Executive Summary

The Office Building is being constructed as part of an office complex development project located in Sayre, PA. The building is five stories tall (all above grade), extending up to 67'-0" at the mean roof height (top of parapet elevation = 74'-5"), and has 85,075 ft^2 of total floor area. The floor structure is made up of 4" thick concrete slabs on composite steel deck (4" total combined depth). The slab is carried by open web steel joists which are supported by wide flange steel beams. The beams carry the gravity loads to wide flange steel columns that distribute the loads down to the foundations. The existing lateral system of the Office Building consists of 16 double angle braced frames (8 in each the N-S and E-W directions).

The Thesis Final Report consists of a lateral system redesign depth study and breadth studies focusing on an enclosure redesign for the Office Building. The structural depth involved an investigation into changing the braced frame lateral force resisting system to a moment frame system and designing the frames and rigid connections. Breadth one outlined a redesign of the building enclosure to an all-glazing curtain wall system as well as a barrier performance analysis of the proposed system, taking into account both heat and vapor flow through the enclosure. Breadth two also looked into the enclosure redesign by determining what kind of effects the new all-glazed facade would have on the heating/cooling loads of the building and how it might impact the mechanical systems.

For the structural depth study, four 3-bay moment frames were designed for the E-W direction and two 5-bay frames were designed for the N-S direction. The sizes of the frame members were controlled by the strict drift limitation set at H/500 under serviceability wind loading (10-year MRI winds). The frames were checked for strength requirements under the nominal 700-year MRI wind loading and all members passed that were checked. Critical and representative beam-to-column joints were selected based on the ETABS direct analysis method results and the moment connections were designed and detailed for those locations. All connections designed were bolted flange-plated type connections.

This connection was chosen to save money, since it allows for the single-plate shear tab and flange plates to be shop-welded to the column flanges and then brought to the site already partially assembled. The beam can then be lifted into place and bolted up quickly on site. Critical columns were checked for stiffening requirements and all ended up being heavy enough to resist panel zone shear as well as local flange bending, web yielding and web crippling without the need for transverse stiffeners or doubler plates. The decision to go with heavy column sections helped to avoid the need for careful stiffener detailing and the costs that go along with fabricating those details.

The moment frame design is still going to be significantly more expensive than if braced frames were used, even if column stiffening needs have been avoided and the number of frames and moment connections has been kept to a minimum. Detailing the foundations, base plates and anchor rods to utilize fixed (or at least partially fixed) column bases may be a cost-effective way

to reduce excessive first-story drifts and decrease frame member sizes. Another design to look into to weigh its costs and benefits would be the use of partially restrained moment connections. These connections are significantly cheaper to make than fully restrained and it may be cost-effective to design a greater number of these connection types throughout a greater number of frames than were required with the full restrained design.

The building enclosure redesign for breadth one was undertaken in an attempt to get rid of the existing insulated metal panels and to open up the Office Building to more natural light. The selection of the Kawneer 1600 curtain wall system was based on structural as well as thermal and solar performances. A practical layout for the glazing system units was developed with consideration of both span distance and C&C wind pressure. Additionally, the barrier performance of the proposed and existing enclosure systems was investigated, taking both heat and vapor transfer into account. It was also determined that the proposed redesign would result in poorer overall thermal resistance for the building, while at the same time, increasing its resistance to vapor transmission.

The performance data found and examined in breadth one was used to analyze the effects of the enclosure redesign on the heating/cooling loads of the Office Building. A 70% increase in both the exterior wall enclosure conduction loads and in the solar loads through the vision glass was calculated. Those 70% increases in the envelope loads were found to be equivalent to a nearly 40% increase in total load demand. Therefore, the mechanical systems would need to be upsized by about 40% in their overall capacity to be able to handle the higher demand brought on by the redesign.