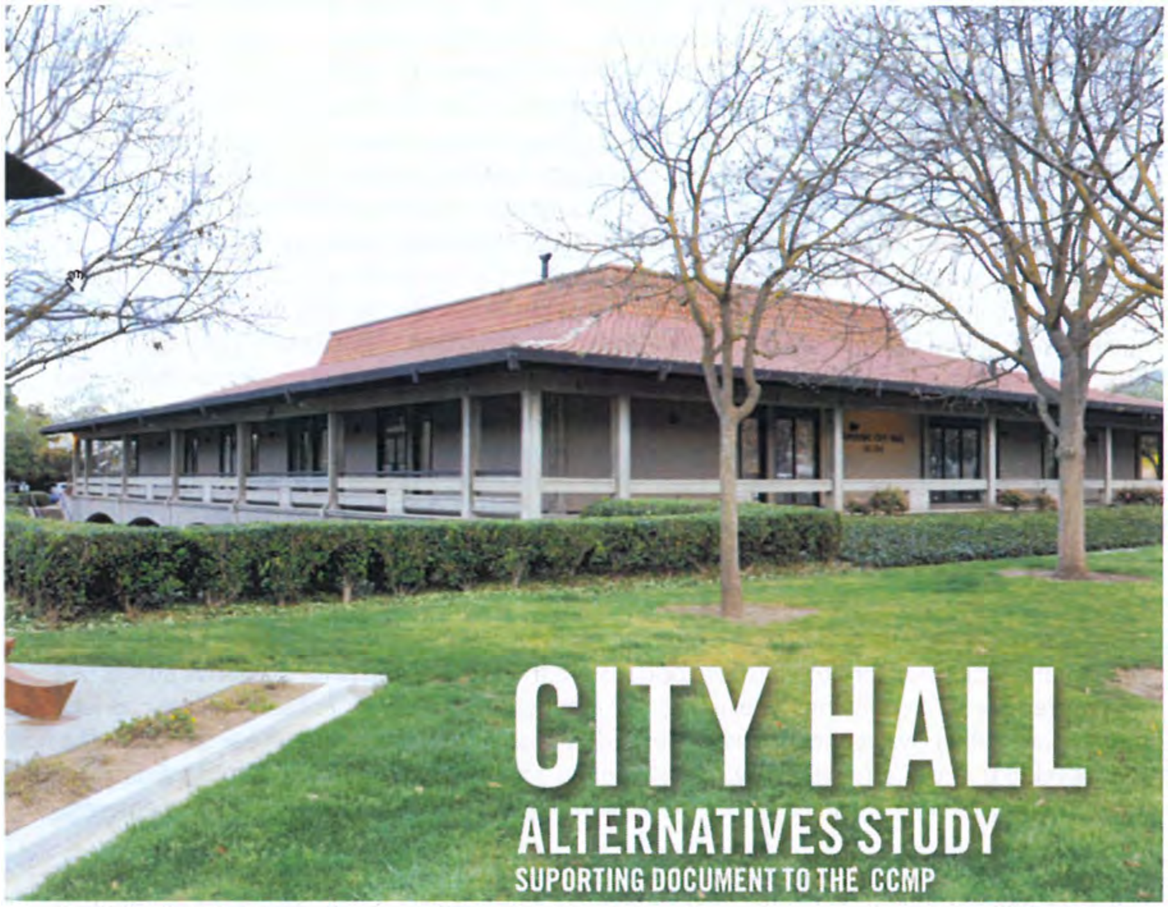
Attachment G2

TIPPING MAR STRUCTURAL ENGINEERING

Cupertino City Hall Alternates Study Structural Evaluation:

10300 Torre Avenue, Cupertino, CA 95014-3202



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September 29, 2014

City of Cupertino
CIP Project # 2013-07
File # 51 045,53
Section # 2,10

Executive Summary

Five alternative options have been discussed for the future of the City Hall, with various degrees of improvement, from performing the minimum amount of architectural remodel and structural strengthening to a brand new replacement building with additional underground parking. The first three options involve the seismic strengthening of the existing structure. This report will focus primarily on those three options, evaluated under the reference standard ASCE41-13 "Seismic Evaluation and Retrofit of Existing Buildings".

The proposed strengthening scheme for Option A involves structural strengthening of the building's seismic force resisting system to satisfy a life safety performance objective and includes minimal architectural remodeling. The limited level of seismic strengthening associated with this option will require the emergency operations center (EOC) to be relocated to another location. As part of this retrofit option, we have confirmed that the strengthening recommendations contained in the "Cupertino City Hall Essential Services Facility Analysis", dated March 27, 2012, could be implemented. The only exception would be the concrete column strengthening could be less intrusively achieved with the addition of new adjacent steel columns in lieu of fiber wrap. The new steel columns would act as secondary support members in the event of seismic related damage to the existing concrete columns. Seismic improvements would also include non-structural elements such as suspended ceilings, partition walls, and glazing systems. These elements would require bracing to seismically strengthen their connections and the replacement of any non-tempered glazing.

The proposed strengthening scheme for Options B and C both involve retrofitting the existing city hall to an immediate occupancy performance objective. This performance objective would allow the EOC to be retained within the existing city hall building. Option B would involve less architectural remodeling, whereas Option C would entail a complete architectural remodel. Option C would allow for a new, large light court in the center of the building, thus requiring additional structural modifications to both the roof and floor level gravity framing systems. Seismically, the structural deficiencies for both of these options are the same as those for Option A above. All options require strengthening the existing roof diaphragm, roof girder collector splice connections, roof girder to shear wall connections, adding additional length of concrete shear wall from the first floor level to the roof, strengthening the exterior colonnade connection to the roof framing, and strengthening the existing concrete columns to withstand anticipated seismic displacements.

Options B and C will require a more extensive strengthening of these elements than Option A, given the more stringent performance objective. As with Option A, non-structural elements will also require strengthening. To achieve immediate occupancy, these element would have to be designed to have only minimal, limited damage after a seismic event. This may be difficult to achieve with the existing building materials to be retained in Option B. In Option C, these elements will be constructed anew, and can be explicitly designed for an immediate occupancy performance objective. Finally, it should be noted that any retrofit intended to achieve an immediate occupancy performance objective will be met using prescriptive code methods that merely increased the force level demands on seismic resisting elements. This prescriptive code based approach does not necessarily assure that the performance goals of uninterrupted operation and immediate occupancy will be met.

The construction of a new City Hall building, Options D and E, will offer the opportunity to design both the building's gravity and seismic force resisting systems for the specific performance objective of immediate occupancy. Options A, B, or C, aim to strengthen the old building by limiting damage to a structure that, even after a costly retrofit is undertaken, is still largely constructed in an antiquated manner. A new City Hall can be constructed with the latest state of the art seismic force resistance technologies, such as base isolation systems or passive energy dissipation devices which will result in a facility that is more earthquake resilient than a traditionally seismically retrofitted structure. Using state of the art, site specific, seismic modeling techniques and ductile detailing practices a greater degree of certainty regarding seismic performance can be intentionally built into the structure to assure that the city's critical service functions do not become interrupted after a large seismic event.

Existing City Hall Construction

The City Hall was originally built in the late 1960's as a one-story building with a full basement. The main roof is consisted of plywood sheathing over 3" tongue and groove decking over 6 and 8 inch timber beams. The timber roof beam are then supported by either steel or concrete girders. The roof framing for the central mechanical well is consisted of plywood sheathing over 2 in timber joists supported by steel beams. The central mechanical well is surrounded by 5' tall wood framed parapet. The main roof and the parapet are covered with clay roof tiles which represent a significant portion of the current roof's self weight and seismic mass. The structure was renovated as part of the Civic Center Improvements project in the mid 1980's. During the renovation, the north side of the basement was excavated to create a concrete terrace, approximately 20 wide, parallel to the building. Portions of the original north basement walls were removed to create new storefronts. An additional 6 inches of shotcrete was added to the remaining north basement wall. The current lateral force resisting system of the structure is 6 inch concrete shear walls above grade and 12 and 18 inch concrete shear walls in the basement. Concrete slab, joists, and girders make up the ground floor framing. Interior concrete columns extend from shallow pad footing foundations to the roof level. Perimeter concrete columns are supported by the basement walls. There is also a perimeter exterior colonnade framed with concrete columns and beams.

Structural Evaluation Methodology

The materials reviewed were the 1965 Cupertino City Hall structural drawings, 1986 Cupertino City Center Improvement architectural drawings, and the Cupertino City Hall Essential Services Facility Analysis Report dated March 27, 2012.

The methodology used to evaluate the existing City Hall structure and the associated reftrofit schemes were based on American Society of Civil Engineers Standard 41-13 "Seismic Evaluation and Retrofit of Existing Buildings" (ASCE 41-13). ASCE 41-13 is a nationally recognized Standard that can be used as a tool to evaluate existing buildings and develop corresponding retrofit schemes. Although the seismic evaluation and retrofit of the existing City Hall is voluntary and the application of ASCE 41-13 is not mandatory, the use of this Standard is more appropriate than design code CBC 2013 that is intended primarily for new building designs. ASCE 41-13 takes into consideration of existing building's material properties, construction details, expected structural component and systems performance, and evaluates them against a selected Performance Objective. The main focus of this study was to evaluate Options B and C at a Performance Objective of Immediate Occupancy under a 20% probability of exceedance in 50 years seismic hazard (Basic Safety Earthquake-1E). Options B and C are classified as a Risk Category IV Essential Facility. A Linear Static Procedure was used for the evaluation and retrofit design. Soil Site Class D was assumed as a geotechnical report was not available at this time.

Seismic Evaluation and Retrofit Recommendations

Retrofit Option A

The objective of Option A is to relocate the EOC to another facility and upgrade the City Hall to a Life Safety Performance Objective under Basic Safety Earthquake-1E. Based on our findings from the existing structure's evaluations at the Immediate Occupancy Performance Objective level and a review of the performance requirements at the Life Safety level, the recommended structural retrofit would be one that is similar to the scheme proposed by AKH Structural Engineers in the "Cupertino City Hall Essential Services Facility Analysis dated March 27, 2012.

As discussed earlier in the report, the existing concrete columns are susceptible to seismic damage due to the limited amount and size of the confinement ties around the longitudinal reinforcement. The lack of confinement ties can limit the column's ductility, or ability to sway and remain undamaged during a seismic event. This limited ductility could cause the column to lose its gravity loading carrying capabilities and ability to provide continued support of the roof framing members. The existing concrete columns should be either paired with secondary steel columns to provide redundant gravity support capabilities or strengthened with fiber reinforced polymer to address this deficiency. The exterior colonnade columns can be fiber wrapped with minimal interruptions to other architectural elements. Where the wrapping activity may not be feasible, such as in areas adjacent to exterior facades, supplemental steel 6x6 columns at the perimeter and steel 8x8 columns at the interior may be placed adjacent to the existing un-wrapped columns to serve as the back-up gravity system.

To satisfy the Life Safety Performance Objective for non-structural components and systems, it is likely a seismic safety film (designed to hold shattered glass in place) will need to be applied to any existing non-safety, non-laminated annealed glass or the glazing panes themselves should be replaced. Additional tie wires for suspended ceiling grids and additional bracing and anchorage for interior partitions should be added to prevent extensive falling of ceiling tiles and wide spread collapse of partition walls during an earthquake. Mechanical systems should also be provided with a minimum level of seismic bracing, if not already in place, to prevent duct work and piping from posing a falling hazard to occupants. Finally, new or existing roof mounted equipment should be properly anchored to roof framing. This may, in some instances of heavy equipment, require additional localized strengthening of the roof framing members themselves.

Retrofit Options B and C

Evaluation of Structural Components

The main structural deficiencies for the existing City Hall are discussed below. These deficiencies are common for both Options.

- Roof diaphragm shear capacity
- Roof collector splice capacity
- Collector to shear wall connection capacity
- Shear wall flexural capacity and seismic detailing
- Concrete column ductility
- Porch colonnade to roof connection

Recommendations for Structural Strengthening

Roof Diaphragm Strengthening Measures

The existing heavy clay roof tiles make up a significant portion of the existing roof's self weight. As the building's seismic force demand is directly proportional to the self weight, it is recommended that the existing clay roof tiles be removed and replaced with a lighter roofing material. Even with the mass of the roof significantly reduced, the force demand on the roof diaphragm is near the capacity limit state for a plywood diaphragm given the shear forces associated with an immediate occupancy performance criteria.

As such, a new High Load Diaphragm will be required for the roof area outboard of the central mechanical well. New 3/4" plywood will be provided over the existing 1/2" plywood and 3x tongue and groove blocking with two rows of 10d nails @ 2 1/2" o.c. along diaphragm boundaries and continuous panel edges, 4" o.c. at other panel edges, and 12" o.c. in field. The existing diaphragm at the central mechanical well will be strengthened with 1 row of 10d nails @ 2" o.c. along diaphragm boundaries and continuous panel edges, 3" o.c. at other panel edge, and 12" o.c. in field. New 4x6 blocking will be added at continuous panel edges perpendicular to joist framing direction.

Roof Level Collector Strengthening Measures

There are several types of collector connections at the roof level, all of which require strengthening to increase their load carrying capacity. Where the existing roof diaphragm collectors are wide flange steel roof beams, they are currently spliced to each other with machine bolts. Theses splices will need to be strengthened with additional new splice plates and new welding as shown in on Sheet S3, Detail 2, of the attached building retrofit drawings. Where existing roof collectors occur at steel wide flange to wood girder locations, additional horizontal Simpson Holdowns or CMST straps are required to strengthen the existing steel beam to timber girder connections, as shown in Detail 1 of Sheet S3. The porch colonnade on the exterior perimeter of the building is constructed of concrete beams and columns. The anchorage connections between these beams/columns and the wood roof framing and diaphragm currently lacks a clear load path and does not have adequate capacity. New connecting members should be installed to provide proper anchorage between the colonnade and the roof diaphragm, as shown in Detail 4 of Sheet S3. Finally, the collector connections anchoring the steel beams to the tops of the existing concrete shear walls need to be strengthened. Additional anchor bolts will be added between existing shear walls and collectors. New shear walls will also be connected to the existing steel roof beam collectors with new anchor bolts.

Additional Concrete Shear Walls

Additional shear walls extending from foundations to roof should be added to provide new/strengthened vertical seismic force resisting elements for the existing structure. The new shear walls will typically be 12" thick concrete walls from the top of existing basement walls to the underside of the roof and 6" thick concrete walls that are overlapped and connected to the face of the existing basement walls with reinforcement dowels, as shown in Detail 3 of Sheet S3. Where the wall length is limited at the north elevation within the basement level, two new new pile caps, with two micro-piles at each cap, should be provided to increase the shear wall overturning resistance along this line and protect the existing very lightly reinforced foundation from associate seismic damage.

Strengthening the Existing Concrete Columns

The concrete columns are connected to all floor levels and to the roof. As such, they will deform as they drift with the rest of the building during an earthquake. Bending moments and shear forces will be induced in these columns as they sway with the building during a seismic event. The long span and inherent flexibility of the wood roof diaphragm will also contribute to the anticipated seismic roof drift making these under-reinforced columns very susceptible to seismic damage. The existing concrete columns have limited confinement reinforcement ties around the longitudinal reinforcements, as noted earlier in this report. Sufficient lateral ties are required in modern building codes to properly confine the longitudinal bars and the concrete core in order for the columns to continue carrying gravity loads when the columns are displaced. The lack of confinement ties is likely to result in limited displacement ductility for the concrete column. The existing columns are to be wrapped and strengthened with fiber reinforced polymer. Wrapping the existing columns will increase the displacement ductility for gravity load carrying capacity.

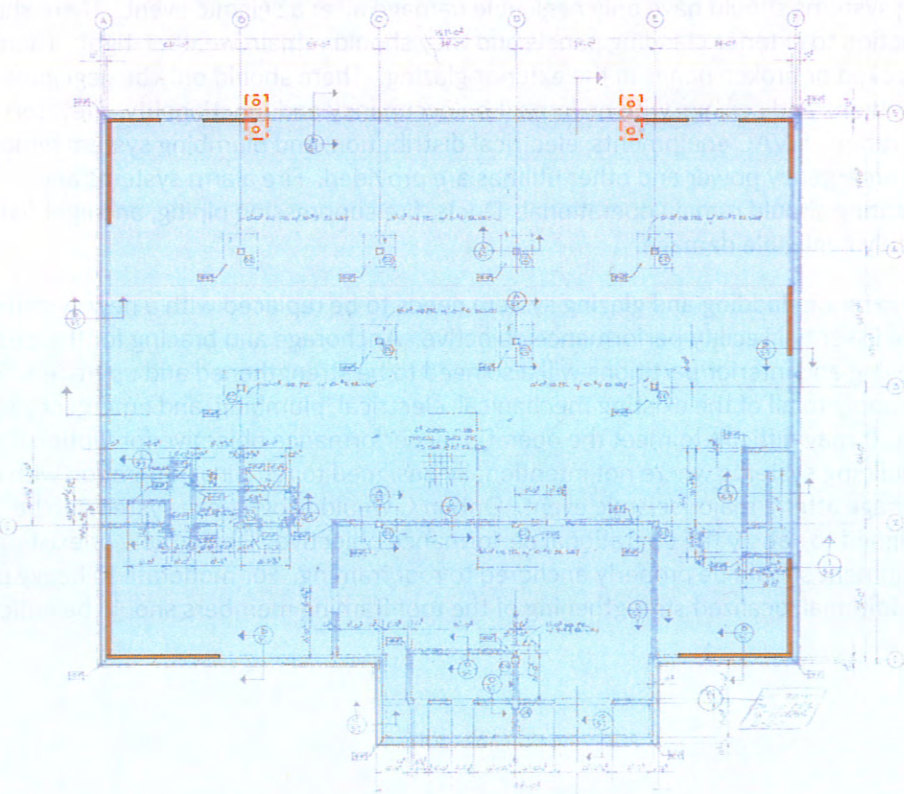
Structural Alterations for Option C

Additional gravity framing modifications also required for the installation of a large new light court and for the relocation of the building's elevator and stairs. Roof framing modifications such as new wood headers, blocking, and strapping are required around the new roof opening. Modifications to existing ground floor concrete framing will also be required to accommodate the new light court and various relocated stairs and elevators. These modification will include new concrete beams to support existing concrete joist framing that have had their existing support framing removed or modified. Retrofit support of gravity framing members often requires precision chipping of existing concrete surfaces, rebar coupling for reinforcment extensions, and welding of anchorage plates to properly anchor the ends of existing concrete members to new concrete supports.

Non-Structural Components and Systems for Options B and C

Existing anchorage and support details for the majority of the architectural, mechanical, electrical, and plumbing components are unknown. Additional as-built documents or site survey may be required to assess the building's non-structural components and systems conformance to the Performance Objective. The Nonstructural Performance Level for an Essential Facility should satisfy the ASCE 41-13 "Operational" Objective, where the nonstructural components and systems are able to perform the same functions they provided before the earthquake. Per ASCE 41-13, Tables C2-5 and C2-6, non-structural components, such as architectural, mechanical, electrical, and plumbing systems should have only negligible damage after a seismic event. There should be no loss of function to exterior cladding panels and they should remain weather-tight. There should not be any cracked or broken panes in the exterior glazing. There should only be negligible damage to interior partitions and ceilings with no impact on occupancy and functionality. Elevators will remain in operation. HVAC equipments, electrical distribution, and plumbing system remain operational if emergency power and other utilities are provided. Fire alarm systems and emergency lighting should remain operational. Ducts, fire suppression piping, and light fixtures should have only negligible damage.

It is likely the exterior cladding and glazing system needs to be replaced with a new system that can satisfy the Essential Facility performance objective. Anchorage and bracing for the existing suspended ceiling and interior partitions will also need to be strengthened and upgraded. Similarly, the same will apply to all of the existing mechanical, electrical, plumbing, and emergency systems if they remain. It may difficult to meet the operational performance objective for Option B where the existing building systems where not intentionally designed to remain in operation with only negligible damage after a major seismic event. Option C would allow these systems to be explicitly designed to satisfy the operational performance objective. Finally, new or existing roof mounted equipment should be properly anchored to roof framing. For moderate to heavy pieces of equipment, additional localized strengthening of the roof framing members should be anticipated.



Legend:

(N) Concrete Wall

(N) Pile Cap with Micropiles

Provide 4' wide x 6' long x 4' deep pile cap with 2 micropiles at each cap. Micropile capacity +/- 150 kip design load.

N

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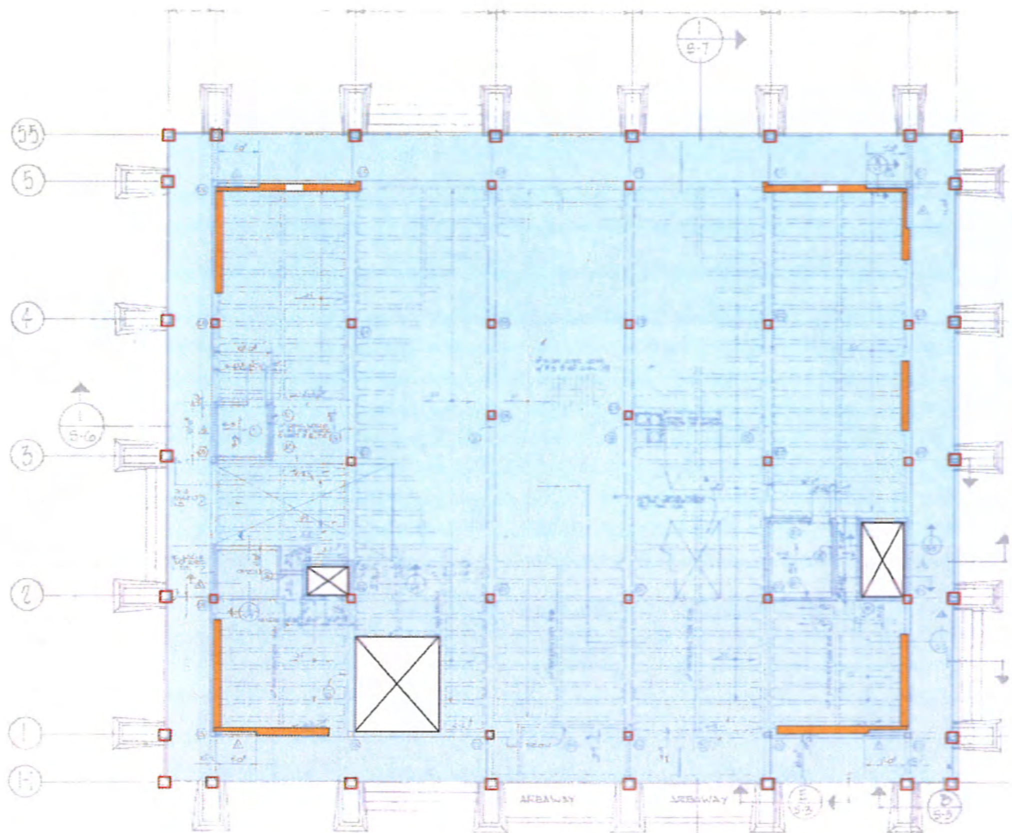
Cupertino City Hall | Option B
Cupertino, CA
TM Project: 2014,094 Scale: As Noted

Terrace Level Plan
September 29 2014

S0



Legend:

(N) Concrete Wall

(N) FRP Wrap @ (E) Columns

N

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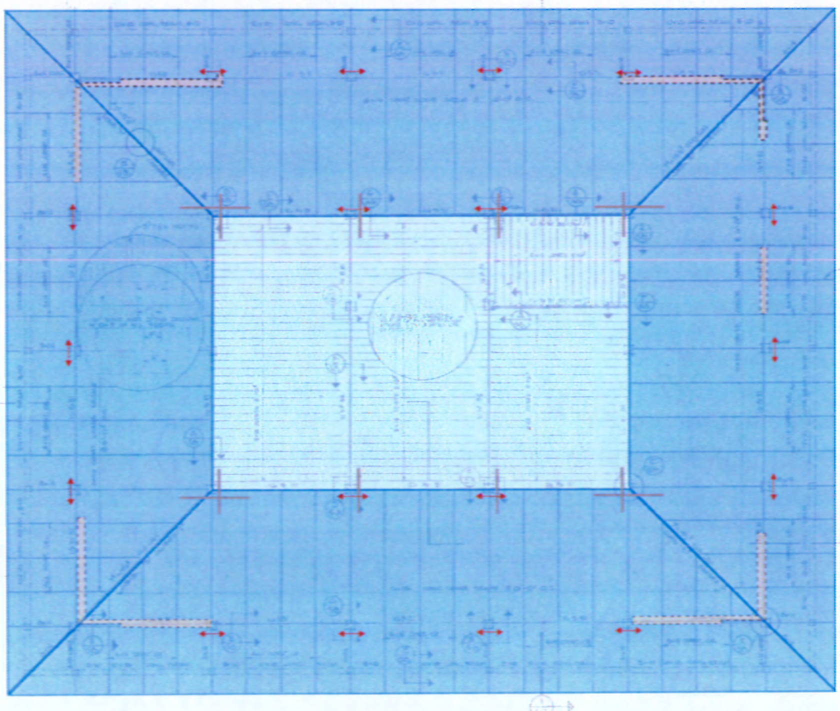
Ground Floor Plan
September 29 2014

S1



Legend:

(N) Concrete Wall Below

(N) High Load Diaphragm
Provide (N) 3/4" Plywood over (E) 1/2" Plywood and 3X T&G Blocking w/ 2 Rows of 10d Nails @ 2 1/2" o.c. along diaphragm boundaries and cont. panel edges, 4" o.c. at other panel edges, and 12" o.c. in field

(E) Reinforced Diaphragm
Reinforce (E) 1/2" Plywood w/ 1 Row of 10d Nails @ 2" o.c. along diaphragm boundaries and cont. panel edges, 3" o.c. at other panel edges, and 12" o.c. in field. Provide (N) 4x6 min. blocking @ cont. panel edges perpendicular to framing direction, typ.

(N) Simpson CMST strap or Simpson Holdown

Retrofitted WF Steel Collector Connection

N

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Cupertino City Hall | Option B
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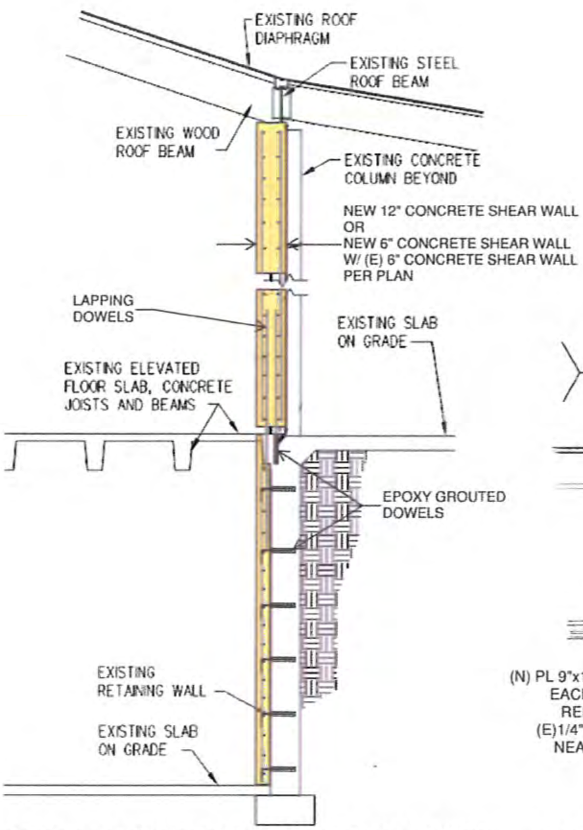
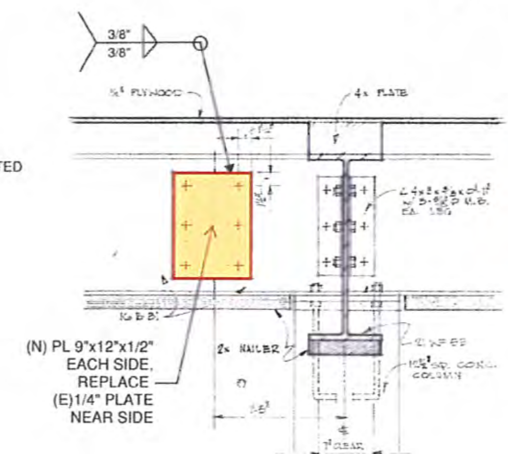
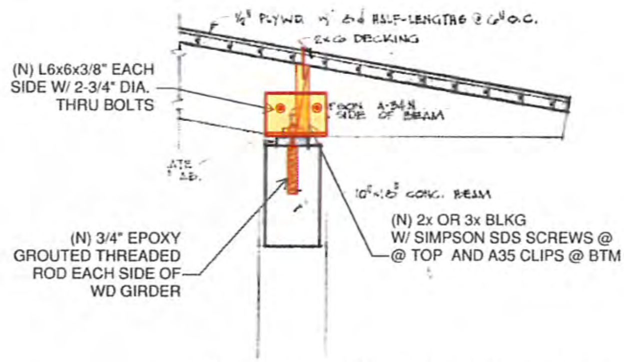
Roof Plan
September 29 2014
S2



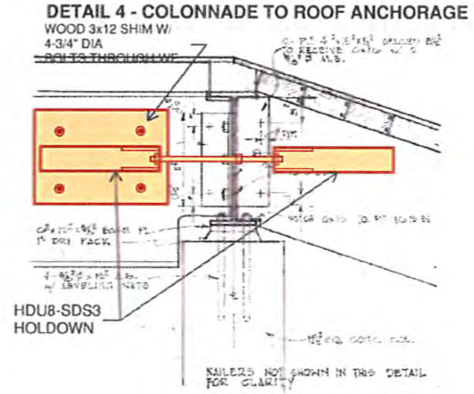
DETAIL 3 - SECTION AT NEW CONCRETE SHEAR WALL



DETAIL 2 - STEEL TO STEEL COLLECTOR SPLICE



DETAIL 4 - COLONNADE TO ROOF ANCHORAGE



DETAIL 1 - STEEL TO WOOD COLLECTOR CONN.

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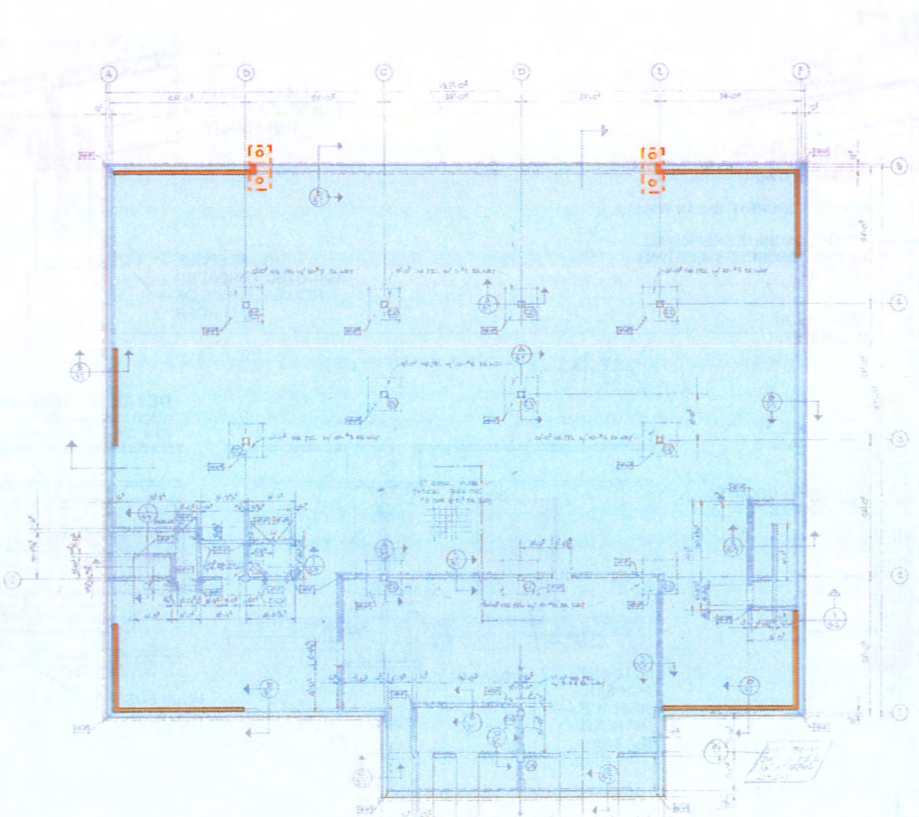
Retrofit Details
September 29 2014
S3



Legend:

(N) Concrete Wall

(N) Pile Cap with Micropiles

Provide 4' wide x 6' long x 4' deep pile cap with 2 micropiles at each cap. Micropile capacity +/- 150 kip design load.

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Cupertino City Hall | Option C - Light Court

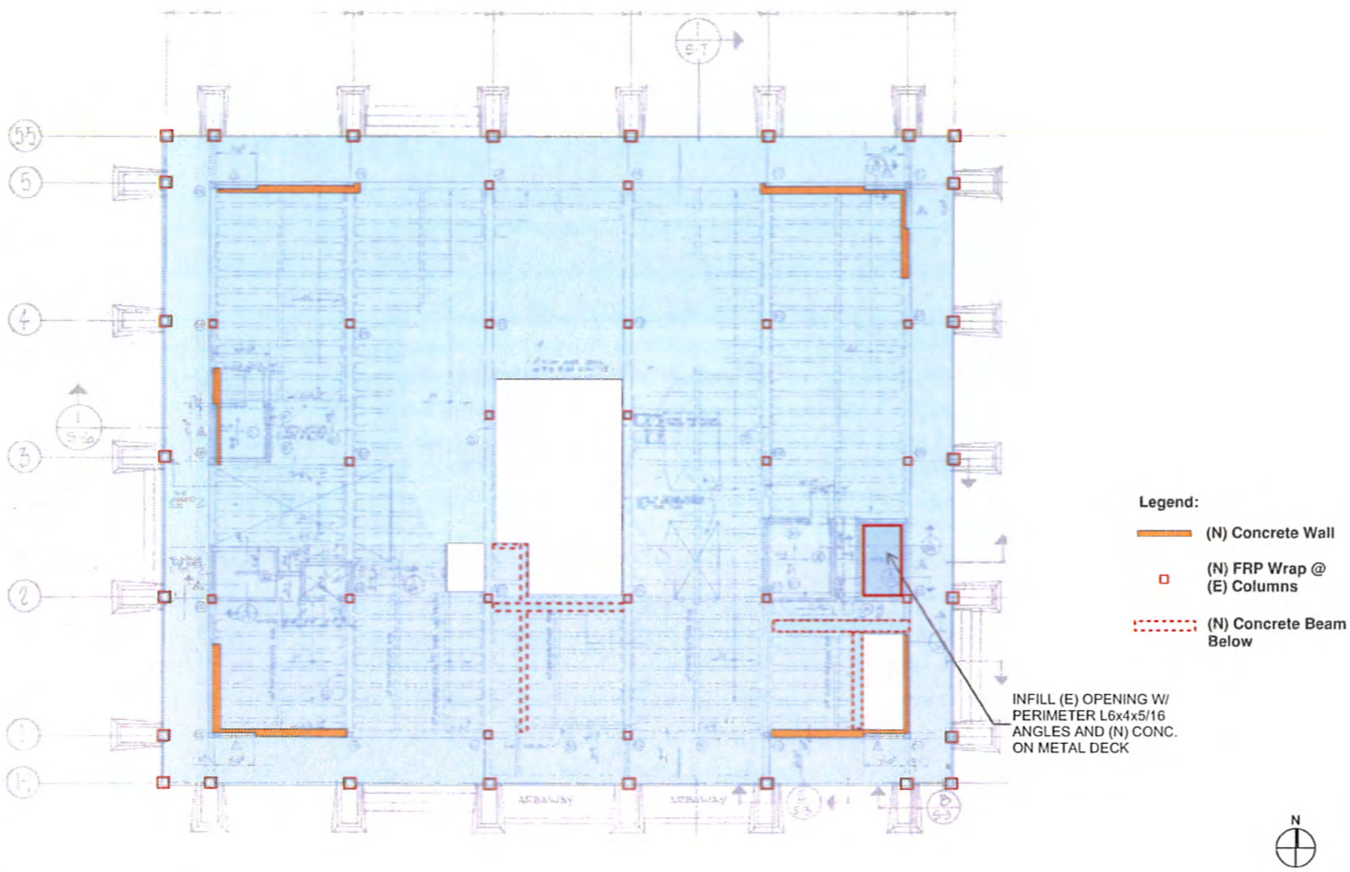
Cupertino, CA

TM Project: 2014,094 Scale: As Noted

Terrace Level Plan

September 29 2014

S0



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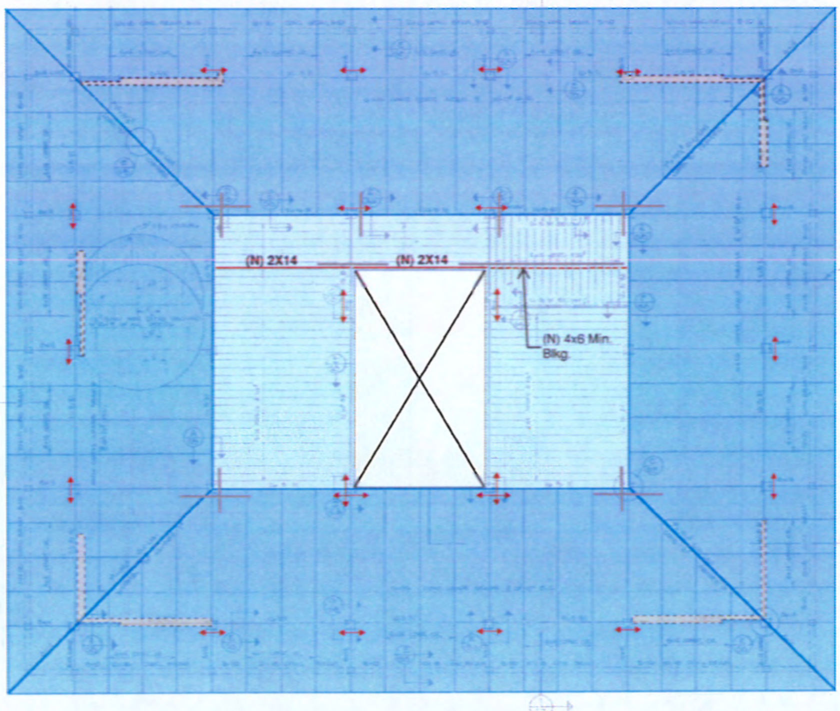
Cupertino City Hall | Option C - Light Court
Cupertino, CA
TM Project: 2014,094 Scale: As Noted

Ground Floor Plan
September 29 2014
S1



Legend:

(N) Concrete Wall Below

(N) High Load Diaphragm
Provide (N) 3/4" Plywood over (E) 1/2" Plywood and 3X T&G Blocking w/ 2 Rows of 10d Nails @ 2 1/2" o.c. along diaphragm boundaries and cont. panel edges, 4" o.c. at other panel edges, and 12" o.c. in field

(E) Reinforced Diaphragm
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(N) Simpson CMST strap or Simpson Holdown

Retrofitted WF Steel Collector Connection

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Roof Plan
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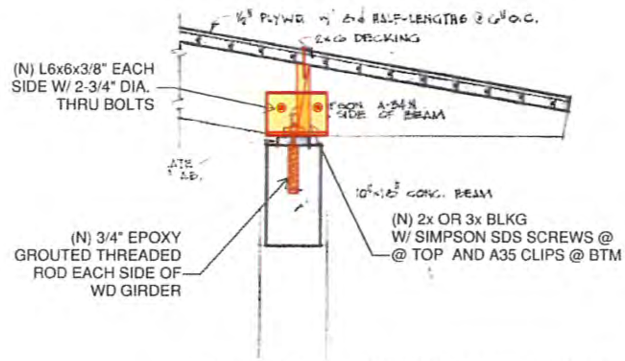
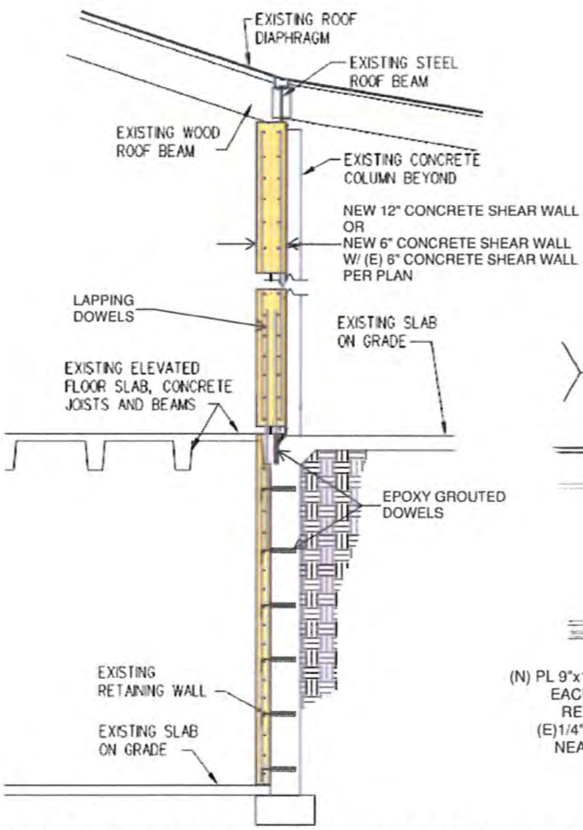
S2



DETAIL 4 - COLONNADE TO ROOF ANCHORAGE



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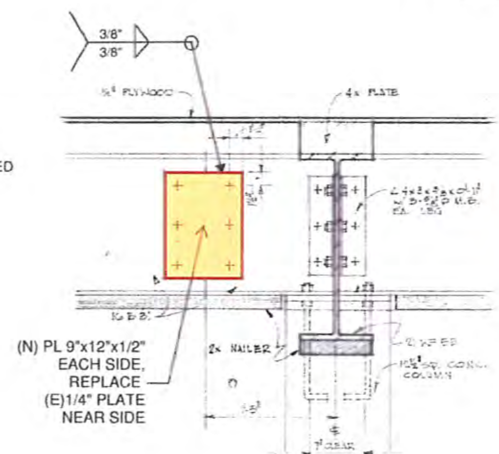
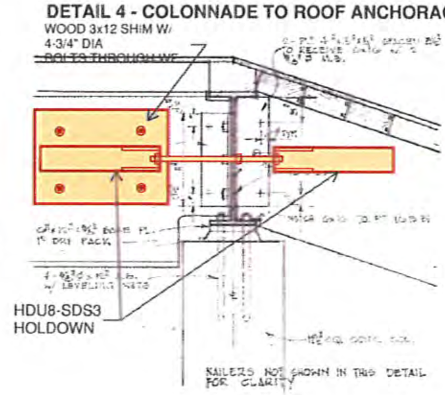


DETAIL 2 - STEEL TO STEEL COLLECTOR SPLICE



DETAIL 1 - STEEL TO WOOD COLLECTOR CONN.

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Retrofit Details
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S3