EXECUTIVE SUMMARY

The Pennsylvania State University Architectural Engineering Department, in conjunction with Thornton Tomasetti Foundation and The Leonhard Center for the Enhancement of Engineering Education developed the first multidisciplinary engineering design thesis, incorporating Integrated Project Delivery and Building Information Modeling. Three students from each of the Architectural Engineering disciplines were selected to work collaboratively to investigate The New York Times Building as an academic case study. This report involves the year long work of one student from each of the four options; Construction Management, Lighting/Electrical, Mechanical and Structural.

The lateral system was changed from a braced frame system to concrete shear walls with coupling beams. This was changed in order to eliminate the out riggers, thermal trusses, and x-bracing to increase transparency of the building. The periods of vibrations were determined to be 6.46 seconds and 6.64 seconds in the west-east and north-south directions respectively. It was also determined that the total building drift is H/690 and the acceleration is 14.6 milli-g's. From these results, the system was deemed acceptable.

In order to make room for this added structure, the electrical feeders were switched from conduit to bus duct. This reduced the access space required, but increased the cost by approximately $500,000.00 for aluminum bus duct. Mechanical duct work was also rerouted due to the increased structural space requirements. Due to 3-D modeling of these systems, early detection of possible problems were found. In response to the structural changes, the architectural layouts of the spaces within the core were also changed. Even with the increased structural requirements, transparency through the building was maintained by protecting the circulation space within the core.

Comparing the original steel core to the proposed concrete core resulted in a cost savings of approximately $20,000,000.00 for the immediately affected steel members replaced by the proposed structural core redesign. These savings were achieved by comparing the original and proposed systems within the Building Information Model for material take-offs. When including the schedule and general conditions, the overall cost savings from this analysis resulted in approximately $16,500,000.00.

The existing curtain wall system was changed from a single façade layer with a ceramic rod shading system to a dynamic curtain wall system incorporating motorized louvered shades and operable windows. The new design was modeled in AutoDesk Revit using nested families and parametric parameters to accurately depict the way in which the facade would work. The daylighting study resulted in a 72% reduction in lighting energy use within the first two rows of lighting around the entire floor plan. This proposed redesign created a cost savings of $56,280 per year for the entire building. An exterior lighting redesign incorporated LED fixtures, which saved approximately 10,000 watts per side of the building. These savings resulted in a cost savings of $17,520 per year.

The BIM model was utilized to investigate interoperability with energy analysis software. IES<VE> successfully imported geometries from Revit and was used to analysis the performance of the existing and proposed glazing, proposed shading and reduced lighting

power densities within the office. An energy analysis resulted in a reduction of building ambient loads translating to an estimated annual cost savings of $45,136.09.

Hybrid Ventilation was investigated as a possible design solution for the New York Times Building to reduce energy usage and costs, as well as increase the sustainability profile of the building. The analysis concluded the addition of 18 operable window curtain wall panels on office floors above Level 21, excluding floors 28 and 51. Additionally, a control sequence was developed describing the operation of the windows in response to environmental and space conditions. Natural ventilation would reduce energy usage by an estimated 35% resulting in an annual energy savings of $145,419.

Using the data generated from the original and new Revit envelope models, an additional cost of applying louvers was found to be approximately $8,400,000.00. When applied to the cooling load savings generated by the louvers, a payback period of 14 years was achieved. A study into incorporating photovoltaics into the facade was completed simultaneously. The analysis showed that incorporating a photovoltaic system into parts of the west and south facades would add approximately $2,500,000 to the cost of the facade. This addition showed a payback of approximately 25 years. Finally, the incorporation of operable windows cost an additional $2,500,000.00. A payback period of 15 years was found when analyzed for additional cooling load savings on top of the savings due to the louvers.

Using Integrated Project Delivery and Building Information Modeling, the layout of tenant spaces changed. This change is a result of enclosing the exposed steel within the interior of the building to eliminate thermal differentials. This resulted in an increase of rentable area averaging approximately 2,000 square feet per floor. When the increased area was applied to New York City leasing costs for Class A offices, an average revenue increase of approximately $1,275,000.00 per floor per year was achieved for the Forest City Ratner Companies' spaces.

The goal of reducing structural members per bay was not met due to vibrations. It was determined that the redesigned floor system resulted in a total structural depth increase of 3/4" and an increase cost of $1.58 per square foot. The floor framing system was decreased by 7.5 psf and all columns were disengaged from the lateral system. This change decreased column sizes. Built-up columns were required in the cantilever bays in order to keep with the Architect's vision of no columns at the storefront, however they are not as large as the existing columns.

A proposed interior lighting redesign incorporated task lighting into the design. The proposed redesign would use .469 Watts per square foot. If these savings were applied to the entire building, the resulting energy savings would be approximately $462,200.00 per year.

A ducted side-wall displacement ventilation system was selected to replace the existing unducted Underfloor Air Distribution (UFAD) system to improve the indoor environment for the building occupants by minimizing distribution of dust and contaminants that may collect in the open plenum space. The system was sized utilizing load factors determined by ASHRAE, and a 3D model was created in Revit MEP to ensure space requirements were met with the raised floor system.