Reinsurance Group of America (RGA) Global Headquarters

Spring 2014

Thesis Proposal

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Chesterfield, MO

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Executive Summary

The Reinsurance Group of America's (RGA) Global Headquarters is located in Chesterfield, Missouri. The complex consists of two, five story office towers framed in steel with glass curtain wall façades and a two story, partially underground parking garage of post-tensioned reinforced concrete with a limestone panel façade. The lateral system consists of steel concentric braced frames in the office towers which change to reinforced concrete shear walls in the parking garage. Four of the five stories of the office towers are cantilevered over the first floor by five feet on three of the four sides and by forty feet on the fourth side. Housing a Fortune 500 company, the complex is meant to represent RGA's local and global presence and is designed for a LEED Silver Certification.

Purpose and Scope

The purpose of this proposal is to define a new design requirement brought forward by the owner and explore its influence on the project. In this case, the owner has proposed adding a publicly accessible green roof that also functions as a roof garden which requires the current structural design to be revised. This proposed scenario and solution are elaborated upon in the body of this proposal. A task list, schedule, and solution method are presented as well to demonstrate the ability to thoroughly investigate this topic. Background information on the project is presented to place the proposed change into the larger context of the building project.

The large parking garage structure is separated by structural separation joints into four sections. Thus, the scope of analysis and design will focus on one area of the parking garage and the steel tower above it. For a visual, see Appendix B.

This proposal has three main sections. First, a structural depth will be studied in which the design will be updated to the newest code and redesigned under the new applied loading from the green roof addition. In the gravity system, special attention will be paid to the cantilever truss system and its supporting members along with roof members that provide cantilever support as well. In the lateral redesign, the chevron type concentric braced frames will be redesigned using buckling restrained braces in place of the traditional HSS braces.

In addition to the structural depth, two breath topics impacted by the intensive green roof garden addition will be studied. An architecture and landscape architecture breadth will include the design of the green roof and its public spaces. The final design will be communicated graphically with an accompanying design narrative. A second breadth study covers the construction implications of the green roof. This section will include a detailed cost analysis of the green roof addition itself, a logistics study of the material transportation and installation, and finally a modified schedule to compare with the original project schedule.

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Building Project Background

The Reinsurance Group of America's Global Headquarters serves as an office and training facility for RGA- a Fortune 500 Company. This building complex features two office towers enclosed by curtain wall façades with a lobby and amenities space linking the two towers, see Figure 1. Inside, the office towers have an open floor plan with a centrally located core that maximizes tenant circulation through the building, flexibility, and functionality within the space. From the highway on the lower side of the site, the two parking garage levels are visible. On the opposing side, these levels are below grade, allowing for a third level of on-grade parking and fire truck access.

Figure 1: Rendering from Highway, Courtesy Gensler

Construction on this 405,000 square foot, $150 million project started in March 2013 and will continue until its expected completion in September, 2014. A Phase Two plan has been developed for the addition of a third office tower similar to the Phase One towers with additional parking to service the new tower. The site, seen below in Figure 2, features three bio-retention basins along the highway. This Design-Build project, at the request of the owner, utilized the LEED Silver Accreditation standards as a design basis.

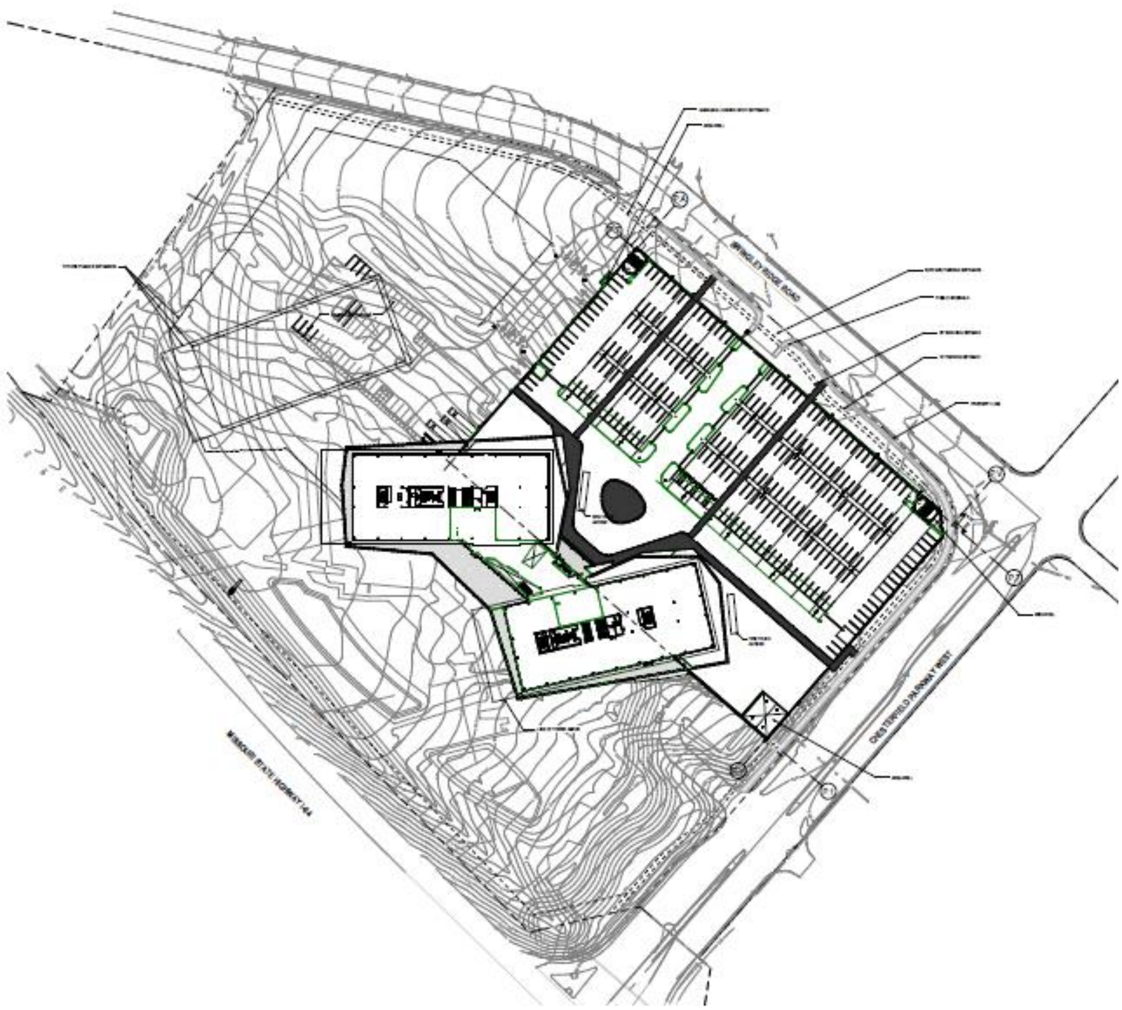


Figure 2: Site Plan Oriented to True North

Structural System Overview

RGA Global Headquarters has two five story, steel and curtain wall office buildings with mirrored, rectangular floor plans. Floors two through five are cantilevered 5' over the first floor on three sides and 40’ on the remaining side. A truss system bearing on a built up-plate girder supports the large cantilever. All exposed steel is Architecturally Exposed Structural Steel (AESS) at the owner's request. The office buildings have a braced frame lateral system that transfers load into concrete shear walls in the below grade parking garage. Post-tensioned one-way slab systems supported by post-tensioned concrete beams comprise the parking garage's structure and support the loading above at the parking levels. The foundation consists of grade beams supported by concrete drilled piers, with the exception of a portion of the site where the bedrock rises to meet the parking garage; there the foundation is a rock bearing spread footing. This section of the report will provide more detail into these systems.

Foundation

A geotechnical report was conducted by SCI Engineering, Inc. in October, 2012, as a follow-up to their report done in January, 1999. Based on their findings, SCI Engineering recommended use of a combination of drilled pier foundations, rock bearing shallow foundations, aggregate piers, and shallow foundations as suitable. Predominant soils in the area were the topsoil, clays, shale, an area of unknown infill, and bedrock with groundwater appearing about 37' to 60' below the existing grade.

Drilled piers are the predominant foundation system selected, bearing on bedrock, with an allowable end bearing pressure of 80 ksf and a concrete compressive strength of 3,000 psi. Pier diameters range from 36" to 78" with Pier caps are typically 3' to 4' in depth. When tension piers are required, rock anchors with a 150 ksi minimum ultimate tensile strength are embedded a minimum of 10' into the limestone bedrock and lapped with vertical reinforcement. Tension piers most commonly support the lateral system and an overall detail is shown below in Figure 3. The rock bearing spread footings are designed for an 8,000 psf net allowable bearing pressure and soil beneath these footings is replaced with 2,000 psi lean concrete. In the case of a footing bearing on soil, a net allowable bearing capacity 2,500 psf is recommended.

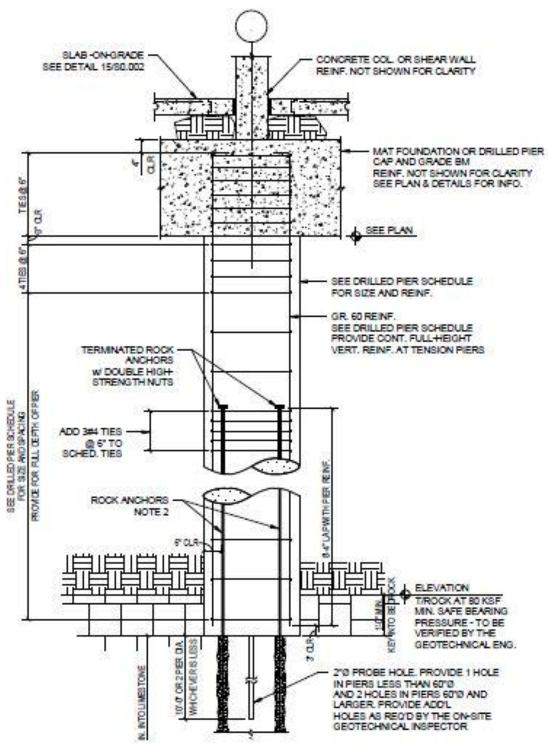


Figure 3: Typical Tension Pier Detail

The final component of the foundation system is the grade beams. They are typically 4,000 psi concrete ranging in size from 18"x18" to 42"x24" with several combinations in between. Reinforcement is Grade 60 and ranges from #8 bars through #11 bars with #4 stirrups. Figure 4 shows a typical detail.

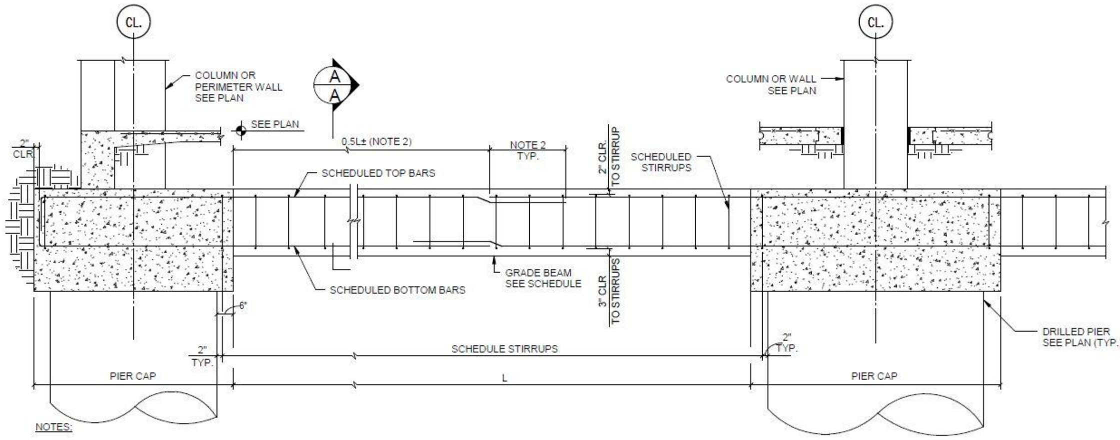


Figure 4: Typical Grade Beam Detail

Substructure

The lowest level of the parking garage is a slab on grade supported by grade beams. For the parking garage, the slab is 5" thick of 3,500 psi concrete placed on compacted subgrade. Mechanical rooms, loading docks and truck service area slabs on this level are 6" thick. Concrete exterior walls on this level are typically 16" thick.

The floor of the upper parking level increases in thickness to 7" and the floor system changes to a 5,000 psi concrete post-tensioned, one-way slab system supported by post-tensioned reinforced concrete beams. Exterior exposed concrete walls are 8" thick and increase to 12" when they are exposed to earth, below level 01 on the higher side of the site. The slab of the parking plaza, the on-grade level of parking, is also a post-tensioned one-way slab system supported by post-tensioned beams. The difference lies in the parking plaza's slab thickness. If there is no fire truck access, the slab is 8 1/2" thick and slabs with fire truck access areas are 9 1/2" thick.

Columns in the parking garage are typically 5,000 psi concrete. There is an exception of four columns of 7000 psi concrete that are continuations of the columns supporting the plate girder and compression members of the cantilever truss system. Square or rectangular column sizes range from 16"x16" up through 32"x32" with a common size of 24"x24" and circular columns range from a 24" diameter to a 36" diameter with the most common diameter being 28". Vertical reinforcement ranges from #8 to #11 bars in these columns.

Superstructure

This section discusses typical bay characteristics and area-specific characteristics that cause the bay configuration in that area to differ from the typical bay. A representative full structural framing plan for the superstructure can be found in Appendix C.

Typical Bay Characteristics

In a typical bay, gravity columns are A992 Grade 50 steel with typical sizes of W10x49, W12x65, W12x79, W12x87, W12x136 on lower levels and W12x65, W12x58, W12x53 on upper levels. When necessary, column splices occur 4' above Level 04. Beam sizes are discussed below. Bays are based on a 30' or 40' length and either a 25' width or a 40' width as shown in Figure 5.

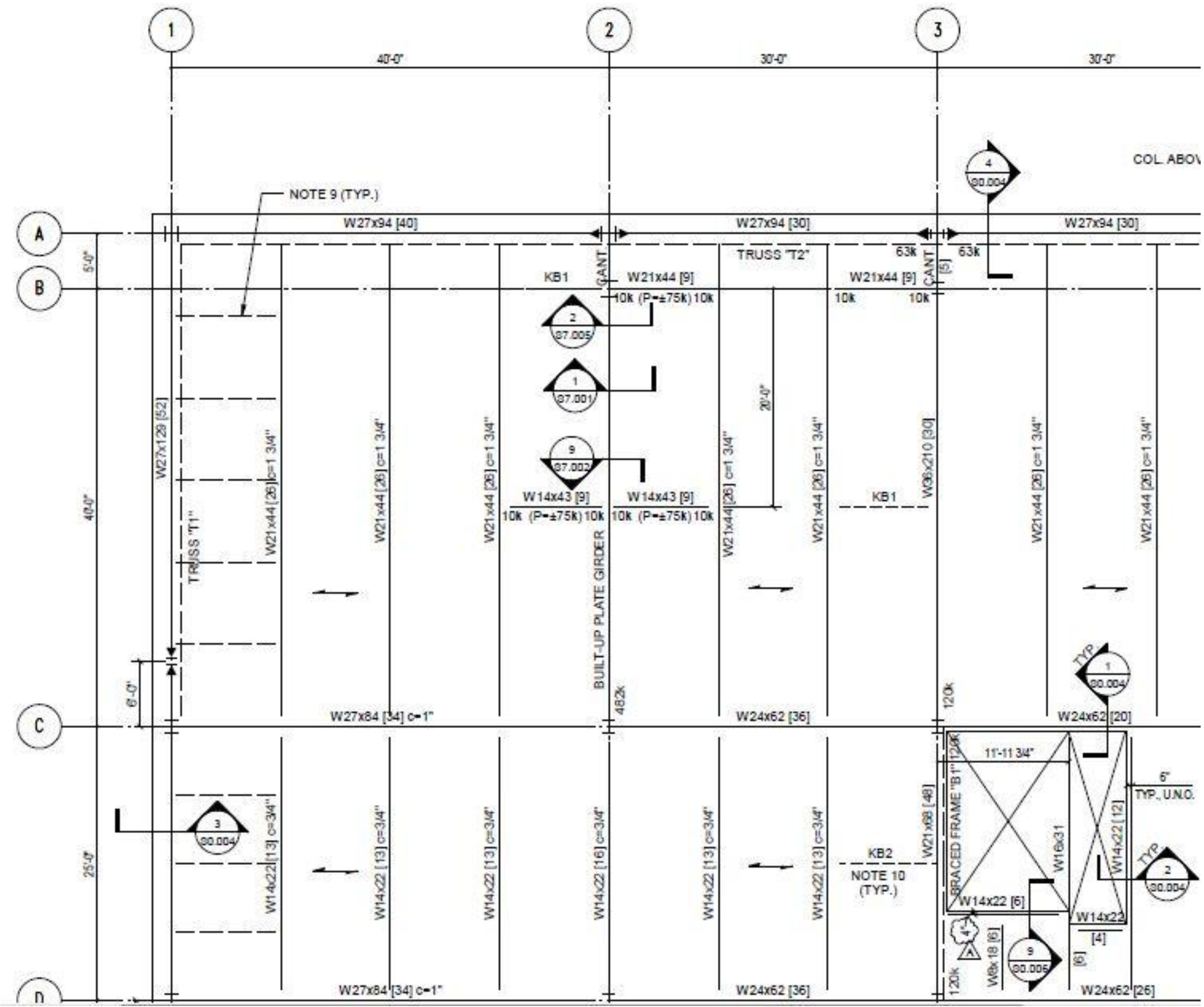


Figure 5: Partial Plan of Typical Bay Dimensions

Base plates are A36 steel and range in thickness from 1" to 2 3/4". Gravity column bases anchor into the foundation with four Grade 55 anchor rods with diameters of 3/4" to 1" and embedded a minimum of 1'. This connection type does not resist significant rotation, so the connection is a pinned base. Typical moment connections consist of a 3/8" minimum shear tab with 5/16" fillet weld to the beam flange and 3/4" diameter A325 slip critical bolts the full length of the shear tab. The flanges are field welded with a full penetration bevel weld with backing.

Area-Specific Characteristics

The floor system on Level 01 of the office structures has multiple sections. Where the office superstructure overlaps the parking structure, the floor is an overbuilt 4" thick, 3,000 psi semi-lightweight concrete slab reinforced with welded wire fabric 1" from the top of the slab. Where the superstructure does not overlap, the floor is a 25" deep pan joist system consisting of a 5" slab and 20" deep pans spaced a maximum of 6' center to center. Typical pan joists are 6" wide at the bottom and have bottom reinforcing ranging from #5 to #9 bars usually in a combination of sizes and top reinforcement sizes are #4 through #6 bars. Pan joists are supported on 25" deep post-tensioned or reinforced concrete beams. In the terrace area, the system changes to a one-way slab supported on concrete beams to support the extra dead load associated with the landscaping materials.

Levels 02 through 05 have a composite floor system consisting of 3" 20 gage galvanized type 3.0SB composite steel deck with 3 1/2" 3,000 psi semi-lightweight concrete topping for a 6 ½" total thickness. Shear studs in all composite floors are specified to be installed in the strong position. The slab is reinforced with welded wire fabric and is unshored during construction. The deck has a maximum span of 11'-9" for a three span condition. Typical beam sizes for these levels include typical interior girders of W24x62, typical perimeter girders of W21x50, and typical infill beams of W21x44 and W14x22 with cambers of 3/4" to 1 3/4". Beams are spaced evenly between columns where possible.

On Level 06, the roof deck is 3" 20 gage Type N composite deck. Typical framing sizes include typical interior girders of W21x50, typical exterior girders of W21x57, and typical infill beams of W21x44 and W12x19 cambered 3/4" were needed. Penthouse framing sizes are typicallyW16x26 girders and infill beams of W16x31 and W12x19 with the addition of C12x20.7 members that support roof davits.

Lateral System

In the steel superstructure, the lateral system is composed of ordinary concentric steel braced frames shown in Figure 7. A floor plan showing the locations of the braced frames is in Figure 6. Typical column sizes for the brace frames are W12x152, W12x136 and W12x120 for the first three stories and decreases to W12x87 for stories four and five with the column splices occurring 4'-0" above Level 04. Beams sizes in the braced frames are W24x84, W24x76, W24x68, W24x55, W21x68, W18x46, W18x35, W14x22 and W16x26. Larger beam sizes are in the lower levels of the braced frames and decrease in size moving upward. Bracing members range from HSS 6x6 to HSS 10x10 with thicknesses of ½" or 5/8" where, again, the larger braces are in the lower levels and decrease moving upward.

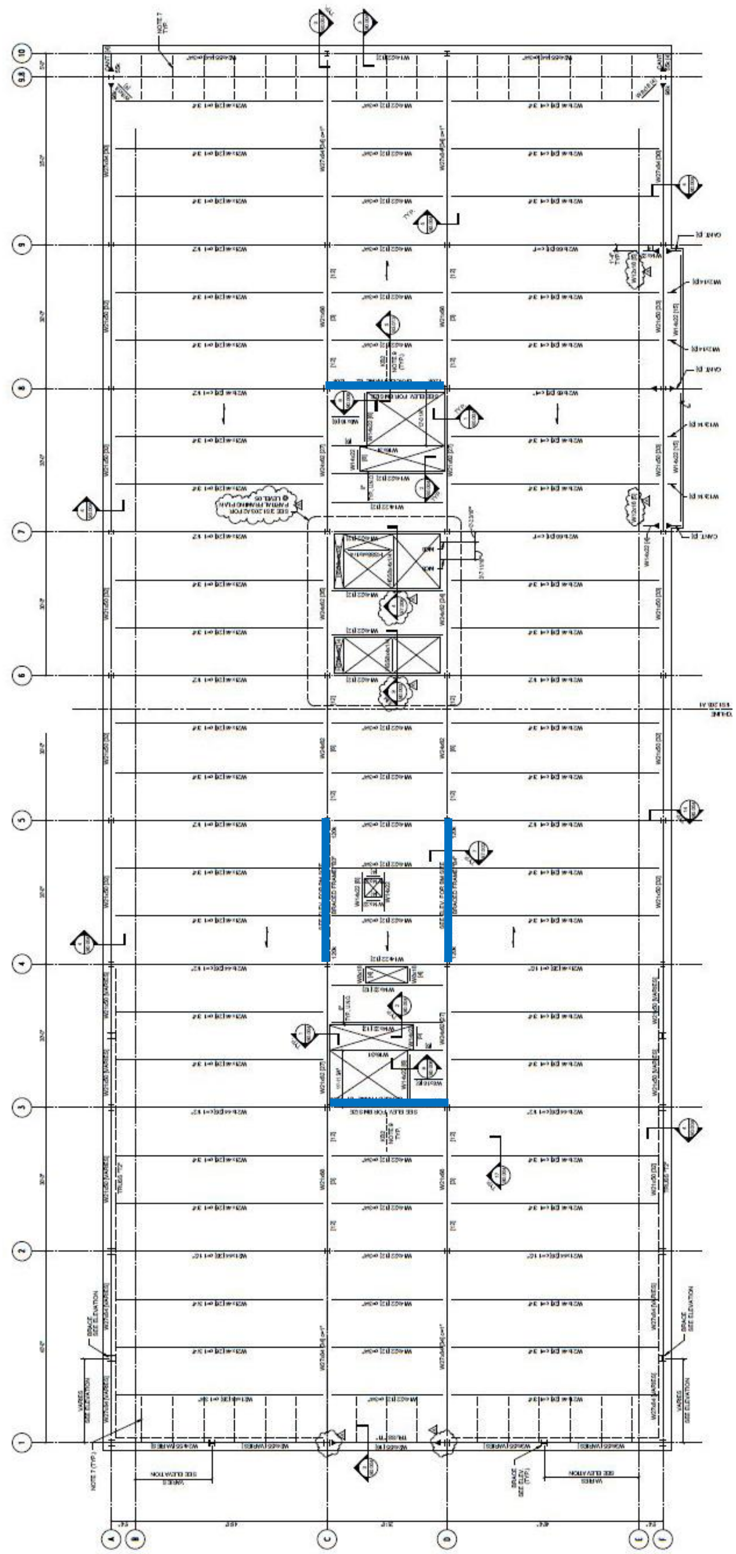


Figure 6: Braced Frame Locations

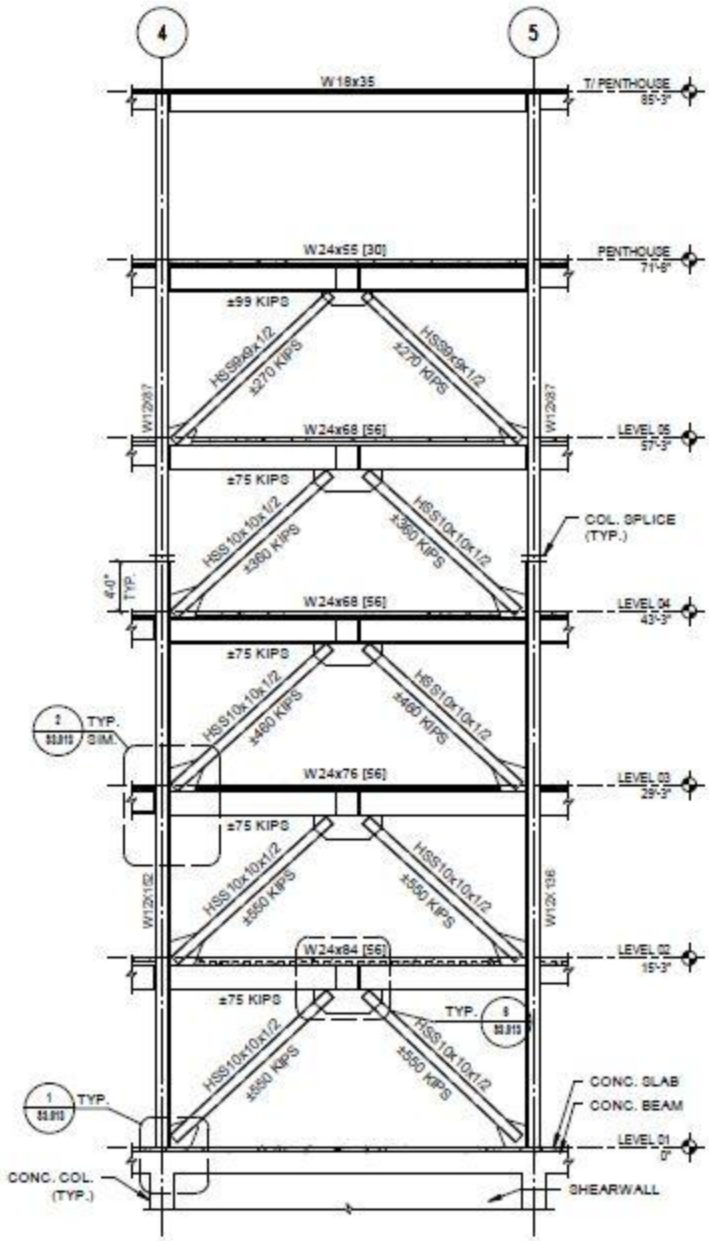


Figure 7: Typical Braced Frame Elevation with Penthouse Support Included

Additional floor diaphragm reinforcement is shown in Figure 8 below. The purpose for this additional reinforcement is to resist flexure the diaphragm, in plan, acts as a beam spanning between the supports of the braced frames. Reinforcement sizes for supplemental diaphragm reinforcement include #4, #5, and #6 bars.

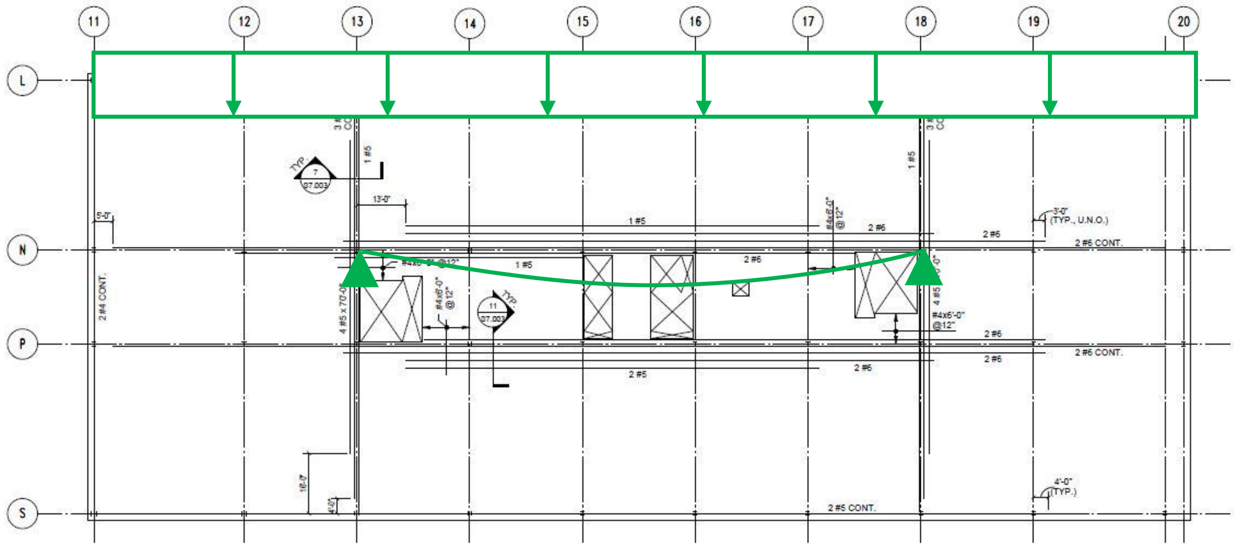


Figure 8: Floor Diaphragm Acting as a Beam Spanning Between Braced Frames

Moving down the building, the braced frames have a pinned base connection to the top of the shear walls. Brace members are welded to a gusset plate, which is welded to an embed plate. This plate, 3/4" thick, uses 3/4" diameter studs embedded into the concrete shear wall to transfer the horizontal forces from the braces into the shear wall. Column base plates are typically 3" thick made of A572 Grade 50 steel with 1 1/4" diameter, grade 105 anchor rods embedded 5' into the concrete column of the shear wall. The tensile and compressive loads are transferred into the shear wall through the base plate and anchor rods. Below in Figure 9 is a detail of this connection.

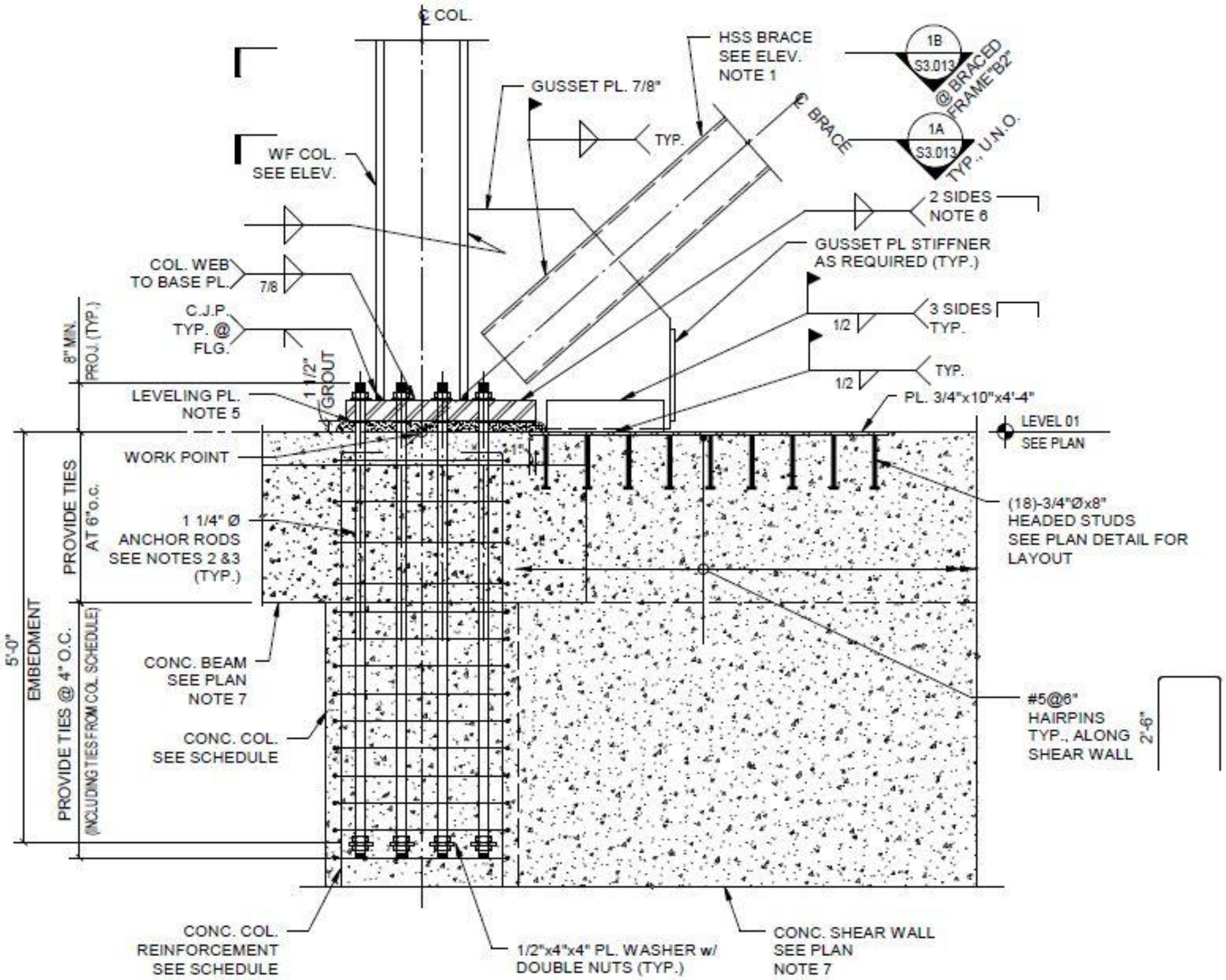


Figure 9: Typical Braced Frame to Shear Wall Connection

In the parking garage substructure, the braced frames are supported on 5,000 psi concrete shear walls. These shear walls are 16" thick with vertical reinforcement ranging from #6@12" o.c. to #10@9", 10", 12", or 13 o.c. bars and horizontal reinforcement of #5 bars at various spacing. Spacing varies based on floor levels and different walls. A sample plan of a shear wall is provided in Figure 10 below. These walls bear on grade beams which transfer the load to the foundation.

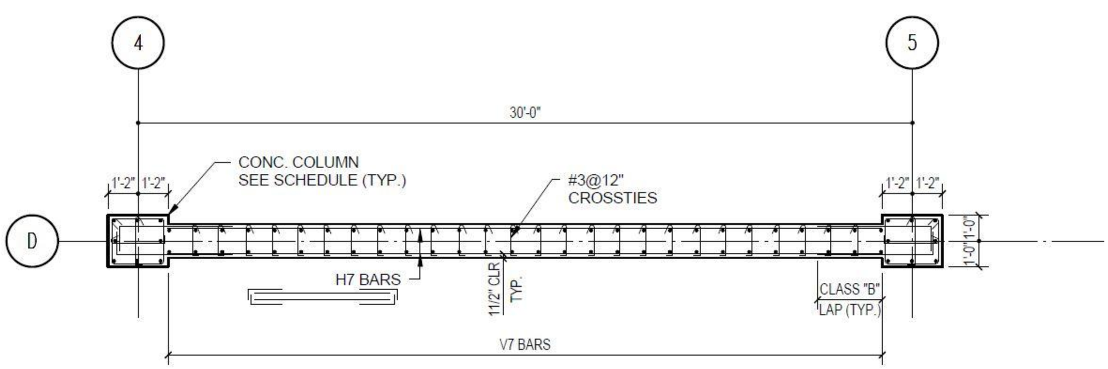


Figure 10: Shear Wall Sample Plan

Cantilever Truss System

Truss T2 is oriented along the longitudinal axis of the building. Two tension members in an inverted "V" and a vertical compression member are the main members of the system. T2 is supporting a 40' cantilever spanning from grid 1 to grid 2 in Figure 11 below. The most exterior tension member, running between grids 1 and 2, is designed for a tension load of 1544 kips and the back span diagonal, running from grids 2 to 4, is designed for a tension load of 1155 kips. Both tension diagonals are W14x176. The vertical compression member on grid 2, a W14x193, is designed for 2380 kips of compression load. These compression members on either side of the building bear on a built-up plate girder to be discussed later.

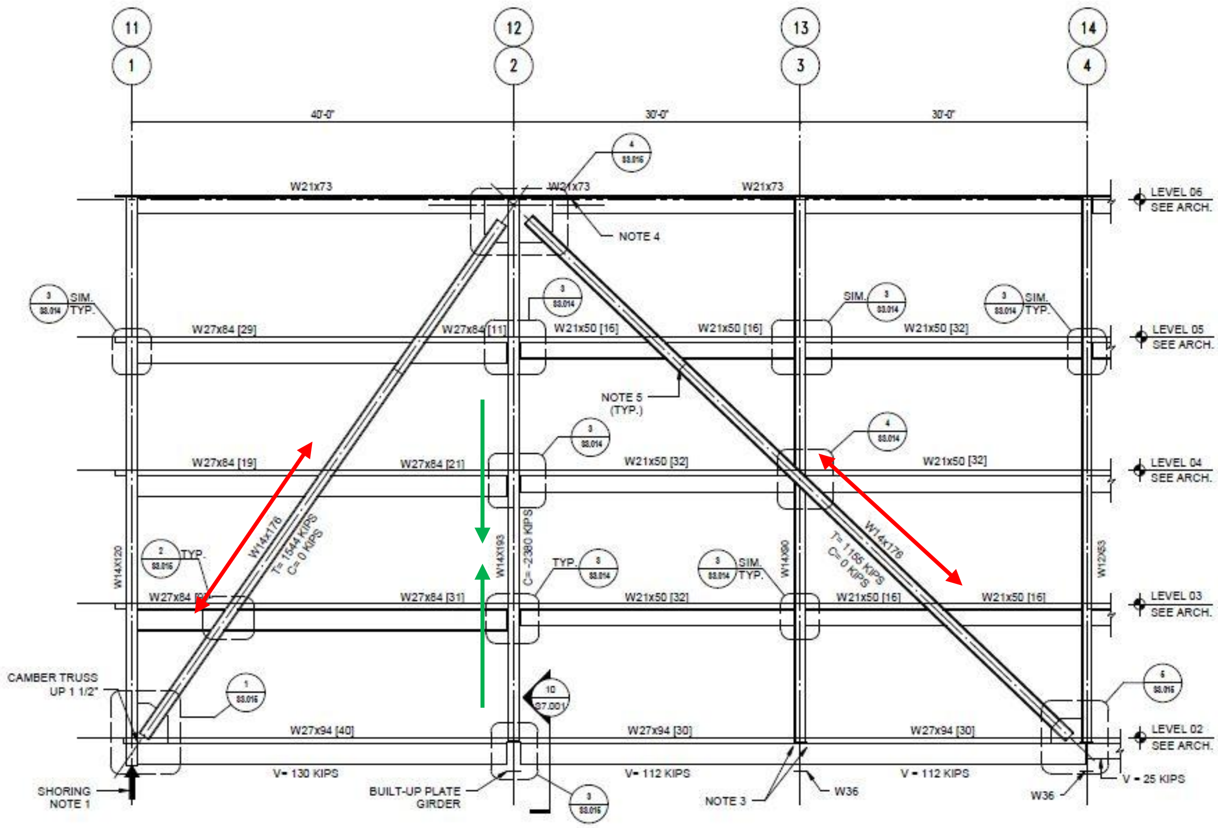


Figure 11: Truss T2 Elevation Highlighting Tensile and Compressive Forces

Truss T1, shown in elevation in Figure 12, is aligned in the transverse direction of the building consisting of W14x159 tension diagonals designed for a factored tension load of 891 kips. At the lower side of the tension members, the truss is cambered up 3/4" at Level 02 and grids N, P, C, and D. In terms of connections, the full moment splice has been offset from grid lines C and D to alleviate congestion at the column line and aid in constructability.

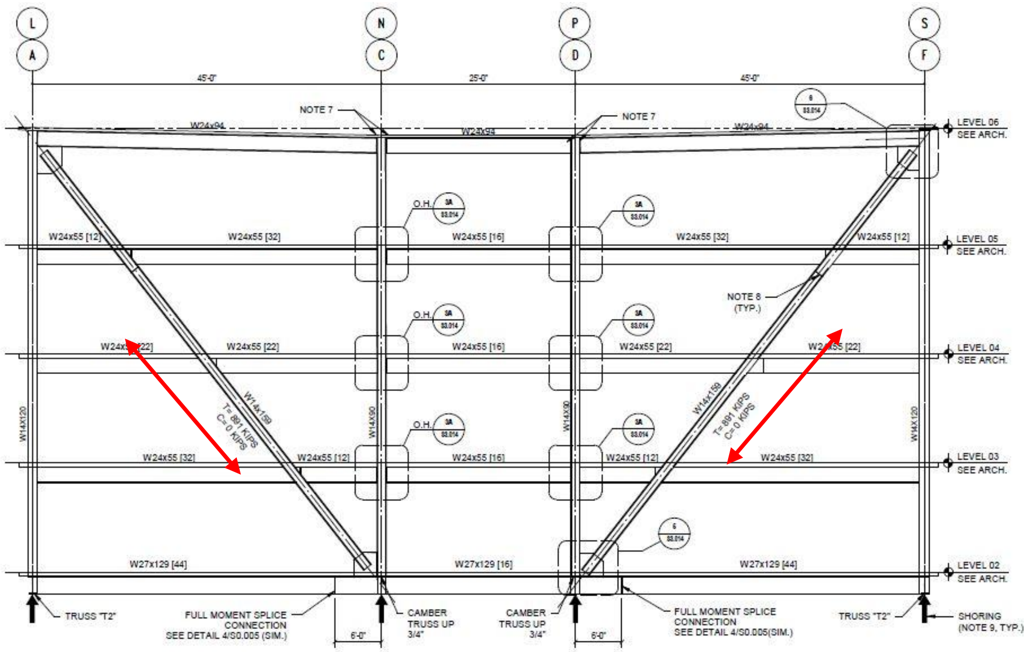


Figure 12: Truss T1 Elevation Highlighting Tensile Forces

To counteract the overturning of the cantilever, the beams on Level 06 are designed for axial tension starting where the exterior tension member of T2 meets the roof, circled in red in Figure 13 below. The truss overturning imposes axial tension loads on all beams going through the back span direction of the building, noted in red arrows in the diagram. The force decreases, or dissipates, as it moves away from the trusses. Under floor horizontal bracing, also designed for axial tension, starts where the exterior diagonal of truss T2 meets the roof which pulls the load toward the core and then follows the same horizontal path in plan through the building.

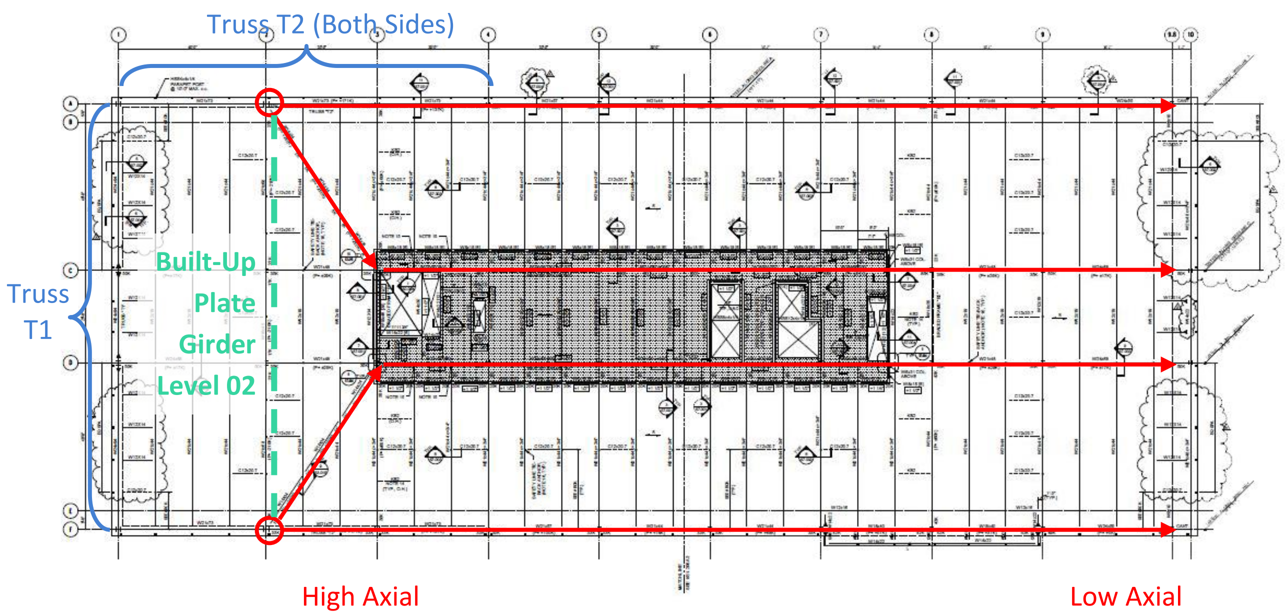


Figure 13: Roof Plan Showing Load Path of Truss System

At major connection points for both trusses, diagonal wide flange members are welded to 3/4" or 7/8" thick gusset plates. Where the truss diagonals intersect columns, the truss member stays continuous and the web is fitted with stiffeners that match the dimensions of the column it is splitting so that both members remain continuous through the connection. Columns and beams connect to girders stiffened with WT members cut to match the connecting column. Gravity beam connections inside these trusses consist of single angle, L4x4x3/8, shear tabs. At the outermost point of the cantilever, the truss system is cambered up 1 1/2" to counteract the deflection caused by dead load added after erection. An example is shown in Figure 14.

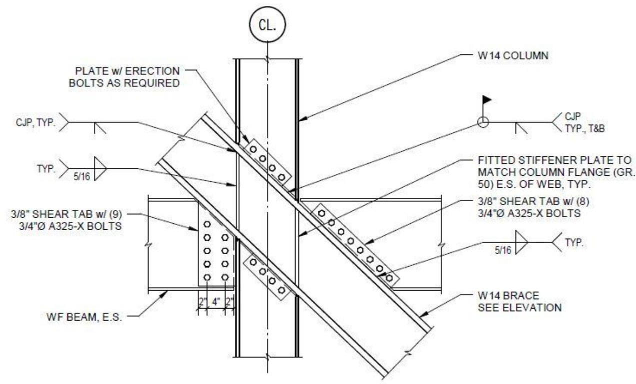


Figure 14: Truss Diagonal Joint Detail

As mentioned before, the compression members of truss T2 bear on the plate girder shown in Figure 15 below. The plate girder, A572 Grade 50 steel, is on Level 02 and spans over four columns on Level 01 which bear on post-tensioned beams in the substructure. Dimensions of the girder are shown in Figure 15 with the exception of 3/8" stiffener plates. It ties into the floor system by studs, angles, and stiffeners. Simple connections made to plate girder are typically seated connections where the bottom flange of the connecting beam has a 3/8" A572 gusset plate welded to the bottom flange. Kicker angles, typically 2L3 1/2x3 1/2x5/16, are welded to the gusset plate and the stiffeners in the plate girder to brace the girder's bottom flange against lateral-torsional buckling.

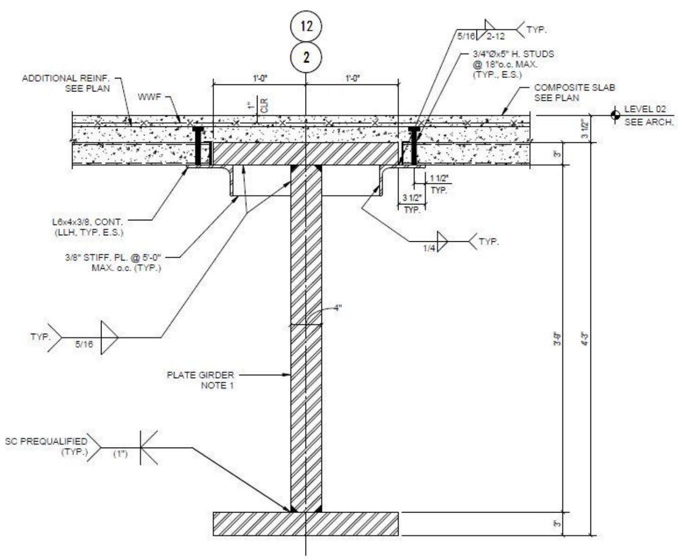


Figure 15: Plate Girder Detail

Problem Statement

A scenario has been created in which the owner has decided to add an intensive green roof that also functions as a publicly accessible roof garden for the tenants of the office towers. In the current design, much of the exterior public spaces double as emergency vehicular access, limiting the material palette to decorative stone and concrete. While there are three bio-retention basins on site, little of the green space is designed for public access and enjoyment. LEED Silver Certification is a design basis for the headquarters complex per the owner's request and since has decided to embrace one of St. Louis County's Sustainability Initiatives. This particular initiative is to incorporate green roofs in new building projects. As a Fortune 500 company, Reinsurance Group of America, Inc. is proud of their employees and strives to provide a healthy work-life balance and therefore desires to use this new green roof as an amenity for the tenant employees to enjoy.

Proposed Solution

This new request presents structural challenges. First, the gravity system will have much more weight to support, so the current gravity system will need resized for new loading. Specific attention will be given to the cantilever truss system and its supporting members. Adding extra weight to roof members also supporting the cantilever increases the flexure and axial tension loads and can make the force interaction more critical for design. Depending on the green roof's weight distribution on top of the cantilever and its back span may help mitigate the cantilever's overturning force couple or add to it, which could require the roof support to be redesigned completely. Secondly, adding an intensive green roof garden adds significant seismic mass and, in turn the seismic force, acting on that roof level. This means that the lateral system will need to be stiffened as well to handle the new seismic load and still operate within acceptable drift limits.

In addition to structural challenges, the green roof garden and its public spaces need to be designed with respect given to the current design. Also, the green roof garden will have significant cost, logistics, and schedule implications that must be considered going forward. These topics are elaborated upon in the following Breadth Study section.

Breadth Study

A green roof addition with public spaces impacts other aspects of the building project aside from the structure. In this proposal the roof garden will be designed as an architecture and landscape architecture breadth study. This project addition will have cost, construction logistics, and schedule implications which will be studied as a construction breadth.

Breadth Topic 1: Architecture/Landscape Architecture

The roof garden needs to be designed considering appropriate plantings, maintenance concerns, code and safety requirements, and the relationship of the public spaces to the plantings. Plantings are largest and heaviest in intensive green roofs and may be seen from the surrounding roadways and buildings, impacting the architectural skyline of the site. The landscape, green space, and public spaces of the roof garden have their own architectural and landscape architectural language that should complement the existing design. For this reason, this breadth will begin researching and designing the intensive green roof garden. Research of precedent projects, fundamentals of green roof design, roof garden design, and code requirements are critical to the design process. Design iterations and evaluations will be conducted until a successful design emerges. Communication of the design will be presented in sketches, 3D visual models, and renderings for creation, refinement and assessment of the design.

Breadth Topic 2: Construction

A second area of study will evaluate the cost, construction logistics, and schedule for the intensive green roof garden implementation. A detailed cost outline will be completed for the green roof garden to show the additional project cost along with a detailed cost comparison of the structural changes. On the logistics side, a study will explore the material arrival on site, storage, and installation needs of the green roof garden and the structural redesign to determine any new or additional considerations needed. Finally, the current project schedule will be revised to include the green roof garden. Both the revised and the original project schedules will be compared to determine how the construction schedule is influenced by adding the green roof garden.

Methods and Research

The first step toward a solution is to design the green roof garden. Research will be conducted on precedent projects, design of roof gardens, public green space, and green roof plantings and consultation with a senior horticulture major (see references in Appendix A). A series of sketches will be created, benchmarked against a developed list of goals, and revised until a successful design emerges. Also, an architecture/landscape architecture consultant will be involved throughout the design process. Once a successful design has been chosen, it will be graphically communicated through sketches, plans, elevations, sections, 3D models in either SketchUp or Revit, renderings, and an accompanying design narrative.

Once the green roof has been designed, the gravity, wind, and seismic loads will be revised under the ASCE 7-10 methodology. Next, the structure will be adapted to the green roof design by generating new gravity and lateral design loads. Each ASCE 7-10 load case will be calculated and input into the two ETABS models; one model of the office tower and one model of the accompanying parking structure. These models will embody the Two Stage Analysis Procedure found in ASCE 7-10 Chapter 12 and will be hand checked for their validity in distributing forces, correct modeling of the buckling restrained braces, and member strength checks.

Aside from the general increase in member sizes caused by the added load, cantilever truss members and supporting members will be redesigned. Main truss members will be designed for the higher compression and tension loads and supporting members for the changes in the interaction of flexure and tension. On a larger scale, the behavior of the cantilever with the green roof garden will be compared to its behavior without it to quantify if the green roof mitigated the cantilever force couple or made it more severe. Foundation effects from the added gravity load will be explored in terms of pier and bearing capacities.

On the other hand, the braced frame lateral system will need strengthened to respond to the higher seismic forces caused by the green roof garden. The current square HSS braces will be replaced with bucking restrained braces which have a more symmetrical, and more efficient, load response in tension versus compression. A chevron configuration is the most ideal for buckling restrained braced frames and will not need to be changed for this redesign. Also, their cores can be encased in HSS shapes, meaning only minimal impact in their appearance which is ideal for the already exposed steel structure. Exploration of the foundation effects will be accomplished by following the lateral forces caused by the green roof through the structure and into the foundation. In terms of modeling, preliminary member trial sizes and modeling assumptions for the buckling restrained braces will be assumed using the buckling restrained braced frames article and webinar (see references in Appendix A). After running the model and developing more accurate predictions of the bucking restrained brace behavior using the previously mentioned article and webinar, the model is refined and run again. Model results will be checked for load distribution, accurate modeling of the buckling restrained braces, member strength, and serviceability.

Lastly, the additional cost of the green roof garden will be determined by a detailed cost analysis using R.S. Means cost data. R.S. Means will also be used to create a cost comparison of the structure before and after the green roof garden addition. The logistical process of the green roof construction will be assessed in terms of material storage on site, transportation to the roof, and installation process. Research into the installation of green roofs will provide a starting point for site space allocation and equipment needed. Then, this information will help develop a modified schedule including the green roof that will be compared to the original to highlight the key schedule effects such as additional project time.

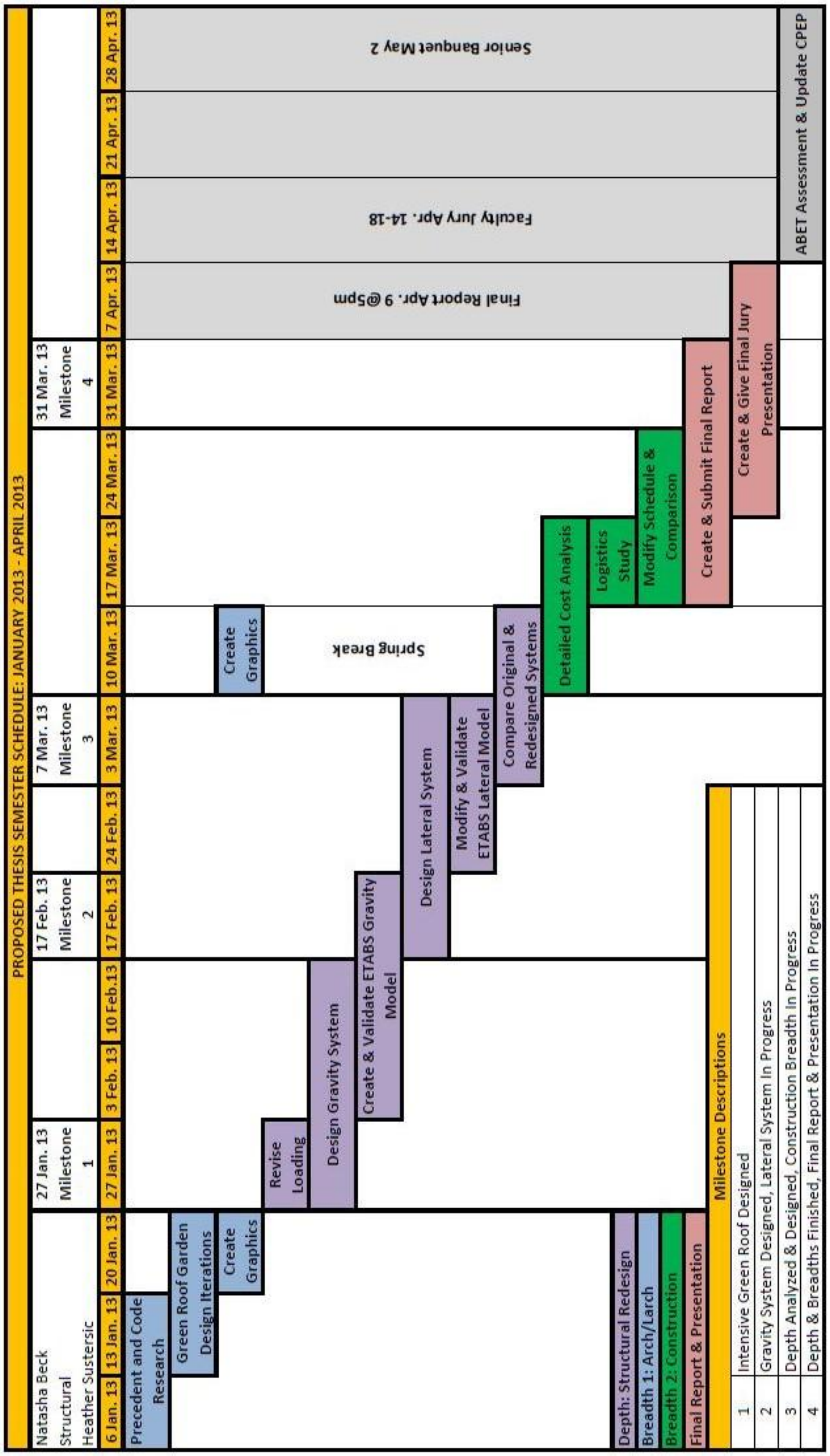
Tasks and Tools

1. Intensive Green Roof Garden Design
    a. Research
        i. Precedent projects for green roofs, roof gardens, public gardens
        ii. Design of public areas
        iii. Proper plantings and planting arrangement design
            1. Contact horticulture major, see references
        iv. Code and safety requirements
    b. Create successful design
        i. Develop a list of design criteria for green roof garden design
        ii. Develop series of sketches and layouts
        iii. Evaluate design with architectural consultant, TBD

        iv. Revise design as needed
        v. Continue until a successful design is developed
    c. Develop visual communication of design
        i. Final sketches, 3D model, and renderings
        ii. Final plans, elevations, and sections
        iii. Write design narrative
        iv. Tools used: SketchUp, Revit, Photoshop
2. Structural Redesign
    a. Determine new loads
        i. Research and apply green roof loading with respect to previous breadth
    b. Design gravity system
        i. Size gravity columns and roof deck
        ii. Create ETABS gravity model
        iii. Analyze cantilever action and resize truss members
        iv. Resize or, if necessary, redesign roof members
        v. Redesign plate girder and its supporting columns
    c. Design lateral system
        i. Determine new wind and seismic loads based on ASCE 7-10
        ii. Revise ETABS model inputs
            1. Determine bucking restrained brace trial size using the buckling restrained braced frames article and webinar, see references
            2. Model buckling restrained braced frames
        iii. Confirm validity and troubleshoot ETABS model as necessary
        iv. Refine model until model is adequate
        v. Evaluate member strength and serviceability
    d. Compare redesigned system to original system
        i. Determine green roof addition influence on the cantilever and its support
        ii. Evaluate impact on foundation
            1. Check local uplift of the foundation under lateral elements
            2. Check bearing capacity (and tension capacity where appropriate) of drilled piers
            3. Check bearing capacity of soil/rock under drilled piers
3. Construction
    a. Create detailed cost analysis for green roof garden and structural redesign and compare
    b. Complete a logistics analysis of landscaping, planting, and public space construction for material storage, movement, and installation
    c. Revise project schedule for new green roof garden and compare for added construction time and other key schedule impacts

Schedule

A weekly schedule for the semester, shown below, illustrates the previous task list in schedule form and highlights the relationships of key project tasks and milestones.



Conclusion

The current design for RGA's Global Headquarters meets the owner's requests, but to embrace St. Louis County's sustainability initiatives for new construction a proposal has been made to include an intensive green roof garden on the office towers. To explore this option more fully, the accessible green roof garden must be researched first and then designed. Next, the structure must be redesigned under the most current building design codes and the new loading condition created by the green roof garden. This includes changes to both the gravity and lateral systems to be adequate for strength and serviceability. Finally, the impact of the above changes to the project will be presented in the form of a cost, logistics, and schedule analysis all of which will be compared to the original design.

Appendix A

References

Planting Consultant:

Samantha Bollinger, Senior Horticulture Major at The Pennsylvania State University

Bucking Restrained Braces Article:

Robinson, Kimberley, S.E., and Angus W. Stocking, L.S. "Buckling Restrained Braces-An Overview." *Continuing Education*. ZweigWhite, n.d. Web. 10 Dec. 2013. <http://continuingeducation.zweigwhite.com/>.

Bucking Restrained Braces Webcast:

Bentley Structural Webcast Series: Design and Specification of Buckling-Restrained Braced Frame Structures Part 2. ZweigWhite, 7 Nov. 2013. Web. 7 Nov. 2013. <http://continuingeducation.zweigwhite.com/webcasts>.

Appendix B

Area Considered

Appendix C

Structural Typical Floor Plan