE: 3/8" = 1'-0"

SHEET NO: S2.03