Life Cycle Assessment of the Leonard S. Klinck Building

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CIVL 498C

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PROVISO

This study is part of a larger study – the UBC LCA Project – which is continually developing. As such the findings contained in this report should be considered preliminary as there may have been subsequent refinements since the initial posting of this report.

If further information is required or if you would like to include details from this study in your research please contact rob.sianchuk@gmail.com.

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CIVL 498C – Final Report

Herman Li
March 29, 2010

Abstract

A life cycle assessment was performed on the Leonard S. Klinck building at the University of British Columbia. The scope of the study was limited to the structure and building envelope from cradle to gate, with the functional unit of per square feet of academic building. Software used in the analysis included OnCenter's OnScreen TakeOff for performing building takeoffs, and the Athena Institute Impact Estimator for calculating the environmental effects. The bill of materials generated for LSK indicated that the largest amounts of material present were batt insulation, gypsum board, concrete, glazing, and polyethylene vapour barrier. The results of the sensitivity analysis revealed that of the aforementioned materials, only additions to the amount of concrete present in the building envelope had any appreciable effect on the end total summary measures. Results from the building performance analysis of LSK using a one-dimensional heat conduction model showed that the energy payback period (where the embodied energy associated with increased insulation materials offset any potential energy savings) for improving the current building envelope to the UBC Residential Environmental Assessment Program's (REAP's) minimum standards was less than one year. The materials altered in this building performance analysis were the insulation in the roof and exterior walls, and the replacement of standard glazing with a high reflectivity variant. Since only these assemblies were altered, the results of the building performance analysis were consistent with those of the sensitivity analysis where an increase in insulation and glazing had no statistical significance on the end environmental impacts.

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1.0 Introduction

The Leonard S. Klinck (LSK) building was constructed in 1947 and opened in 1948 as the New Applied Science Building. It was funded by the B.C. government and cost approximately $928000[1] to construct. It was renamed the Engineering Building in 1951, the Civil Engineering Building in the 1960s, then the Computer Science Building until being renamed the Leonard S. Klinck Building in 2000. Its current name honours Dr. Lenoard S. Klinck, the second president of the University of British Columbia (UBC) and the First Dean of Agriculture. The LSK building is located at 6356 Agricultural Road on UBC's campus, and its current occupants include the Institute of Applied Mathematics and Statistics department. The current structure has undergone renovation, with features such as a main lobby and second floor mezzanine added to the original construction. Table 1 below lists and compares the amenities and space usage for the building in the original plans.

Table 1 - Space Usage

	Room Count	Total Area (square feet)
Classrooms	19	20154
Offices/Office Spaces	27	1991
Testing Labs	9	15074
Library	1	3024
Study/Research/Prep/Computer Lab Rooms	5	3193
Storage Rooms	10	5653
Stairwells/Halls/Atriums	n/a	17331
Washrooms/Locker Rooms	8	1390
Mechanical Rooms	4	5119
Auditorium/Lecture Halls	3	6392

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[1] http://www.library.ubc.ca/archives/bldgs/compsci.html

The building envelope characteristics are given in Table 2 below. Note the lack of insulation in the exterior walls, with insulation only present in the roof envelope.

Table 2 - Building Envelope Characteristics

Structure	Reinforced concrete frame, concrete columns and concrete beams
Floors	Basement: concrete slab on grade; First/Second/Third/Fourth Floors: suspended concrete slabs and steel joist
Exterior Walls	Basement, First/Second/Third/Fourth Floors: cast-in-place concrete
Interior Walls	Basement, First/Second/Third/Fourth Floors: gypsum board on steel stud walls
Windows	Standard glazing, aluminum frame
Roof	Suspended concrete slab and steel joist with standard modified 2-ply bitumen membrane ,fibreglass batt insulation, 6 mil polyethylene vapour barrier

2.0 Goal of Study

This life cycle analysis (LCA) of the Leonard S. Klinck (LSK) building at the University of British Columbia was carried out as an exploratory study to determine the environmental impact of its design. This LCA of the LSK building is also part of a series of twenty-nine others being carried out simultaneously on respective buildings at UBC with the same goal and scope.

The main outcomes of this LCA study are the establishment of a materials inventory and environmental impact references for the LSK building. An exemplary application of these references is in the assessment of potential future performance upgrades to the structure and envelope of the LSK building. When this study is considered in conjunction with the twenty-nine other UBC building LCA studies, further applications include the possibility of carrying out environmental performance comparisons across UBC buildings over time and between different materials, structural types and building functions. Furthermore, as demonstrated through these potential applications, this LSK building LCA can be seen as an essential part of the formation of a powerful tool to help inform the decision making process of policy makers in establishing quantified sustainable development guidelines for future UBC construction, renovation and demolition projects.

The intended core audience of this LCA study are those involved in building development related policy making at UBC, such as the Sustainability Office, who are involved in creating policies and frameworks for sustainable development on campus. Other potential audiences include developers, architects, engineers and building owners involved in design planning, as well as external organizations such as governments, private industry and other universities whom may want to learn more or become engaged in performing similar LCA studies within their organizations.

2.1 Scope of Study

The product system being studied in this LCA is the structure and envelope of the LSK building on a square foot finished floor area of academic building basis. In order to focus on design related impacts, this LCA encompasses a cradle-to-gate scope that includes the raw material extraction, manufacturing of construction materials, and construction of the structure and envelope of the LSK building, as well as associated transportation effects throughout.

2.2 Tools, Methodology and Data

Two main software tools are to be utilized to complete this LCA study; OnCenter's OnScreen TakeOff and the Athena Sustainable Materials Institute's Impact Estimator (IE) for buildings.

The study will first undertake the initial stage of a materials quantity takeoff, which involves performing linear, area and count measurements of the building's structure and envelope. To accomplish this, OnScreen TakeOff version 3.6.2.25 is used, which is a software tool designed to perform material takeoffs with increased accuracy and speed in order to enhance the bidding capacity of its users. Using imported digital plans, the program simplifies the calculation and measurement of the takeoff process, while reducing the error associated with these two activities. The measurements generated are formatted into the inputs required for the IE building LCA software to complete the takeoff process. These formatted inputs as well as their associated assumptions can be viewed in Annexes A and B respectively.

Using the formatted takeoff data, version 4.0.64 of the IE software, the only available software capable of meeting the requirements of this study, is used to generate a whole building LCA model for the LSK building in the Vancouver region as an Institutional building type. The IE software is designed to aid the building community in making more environmentally conscious material and design choices. The tool achieves this by applying a set of algorithms to the inputted takeoff data in order to complete the takeoff process and generate a bill of materials (BoM). This BoM then utilizes the Athena Life Cycle Inventory (LCI) Database, version 4.6, in order to generate a cradle-to-grave LCI profile for the building. In this study, LCI profile results focus on the manufacturing (inclusive of raw material extraction), transportation of construction materials to site and their installation as structure and envelope assemblies of the LSK building. As this study is a cradle-to-gate assessment, the expected service life of the LSK building is set to 1 year, which results in the maintenance, operating energy and end-of-life stages of the building's life cycle being left outside the scope of assessment.

The IE then filters the LCA results through a set of characterization measures based on the mid-point impact assessment methodology developed by the US Environmental Protection Agency (US EPA), the Tool for the Reduction and Assessment of Chemical and other environmental Impacts (TRACI) version 2.2. In order to generate a complete environmental impact profile for the LSK building, all of the available TRACI impact assessment categories available in the IE are included in this study, and are listed as;

- Global warming potential
- Acidification potential
- Eutrophication potential
- Ozone depletion potential
- Photochemical smog potential
- Human health respiratory effects potential
- Weighted raw resource use
- Primary energy consumption

Using the summary measure results, a sensitivity analysis is then conducted in order to reveal the effect of material changes on the impact profile of the LSK building. Finally, using the UBC Residential Environmental Assessment Program (REAP) as a guide, this study then estimates the embodied energy involved in upgrading the insulation and window R-values to REAP standards and generates a rough estimate of the energy payback period of investing in a better performing envelope.

The primary sources of data used in modeling the structure and envelope of the LSK building are the original architectural and structural drawings from when the was initially constructed in 1947. The assemblies of the building that are modeled include the foundation, columns and beams, floors, walls and roofs, as well as their associated envelope and/or openings (i.e. doors and windows). The decision to omit other building components, such as flooring, electrical aspects, HVAC system, finishing and detailing, etc., are associated with the limitations of available data and the IE software, as well as to minimize the uncertainty of the model. In the analysis of these assemblies, some of the drawings lack sufficient material details, which necessitate the usage of assumptions to complete the modeling of the building in the IE software. Furthermore, there are inherent assumptions made by the IE software in order to generate the bill of materials and limitations to what it can model, which necessitated further assumptions to be made. These assumptions and limitation will be discussed further as they emerge in the Building Model section of this report and, as previously mentioned, all specific input related assumptions are contained in the Input Assumptions document in Appendix B.

3.0 Building Model

3.1 Takeoffs

Takeoffs were done using OnCenter's OnScreen TakeOff software, which allowed PDF copies of the architectural and structural building plans to be imported and scaled for use. Structural drawings were used to perform the takeoffs for the foundation, exterior walls and glazing, floors, roofs, beams, and columns. Architectural drawings were used to perform the takeoffs for the interior walls. A site visit was performed to verify building architecture where the drawing details were difficult to understand, as well as to obtain information on the glazing and frame type, as well as the interior wall and door construction.

Takeoffs for both exterior and interior walls were done using a linear condition, with the units in linear feet. Floors, roofs, and slabs were measured using an area condition, with the units in square feet. Footings were measured individually, with larger sections measured using a linear condition. Stairwells were also measured as a footing, with an average thickness measured from drawing cross sections. Beams and columns were counted individually where shown on the drawings; their respective bay and span sizes were measured using the dimensioning tool. Where beams were not shown but a floor known to be supported by columns, the supported area was measured using an area condition which could then be resolved into equivalent bay and span sizes. A count condition was also used to count the number of doors in the partitions. Dimensions that were not explicitly shown on the drawings or given in notes were measured using the software's own dimensioning tool (where applicable), or assumed in some cases.

A standard logical nomenclature was followed for naming each condition, and the same name was shared between both OnScreen TakeOff and the Athena Impact Estimator software. The naming convention allowed individual conditions to easily be identified by including information such as the assembly type, material, dimensions, floor on which it was located, location in the building, and other descriptive identifiers. The same standards for assembly nomenclature were adopted for all of the other models of buildings at UBC.

A source of difficulty in performing the takeoffs came from the quality of the scanned drawings. In the case of the drawings for the LSK building, the original drawings were drawn by hand, thus some discolouration and blurriness of the lines was present in the scanned copies. In some cases, small printed text, as well as written dimensions, was illegible even when magnified due to poor resolution. As a result, an educated guess of the words, or direct measurement using the dimensioning tool had to be performed as a substitute. Where assembly data was not available, appropriate components had to be assumed to be present to continue with the analysis.

3.2 Modeling and Assumptions

3.2.1 Foundation

The Impact Estimator took inputs of length, width, thickness, concrete strength, and flyash content for modeling slab on grades. Inputs for footings were identical except for the addition of a rebar type selection. Slabs on grade were measured using an area condition with units of square feet, with the thicknesses read directly off of the drawings. Takeoffs for footings used a count condition with dimensions read directly off of the drawings; however, longer sections of footings were sometimes measured using a linear condition. In the Athena Impact Estimator, slab on grade inputs were limited to being either a 4” or 8” thickness, thus the measured areas had to be adjusted while keeping the total material volume equal in order to account for this input limitation. The Impact Estimator was also limited to inputs of 3000 psi, 4000 psi, or 9000 psi. Where the concrete was found to have a different value than these accepted inputs, the closest value was substituted. For the footings, the Impact Estimator limited the thickness to be between 7.5” and 19.7” thick. As there are a number of cases where footing thicknesses exceed 19”, their widths were increased accordingly to maintain the same volume of footing while accommodating this limitation. The concrete flyash content was assumed to be average for both the slab on grade and footings. Lastly, the concrete stairs were modelled as footings. All stairs had the same thickness and width, so the total length of stairs was measured and were combined into a single input.

3.2.2 Walls

The Impact Estimator took inputs of length, height, thickness, concrete strength, flyash content, and rebar type as inputs for modeling cast-in-place walls. For steel stud partition walls, the inputs were length, height, sheathing type, stud spacing, stud weight, and stud thickness. Additional information on the envelope assembly and opening types and dimensions could also be input. Exterior and interior walls were measured using a linear condition with units of feet. The length of the concrete cast-in-place walls needed adjusting to accommodate the wall thickness limitation of 8” or 12” in the Impact Estimator. The Impact Estimator was limited to inputs of 3000 psi, 4000 psi, or 9000 psi. Where the concrete was found to have a different value than those accepted inputs, the closest value was substituted. Flyash content was assumed to be average. #5 rebar was substituted for #4 rebar since the Impact Estimator input for cast-in-place wall assemblies was limited to #5 or #6 rebar. Since interior partition data was not available, the partitions were assumed to be metal stud, with light gauge (25Ga) steel studs at 16" O.C., with a 5/8" gypsum board completing the assembly.

3.3.3 Columns and Beams

The Impact Estimator calculated the sizing of beams and columns based on the following inputs; number of beams, number of columns, floor to floor height, bay size, supported span and live load. Columns and beams were accounted for in OnScreen using a count condition, with the bay and span sizes measured using the dimensioning tool. Where beams were present but of varying length, the bay size was averaged. Where no beams were present in the plans, concrete columns were accounted for on each floor, while each floor's area was measured. The number of beams supporting each floor was assigned an average bay and span size in order to cover the measured area. Since the live loading was not located within the provided building information, a live load of 75psf on all four floors and the basement level were assumed.

3.3.4 Floors

The Impact Estimator calculated the thickness of the suspended slab based on floor width, span, concrete strength, concrete flyash content and live load. The concrete suspended slab group was assumed to have a live load of 75psf. Since the maximum span input for the Impact Estimator for concrete suspended slabs was limited to 30 ft, the width was adjusted accordingly to maintain the same measured area. The Impact Estimator calculated the thickness of the steel joist floor based on the floor width, length, steel gauge, joist type and spacing, and also had the decking type and thickness as inputs. The steel joist floor was assumed to have a decking thickness of 5/8" (type: none) and steel gauge of 18. Since the maximum length input for the Impact Estimator for Steel Joist Floors was limited to 18 ft, the width was adjusted accordingly to maintain the same measured area.

3.3.5 Roofs

The Impact Estimator calculated the thickness of the suspended slab based on roof width, span, concrete strength, concrete flyash content and live load. The concrete suspended slab group was assumed to have a live load of 75psf. Since the maximum span input for the Impact Estimator for concrete suspended slabs was limited to 30 ft, the width was adjusted accordingly to maintain the same measured area. The Impact Estimator calculated the thickness of the steel joist floor based on the floor width, length, steel gauge, joist type and spacing, and also had the decking type and thickness as inputs. The assumptions made for the Steel Joist Roof were a decking thickness of 5/8" (type: none) and steel gauge of 18. Since the maximum length input for the Impact Estimator for steel joist roofs was limited to 18 ft, the width was adjusted accordingly to maintain the same measured area. Roof assembly data was unavailable but insulation was known to be present, so a generic roof assembly was created and used for each roof type.

The roof envelope was assumed to be standard modified bitumen membrane 2 ply, the insulation assumed to be 6" fiberglass batt, and the vapour barrier assumed to be 6 mil polyethylene.

3.3.6 Extra Basic Materials

Skylight glazing was modeled separately as an extra basic material due to the glazing being angled and not flat against the roof surface. The angle of inclination was estimated to be 45 degrees; thus the measured base area of the glazing multiplied by the square root of 2 (1.41) to account for this.

3.3.7 Inputs and Assumptions Details

Details of the specific inputs for each assembly group and component can be found in Appendix A: IE Inputs Document. Details of the specific assumptions and their related calculations can be found in Appendix B: IE Inputs Assumptions Document.

4.0 Bill of Materials

The bill of materials for LSK generated by OnScreen Takeoff is presented below in Table 3.

Table 3 - Bill of Materials

Material	Quantity	Unit
5/8" Regular Gypsum Board	11467.1151	m2
6 mil Polyethylene	2270.1335	m2
Aluminum	7.1159	Tonnes
Batt. Fiberglass	13255.9357	m2 (25mm)
Concrete 20 MPa (flyash av)	4197.5122	m3
Concrete 30 MPa (flyash av)	792.9256	m3
EPDM membrane	468.883	kg
Expanded Polystyrene	6.51	m2 (25mm)
Galvanized Sheet	0.1238	Tonnes
Galvanized Studs	51.1081	Tonnes
Joint Compound	11.4444	Tonnes
Modified Bitumen membrane	2204.2208	kg
Nails	0.9325	Tonnes
Paper Tape	0.1314	Tonnes
Rebar, Rod, Light Sections	299.6862	Tonnes
Screws Nuts & Bolts	1.2586	Tonnes
Small Dimension Softwood Lumber, kiln-dried	11.8195	m3
Softwood Plywood	887.5079	m2 (9mm)
Solvent Based Alkyd Paint	0.5896	L
Standard Glazing	2257.1319	m2
Water Based Latex Paint	100.8772	L
Welded Wire Mesh / Ladder Wire	2.7039	Tonnes

The five largest amounts of material are Batt. Fiberglass, 5/8" Regular Gypsum Board, Concrete 20 MPa (flyash average), Standard Glazing, and 6 mil polyethylene. The specific assemblies contributing to these largest amounts of material may have included assumptions that affect the output of the bill of materials.

4.1 Batt. Fibreglass

The roof assembly was the only source containing batt fibreglass insulation. Both the concrete suspended slab roofs and steel joist roofs contained this insulation. This material was among the largest accounted for in the bill of materials due to the large area of the building roof. It was determined from the building drawings that insulation was present; however, the specific type was not indicated. The insulation was assumed to be batt fibreglass, a common roofing insulator, and the thickness of 6 inches assumed based on a minimum R-value of 19 for non-residential roofs[2], and an average R-value of 3.25[3]. Different assumptions with regards to the insulation type or thickness would have no effect on the bill of materials value for batt fibreglass since the output value was in square meters, and the total area of roof coverage would remain constant.

4.2 Regular Gypsum Board 5/8"

The steel stud partition wall assembly was the source of 5/8" regular gypsum board. A large amount of gypsum board was present since it was the primary assembly component of the interior partition walls, and thus had a large overall surface area. Wall assembly data was unavailable, so the assumption of a steel stud partition wall was made, and the type and thickness of the gypsum board was also assumed. However, since the bill of materials output for the gypsum board was in square meters, different assumptions regarding the stud type, board type, and board thickness would have no effect on the final value.

4.3 Concrete 20 MPa (flyash average)

Concrete was a major building component, present in most assemblies including the cast-in-place exterior walls, slabs on grade, columns, beams, suspended slab floors and roofs, and footings. For the cast-in-place walls, slabs on grade, and footings, changes to the assumptions of flyash content being average, and adjustments made to the concrete strength and rebar type (where necessary to meet Impact Estimator input limitations) would not affect the output of the bill of materials for concrete since the final value was in units of cubic meters, and the volume of those assemblies would have remained constant. However, for

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[2] Table B-15 Building Envelope Requirements, ASHRAE Standard 90.1-2001

[3] http://progress-energy.com/custservice/carres/energytips/rvalues.asp

the concrete columns, beams, and suspended slab roofs and floors, any assumptions made for flyash content, live load, and concrete strength would have affected the results since those inputs were used by the Impact Estimator to calculate thicknesses; directly affecting the volume of concrete measured. For the bill of materials generated, no assumptions regarding concrete strength were made in the analysis of the columns, beams, floors, and roofs, but an assumption of a 75 psf live load was made for these assemblies, and an additional assumption of average flyash content made for the suspended slabs. Variations to either of these assumptions would have resulted in an overestimation or underestimation of the total concrete volume.

4.4 Standard Glazing

The majority of the glazing was from the cast-in-place exterior walls, with a small proportion from the roof (skylight glazing, accounted for under extra basic materials). Since the glazing accounted for a large proportion of the exterior wall area, it was found to be one of the larger output values from the bill of materials. During a site visit, the glazing was found to be single-paned with no reflective surfaces indicating the glazing was of a standard type with no low E coatings. Nevertheless, differences in the input of glazing type would not have affected the bill of materials output since the glazing was measured in square meters, and the total measured area would not have been affected.

4.5 Polyethylene 6mm

The roof assembly was the only source containing the 6mm polyethylene vapour barrier. Both the concrete suspended slab roofs and steel joist roofs contained this vapour barrier. This material was among the largest accounted for in the bill of materials due to the large area of the building roof. A vapour barrier was not explicitly seen in the drawings, but reasonably assumed to be present since there was insulation in the roof assembly. Polyethylene of 6mm was chosen for its commonality. The assumption of its thickness had no impact on the final bill of materials output since the final value was in units of square meters, and the roof coverage area would not have changed.

5.0 Summary Measures

5.1 Results by Life Cycle Stages

The summary measures by life cycle stages are given in Table 4 below.

Table 4 - Summary Measures by Life Cycle Stage

	Manufacturing			**Construction**			**Total Effects**	**Total Effects per Sq. Ft**
	Material	Transportation	**Total**	Material	Transportation	**Total**		
Primary Energy Consumption MJ	1.48E+07	5.08E+05	**1.54E+07**	9.18E+05	1.23E+06	**2.15E+06**	**1.75E+07**	**183**
Weighted Resource Use kg	1.37E+07	3.39E+02	**1.37E+07**	2.13E+04	7.92E+02	**2.21E+04**	**1.37E+07**	**143.07**
Global Warming Potential (kg CO2 eq)	1.53E+06	8.99E+02	**1.53E+06**	6.27E+04	2.21E+03	**6.49E+04**	**1.60E+06**	**16.72**
Acidification Potential (moles of H+ eq)	6.17E+05	3.05E+02	**6.17E+05**	3.13E+04	7.06E+02	**3.20E+04**	**6.49E+05**	**6.79**
HH Respiratory Effects Potential (kg PM2.5 eq)	5.77E+03	3.68E-01	**5.77E+03**	3.50E+01	8.49E-01	**3.59E+01**	**5.81E+03**	**0.06**
Eutrophication Potential (kg N eq)	7.38E+02	3.17E-01	**7.38E+02**	3.08E+01	7.32E-01	**3.15E+01**	**7.70E+02**	**0.01**
Ozone Depletion Potential (kg CFC-11 eq)	2.57E-03	3.70E-08	**2.57E-03**	5.09E-11	9.07E-08	**9.07E-08**	**2.57E-03**	**0.00**
Smog Potential (kg NOx eq)	7.04E+03	6.87E+00	**7.05E+03**	7.64E+02	1.58E+01	**7.80E+02**	**7.84E+03**	**0.08**

For our LCA analysis, we were concerned only with cradle to gate, and thus the life cycle stages of relevance were the manufacturing and construction stages. Manufacturing includes resource extraction, resource transportation and manufacturing of specific materials, products or building components, while construction includes product/component transportation from the point of manufacture to the building site and on-site construction activities[4]. Each life cycle stage was further divided into effects resulting from the material production or use, and the transportation of the materials. The total effects were the sum of the effects from the manufacturing, construction, and end-of-life stages (end-of-life not tabulated in Table 4), and the total effects per square foot were obtained by dividing the total effects by the total floor area of the building (95615 square feet).

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[4] Description as given by the Athena Institute Impact Estimator software.

5.2 Summary Measure Categories

The summary measure categories included primary energy consumption, weighted resource use, global warming potential, acidification potential, human health respiratory effects potential, eutrophication potential, ozone depletion potential, and smog potential. A brief description of each category will be presented below[5].

5.2.1 Primary Energy Consumption

Primary energy consumption is reported in mega-joules, and includes all direct and indirect energy used to transform or transport raw materials into building products, including the embodied energy in raw materials used as energy sources in production processes. The indirect energy use associated with processing, transporting, converting and delivering fuel and energy is also included.

5.2.2 Weighted Resource Use

Weighted resource use is reported in kilograms, and is the sum of the weighted resource requirements for all products used. The weighting used reflects the relative ecological impacts of resource extraction, and are applied to the amounts of raw resources used to manufacture each building product. Weighted scores are used since a unit of one resource may not be comparable to a unit of another resource when it comes to the environmental implications of their extraction.

5.2.3 Global Warming Potential

Global warming potential is a reference measure reported in units of tonnes carbon dioxide equivalent, which is the common reference standard for measuring greenhouse gas effects and represents the heat trapping capability of carbon dioxide. All relevant process emissions of greenhouse gasses are included in the global warming potential index, and the Impact Estimator uses 100-year time horizon figures from the International Panel on Climate Change as a basis for calculating the equivalence index.

5.2.4 Acidification Potential

Acidification potential is recorded in units of moles of H+ equivalent for air or water emissions, and is a regional impact affecting human health when high concentrations of NO_x and SO_2 are attained.

5.2.5 Human Health Respiratory Effects Potential

Human health respiratory effects potential is recorded in units of kilograms $PM_{2.5}$ (a measure of particulate size) equivalent. Particulate matter has a considerable effect on the human respiratory system, resulting in asthma, bronchitis, acute pulmonary disease, and other detrimental impacts.

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[5] See footnote 4.

5.2.6 Eutrophication Potential

Eutrophication potential is recorded in units of kilograms nitrogen equivalent, and is a measure of the potential for fertilization of surface waters by nutrients that were previously scarce. This leads to the proliferation of aquatic photosynthetic plant life, and may have long range consequences such as the death of other aquatic life in the region.

5.2.7 Ozone Depletion Potential

Ozone depletion potential is recorded in units of kilograms CFC-11 equivalent, and accounts for impacts related to the reduction of the stratospheric ozone layer due to emissions of ozone depleting substances (CFCs, HFCs, and halons). Each contributing substance is characterized relative to CFC-11.

5.2.8 Smog Potential

Smog potential is recorded in units of kilograms NO_x equivalent, and is a measure of photochemical ozone creation potential. Under certain climatic conditions, the emissions from industry and transportation can be trapped at a ground level, with nitrogen oxides reacting with volatile organic compounds to produce photochemical smog.

5.3 Interpretation and Assumptions

The summary measures are best interpreted alongside of results from the life cycle assessment of other UBC buildings; this gives context to the absolute values when a baseline average is available for comparison. The interpretation of the results should also consider the uncertainties inherent in the impact assessment process. Data uncertainty arises from unknown substance lifetimes, travel potential, and proliferation potential. Characterization factors are not known, contributing to model uncertainty. Temporal and spatial variability arises from regional differences in the sensitivity of the receiving environment, distribution of emissions, interactions between pollutants, and the time horizon considered for toxicity measurement. In addition, uncertainty exists in the results due to user error, extending to all stages of the life cycle assessment, including errors in measuring data from OnScreen and inputting data into the Impact Estimator.

5.4 Sensitivity Analysis

Five different sensitivity analyses were performed on the five largest amounts of material given by the bill of materials output: batt fibreglass, 5/8” regular gypsum board, concrete 20Mpa with average flyash content, standard glazing, and 6 millimetre polyethylene. The amount of each material was individually increased by 10%, and the Impact Estimator summary measures by life cycle stage results generated and compared with the original values. The percent change in the total effects was then graphed in their corresponding summary measure categories. The results are given in Figure 1 below.

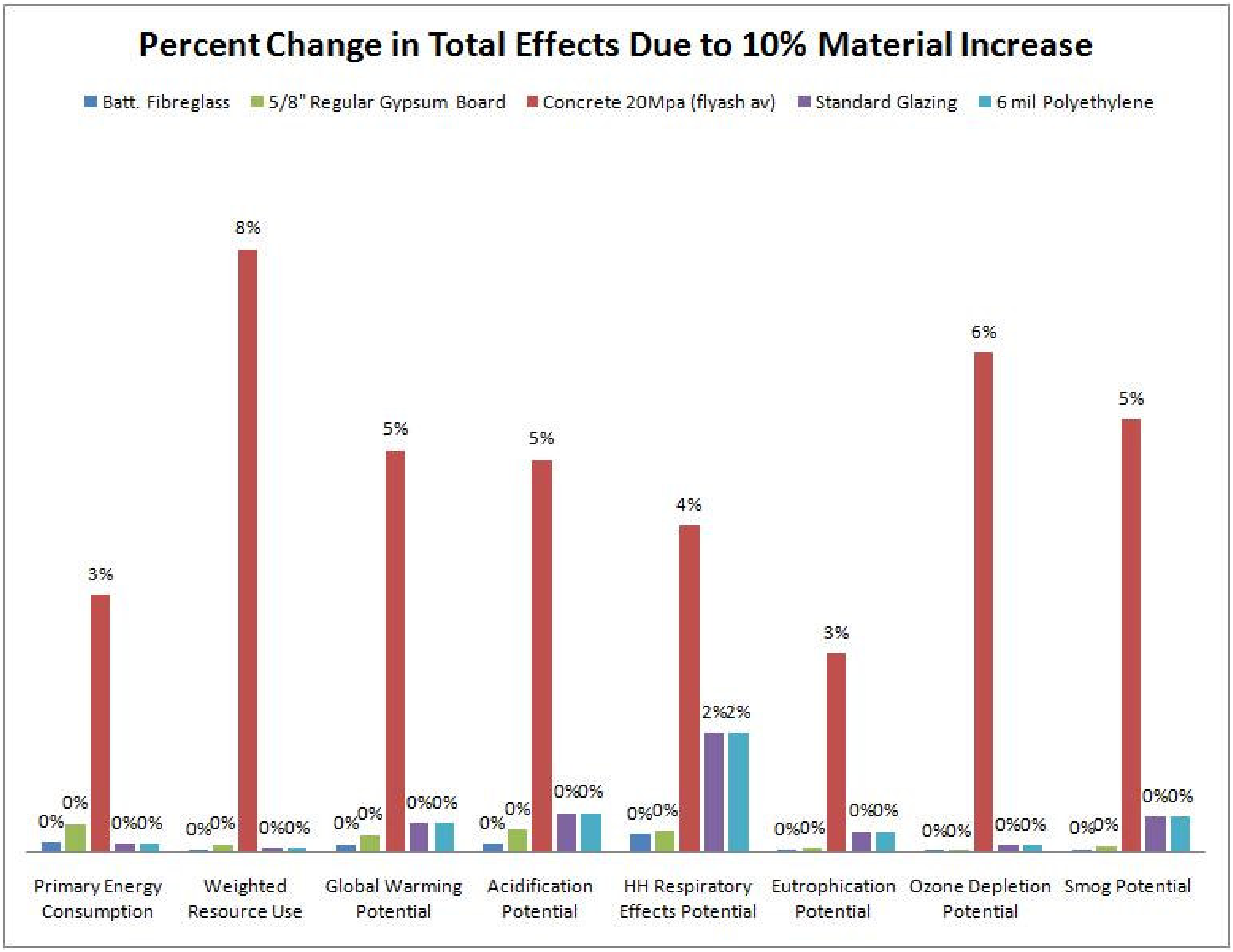

Figure 1 - Sensitivity Analysis of Selected Building Materials

We see from the results that a 10% increase in the amount of batt fibreglass insulation, gypsum board, glazing, and polyethylene vapour barrier have an almost negligible effect on all summary measure categories except for the human health respiratory effects potential (where a 2% increase is seen for both the glazing and polyethylene vapour barrier). We can conclude also that a 10% increase in any other building materials (except concrete) would have an even lesser effect on the summary measure categories since they are of an even lesser amount. The only material in which a 10% increase created a statistically significant increase in the total effects is the 20Mpa concrete.

Performing a sensitivity analysis in the design stage or prior to any major renovations would allow the building designers to optimize material usage for the purpose of decreasing the end environmental impacts. If we take the previous results from LSK as an example, the building designers would conclude that any significant increase in the amount of concrete used in the structure would have a considerable impact, whereas the same proportional increase in another building material would not. Since a 10% increase in the amount of batt fibreglass insulation was found to have a negligible impact on the total effects, designers may opt to increase the amount of insulation present in the building to obtain better energy performance for the duration of the service life. Although a 10% increase in the amount of glazing shows the same marginal increase in total effects, we have to consider that an increase in glazing (for the purpose of replacing concrete on the exterior facade) would not necessarily reduce the overall environmental impact since our life cycle assessment considers only cradle to gate effects; the environmental cost of greater energy usage during the service life is not accounted for due to our previously identified assumptions and limitation of scope.

6.0 Building Performance

6.1 Materials and Embodied Energy

The primary factor in determining building performance was the type of insulating material used in the building envelope as well as the thermal conductance of the glazing in the exterior walls. Since LSK was an older building (constructed in 1947) the exterior walls had no materials specifically added for insulating properties, and the glazing was single pane with no reflective properties. The only insulation present was in the roof assembly, and was modeled as 6” fibreglass batt.

Increasing the amount of insulation in the building allowed for reduced heat conduction through the building envelope, reducing the load on the mechanical systems tasked with maintaining thermal comfort and resulting in energy savings. However, an increase in insulating materials also resulted in an increase in the embodied energy; hence, a trade-off existed where the energy savings of increased insulation balanced the increased embodied energy of including the extra insulation.

The total areas of the exterior walls, glazing, and roof were measured, and a weighted average of their thermal resistance values (R-values) was calculated based on those areas. An improved model was then created with added insulation materials to bring individual component R-values up to UBC’s Residential Environmental Assessment Program’s (REAP’s) minimum thermal resistance standards. Table 5 highlights the differences between the insulation and glazing types used, and Table 6 presents the difference in R-values between the models.

Table 5 - Insulation Types

	Current Building	Improved Building
Exterior Wall	No insulation	5.5” Blown cellulose
Window	Standard glazing (single pane)	Low E tin argon filled glazing (3mm glass with ½” airspace)
Roof	6” Batt fibreglass	13” Batt fibreglass

Table 6 - Building R-Values

		R-Value (ft2.degF.h/BTU)	
	Total Area (ft2)	'Current' Building	'Improved' Building
Exterior Wall	27442	0.00	18
Window	18656	0.91	3.45
Roof	24064	18.84	40
Weighted Average	70162	6.70	21.68

Each model was then input into the Impact Estimator to calculate the difference in embodied energy between the current building and the improved building with extra insulation. The results are shown in Table 7 below.

Table 7 - Embodied Energy Results

Impact Category	Units	Current	Improved
Primary Energy Consumption	MJ	17,884,443.20	18,165,451.16

6.2 Energy Modeling

To obtain information on LSK’s building performance, as well as to estimate the payback period of increasing the current amount of insulation to a level meeting REAP’s insulation standards, a simple energy model was created. Standard energy modeling techniques such as the use of Radiant Time Series Coefficients for modeling solar radiation gains and Conduction Time Series Coefficients for modeling the time effects of thermal mass were not used since only a rough estimate was required. Monthly average temperatures were used such that only heat losses occurred; heat gains through solar radiation as well as heat conduction through floor slabs were not considered. In this way, the analysis was simplified to that of a one dimensional heat conduction model.

6.3 Energy Payback Period

The annual energy consumption of each building was then calculated using this model, with the room temperature constant and the outside temperatures set to Vancouver's monthly historical average temperatures. The results were then graphed, and the energy payback period determined. Figure 2 shows the payback period in years; the time scale was determined to be too large, and the payback period was then represented in months and is shown in Figure 3.

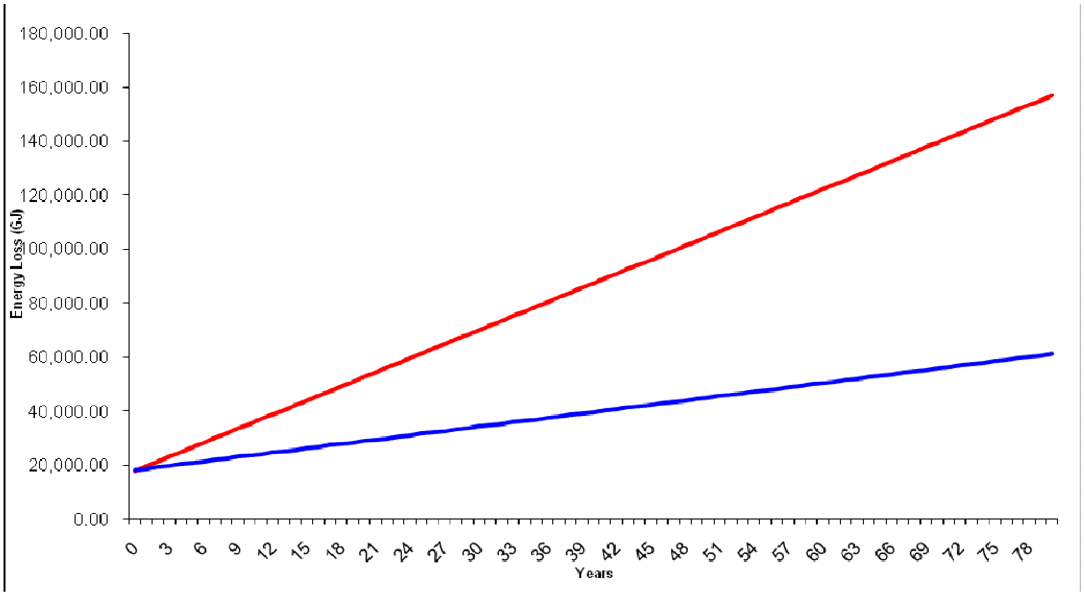

Figure 2 - Payback Period: Years

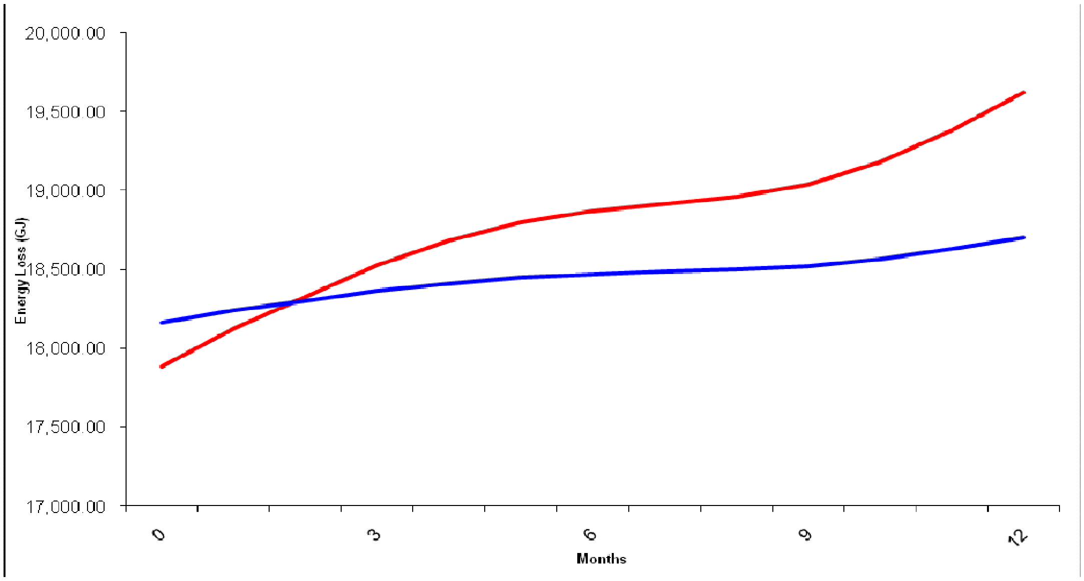

Figure 3 - Payback Period: Months

From Figure 2, the payback period was found to be less than one year of operation. Assuming that LSK began its service life in January, the payback period would be approximately 1.5 months, with the breakeven point in mid-February. Since January is the coldest month on average for any given year, this payback period represents the lower limit, and will increase if the service life is assumed to begin during another month. Given the long service lives of buildings on campus at UBC (after renovations, LSK has been in service for 62 years), it is obvious that increasing the thermal resistance of the building envelope materials would result in considerable energy savings. This result is due in part to the low embodied energy cost of increasing the amount of insulation in the building. The total embodied cost of the increased insulation was approximately 1.6% of the original building's embodied energy; a small proportion considering the weighted R-value was approximately tripled as a result, and the annual energy losses through the building envelope reduced by approximately 70%.

6.4 Renovation Considerations

If modifications to the existing structure were to be undertaken to improve building performance, certain considerations must be taken into account. Given the number of years that the LSK building has already been in service (62 years), its remaining service life must be decided on and a separate analysis performed on this time frame. This is not to determine if there will be any energy savings since we have already determined the energy payback period to be less than one year of operation; rather, this is to determine whether it is financially reasonable to do so. In other words, the monetary cost of installing the insulation should be compared with the monetary cost of the energy savings for the remaining duration of the service life.

Adding the blown cellulose to the exterior cast-in-place walls may prove to be a challenge since a separate wall layer will be needed to separate the insulation from the building occupants, while the same window opening positions will need to be maintained. For the roof, the difficulty lies in extending the added insulation to the edges of the exterior walls at the perimeter to remove thermal bridging which decreases the effectiveness of the insulation considerably. The waste from performing the renovations, as well as the waste resulting from replacing all the existing glazing with a high performance variant should also be considered as an environmental cost.

7.0 Conclusions

The life cycle assessment of the Leonard S. Klinck building was performed on the structure and envelope on a per square foot finished floor area of academic building basis, and considered total environmental effects from cradle to gate. The bill of materials generated from the Impact Estimator showed that the top 5 largest amounts of materials present were batt fibreglass, 5/8” regular gypsum board, 20 MPa concrete with average flyash content, standard glazing, and 6 mil polyethylene vapour barrier. The results of the sensitivity analysis revealed that within the top 5 material contributors, 20 MPa concrete with average flyash content was the only material where a 10% increase resulted in a significant increase in all summary measure categories. Results from the building performance analysis showed that increasing the current levels of insulation in the roofs and exterior walls, as well as replacing the current glazing with a higher thermal performance variant to the standards set out by the UBC Residential Environmental Assessment Program’s (REAP’s) minimum R-value requirements would result in significantly improved building performance with a energy payback period of less than one year of operation. However, considerations such as the age of the building and its remaining service life must be taken into account, as well as difficulties in renovating the existing building envelope. The financial feasibility of such a project must also be considered, and the monetary cost savings of decreased energy consumption compared with the cost of the renovations. The results of this LCA study should be compared with the LCAs of other building types such as those with wood frame or steel structures with curtain wall assemblies to determine which results in lower end environmental effects, with the aim to aid future design and development efforts at UBC. Building performances should also be compared to determine the optimal amount of insulation that should be included in the design of new structures to increase energy efficiency. A future possible extension of the current LCA study is to perform material and waste accounting at the time of the building’s demolition, and use that data to supplement the end-of-life summary measures effects calculated by the Impact Estimator.

Appendix A – IE Input Document

Assembly Group	Assembly Type	Assembly Name	Input Fields	Input Values	
				Known/ Measured	EIE Inputs
1 Foundation					
	1.1 Concrete Slab-on-Grade				
		1.1.1 SOG_3"_3000psi			
			Length (ft)	31.35	27.15
			Width (ft)	31.35	27.15
			Thickness (in)	3	4
			Concrete (psi)	3000	3000
			Concrete flyash %	-	average
		1.1.2 SOG_4"_2000psi			
			Length (ft)	54.16	54.16
			Width (ft)	54.16	54.16
			Thickness (in)	4	4
			Concrete (psi)	2000	3000
			Concrete flyash %	-	average
		1.1.3 SOG_4"_3000psi			
			Length (ft)	133.99	133.99
			Width (ft)	133.99	133.99
			Thickness (in)	4	4
			Concrete (psi)	3000	3000
			Concrete flyash %	-	average
		1.1.4 SOG_5"_3000psi			
			Length (ft)	67.30	75.24
			Width (ft)	67.30	75.24
			Thickness (in)	5	4
			Concrete (psi)	3000	3000
			Concrete flyash %	-	average
		1.1.5 SOG_6"_3000psi			
			Length (ft)	18.25	22.35
			Width (ft)	18.25	22.35
			Thickness (in)	6	4
			Concrete (psi)	3000	3000+F404

			Concrete flyash %	-	average
		1.1.6 SOG_Driveway			
			Length (ft)	66.49	66.49
			Width (ft)	66.49	66.49
			Thickness (in)	4	4
			Concrete (psi)	3000	3000
			Concrete flyash %	-	average
	1.2 Concrete Footing				
		1.2.1 Footing_1-5			
			Length (ft)	16	16
			Width (ft)	3	3.32
			Thickness (in)	21	19
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#5	#5
		1.2.2 Footing_104Wide_104Deep			
			Length (ft)	249	249
			Width (ft)	1.33	1.33
			Thickness (in)	16	16
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#5	#5
		1.2.3 Footing_106Wide_12Deep			
			Length (ft)	332	332
			Width (ft)	1.5	1.5
			Thickness (in)	12	12
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#5	#5
		1.2.4 Footing_109			
			Length (ft)	7	7
			Width (ft)	7	12.16
			Thickness (in)	33	19
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#5	#5
		1.2.5 Footing_109A_110A			
			Length (ft)	7.5	7.5
			Width (ft)	3.75	3.75
			Thickness (in)	18	18
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#5	#5
		1.2.6 Footing_109Wide_12Deep			

	Length (ft)	12	12
	Width (ft)	1.75	1.75
	Thickness (in)	12	12
	Concrete (psi)	2500	3000
	Concrete flyash %	-	average
	Rebar	#5	#5
1.2.7 Footing_117_118			
	Length (ft)	9	9
	Width (ft)	4.5	4.74
	Thickness (in)	20	19
	Concrete (psi)	2500	3000
	Concrete flyash %	-	average
	Rebar	#5	#5
1.2.8 Footing_12Wide_12Deep			
	Length (ft)	210	210
	Width (ft)	1	1.00
	Thickness (in)	12	12
	Concrete (psi)	2500	3000
	Concrete flyash %	-	average
	Rebar	#5	#5
1.2.9 Footing_15-19			
	Length (ft)	13	13
	Width (ft)	4	4.42
	Thickness (in)	21	19
	Concrete (psi)	2500	3000
	Concrete flyash %	-	average
	Rebar	#5	#5
1.2.10 Footing_16_17_20_21			
	Length (ft)	20	20
	Width (ft)	5	6.32
	Thickness (in)	24	19
	Concrete (psi)	2500	3000
	Concrete flyash %	-	average
	Rebar	#5	#5
1.2.11 Footing_16Wide_12Deep			
	Length (ft)	21	21
	Width (ft)	1.33	1.33
	Thickness (in)	12	12
	Concrete (psi)	2500	3000
	Concrete flyash %	-	average
	Rebar	#5	#5
1.2.12 Footing_16Wide_8Deep			
	Length (ft)	272	272
	Width (ft)	1.33	1.33
	Thickness (in)	8	8

			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#5	#5
		1.2.13 Footing_18-22			
			Length (ft)	13	13
			Width (ft)	3.50	3.87
			Thickness (in)	21	19
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#5	#5
		1.2.14 Footing_2			
			Length (ft)	5	5.00
			Width (ft)	3.67	4.06
			Thickness (in)	21	19
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#5	#5
		1.2.15 Footing_203Wide_15Deep			
			Length (ft)	385	385
			Width (ft)	2.25	2.25
			Thickness (in)	15	15
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#5	#5
		1.2.16 Footing_22Wide_12Deep			
			Length (ft)	128	128
			Width (ft)	1.83	1.83
			Thickness (in)	12	12
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
	i		Rebar	#5	#5
		1.2.17 Footing_29-34			
			Length (ft)	13	13
			Width (ft)	3	3.32
			Thickness (in)	21	19
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#5	#5
		1.2.18 Footing_3			
			Length (ft)	5	5
			Width (ft)	3.5	3.87
			Thickness (in)	21	19
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#5	#5

1.2.19 Footing_300Wide_18Deep			
	Length (ft)	4	4
	Width (ft)	3	3
	Thickness (in)	18	18
	Concrete (psi)	2500	3000
	Concrete flyash %	-	average
	Rebar	#5	#5
1.2.20 Footing_306Wide_18Deep			
	Length (ft)	11	11
	Width (ft)	3.5	3.5
	Thickness (in)	18	18
	Concrete (psi)	2500	3000
	Concrete flyash %	-	average
	Rebar	#5	#5
1.2.21 Footing_30_31			
	Length (ft)	8	8
	Width (ft)	4	4
	Thickness (in)	18	18
	Concrete (psi)	2500	3000
	Concrete flyash %	-	average
	Rebar	#5	#5
1.2.22 Footing_32_39			
	Length (ft)	9	9
	Width (ft)	4.5	4.74
	Thickness (in)	20	19
	Concrete (psi)	2500	3000
	Concrete flyash %	-	average
	Rebar	#5	#5
1.2.23 Footing_36			
	Length (ft)	4.75	4.75
	Width (ft)	4.75	5.5
	Thickness (in)	22	19
	Concrete (psi)	2500	3000
	Concrete flyash %	-	average
	Rebar	#5	#5
1.2.24 Footing_38			
	Length (ft)	5.25	5.25
	Width (ft)	5.25	6.63
	Thickness (in)	24	19
	Concrete (psi)	2500	3000
	Concrete flyash %	-	average
	Rebar	#5	#5
1.2.25 Footing_4-8			
	Length (ft)	18	18
	Width (ft)	2.75	3.04

			Thickness (in)	21	19
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#5	#5
		1.2.26 Footing_40			
			Length (ft)	3.75	3.75
			Width (ft)	3.75	3.75
			Thickness (in)	18	18
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#5	#5
		1.2.27 Footing_44			
			Length (ft)	14	14
			Width (ft)	2	2
			Thickness (in)	12	12
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#5	#5
		1.2.28 Footing_49_50_58_59			
			Length (ft)	10.67	10.67
			Width (ft)	2.67	2.67
			Thickness (in)	12	12
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#5	#5
		1.2.29 Footing_51_60			
			Length (ft)	17	17
			Width (ft)	8.5	13.42
			Thickness (in)	30	19
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#5	#5
		1.2.30 Footing_52			
			Length (ft)	8.75	8.75
			Width (ft)	8.75	17.04
			Thickness (in)	37	19
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#5	#5
		1.2.31 Footing_53			
			Length (ft)	3.25	3.25
			Width (ft)	3.25	3.25
			Thickness (in)	16	16
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average

	Rebar	#5	#5
1.2.32 Footing_54			
	Length (ft)	8	8
	Width (ft)	8	14.74
	Thickness (in)	35	19
	Concrete (psi)	2500	3000
	Concrete flyash %	-	average
	Rebar	#5	#5
1.2.33 Footing_55			
	Length (ft)	5.25	5.25
	Width (ft)	5.25	6.63
	Thickness (in)	24	19
	Concrete (psi)	2500	3000
	Concrete flyash %	-	average
	Rebar	#5	#5
1.2.34 Footing_61			
	Length (ft)	8	8
	Width (ft)	8	14.74
	Thickness (in)	35	19
	Concrete (psi)	2500	3000
	Concrete flyash %	-	average
	Rebar	#5	#5
1.2.35 Footing_62			
	Length (ft)	3.25	3.25
	Width (ft)	3.25	3.25
	Thickness (in)	16	16
	Concrete (psi)	2500	3000
	Concrete flyash %	-	average
	Rebar	#5	#5
1.2.36 Footing_63			
	Length (ft)	8	8
	Width (ft)	8	14.74
	Thickness (in)	35	19
	Concrete (psi)	2500	3000
	Concrete flyash %	-	average
	Rebar	#5	#5
1.2.37 Footing_64			
	Length (ft)	5.25	5.25
	Width (ft)	5.25	6.63
	Thickness (in)	24	19
	Concrete (psi)	2500	3000
	Concrete flyash %	-	average
	Rebar	#5	#5
1.2.38 Footing_68_69_70			
	Length (ft)	2.25	2.25

			Width (ft)	2.25	2.25
			Thickness (in)	12	12
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#5	#5
		1.2.39 Footing_6_7			
			Length (ft)	4	4
			Width (ft)	4	4
			Thickness (in)	18	18
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#5	#5
		1.2.40 Footing_71			
			Length (ft)	8	8
			Width (ft)	8	14.74
			Thickness (in)	35	19
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#5	#5
		1.2.41 Footing_72			
			Length (ft)	7.5	7.5
			Width (ft)	7.5	13.42
			Thickness (in)	34	19
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#5	#5
		1.2.42 Footing_73			
			Length (ft)	2.5	2.5
			Width (ft)	2.5	2.5
			Thickness (in)	14	14
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#5	#5
		1.2.43 Footing_74			
			Length (ft)	7.5	7.5
			Width (ft)	7.5	13.42
			Thickness (in)	34	19
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#5	#5
		1.2.44 Footing_75			
			Length (ft)	5	5
			Width (ft)	5	6.32
			Thickness (in)	24	19
			Concrete (psi)	2500	3000

	Concrete flyash %	-	average
	Rebar	#5	#5
1.2.45 Footing_77_86_94_101_108			
	Length (ft)	16.25	16.25
	Width (ft)	3.25	3.25
	Thickness (in)	16	16
	Concrete (psi)	2500	3000
	Concrete flyash %	-	average
	Rebar	#5	#5
1.2.46 Footing_78_79			
	Length (ft)	14	14
	Width (ft)	7	12.16
	Thickness (in)	33	19
	Concrete (psi)	2500	3000
	Concrete flyash %	-	average
	Rebar	#5	#5
1.2.47 Footing_80_89			
	Length (ft)	14	14
	Width (ft)	7	12.16
	Thickness (in)	33	19
	Concrete (psi)	2500	3000
	Concrete flyash %	-	average
	Rebar	#5	#5
1.2.48 Footing_82			
	Length (ft)	4	4
	Width (ft)	4	4
	Thickness (in)	18	18
	Concrete (psi)	2500	3000
	Concrete flyash %	-	average
	Rebar	#5	#5
1.2.49 Footing_87			
	Length (ft)	7.5	7.5
	Width (ft)	7.5	13.42
	Thickness (in)	34	19
	Concrete (psi)	2500	3000
	Concrete flyash %	-	average
	Rebar	#5	#5
1.2.50 Footing_88_96_103_110			
	Length (ft)	31	31
	Width (ft)	7.75	13.87
	Thickness (in)	34	19
	Concrete (psi)	2500	3000
	Concrete flyash %	-	average
	Rebar	#5	#5

		1.2.51 Footing_95_102			
			Length (ft)	7.5	7.5
			Width (ft)	7.5	13.42
			Thickness (in)	34	19
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#5	#5
		1.2.52 Stairs_Concrete_Total			
			Length (ft)	56.66	56.66
			Width (ft)	56.66	56.66
			Thickness (in)	15	15
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#5	#5
2 Walls					
	2.1 Cast In Place				
		2.1.1 Wall_Cast-In-Place_06Thick_1000Height			
			Length (ft)	132	99
			Height (ft)	10	10
			Thickness (in)	6	8
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#4	#5
		2.1.2 Wall_Cast-In-Place_06Thick_300Height			
			Length (ft)	201	150.75
			Height (ft)	3	3
			Thickness (in)	6	8
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#4	#5
		2.1.3 Wall_Cast-In-Place_06Thick_700Height			
			Length (ft)	22	16.5
			Height (ft)	7	7
			Thickness (in)	6	8
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#4	#5
		2.1.4 Wall_Cast-In-Place_08Thick_1000Height			
			Length (ft)	959	959
			Height (ft)	10	10
			Thickness (in)	8	8
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average

			Rebar	#4	#5
		Door Opening	Number of Doors	1	1
			Door Type	Steel Exterior Door	Steel Exterior Door
		2.1.5 Wall_Cast-In-Place_08Thick_1300Height			
			Length (ft)	23	23
			Height (ft)	13	13
			Thickness (in)	8	8
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#4	#5
		2.1.6 Wall_Cast-In-Place_08Thick_1400Height			
			Length (ft)	266	266
			Height (ft)	14	14
			Thickness (in)	8	8
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#4	#5
		Window Opening	Number of Windows	2	2
			Total Window Area (ft2)	168	168
			Frame Type	Aluminum	Aluminum
			Glazing Type	Standard	Standard
		2.1.7 Wall_Cast-In-Place_08Thick_1500Height			
			Length (ft)	326	326
			Height (ft)	15	15
			Thickness (in)	8	8
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#4	#5
		Window Opening	Number of Windows	2	2
			Total Window Area (ft2)	180	180
			Frame Type	Aluminum	Aluminum
			Glazing Type	Standard	Standard
		2.1.8 Wall_Cast-In-Place_08Thick_1900Height			
			Length (ft)	82	82
			Height (ft)	19	19
			Thickness (in)	8	8
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#4	#5
		Window Opening	Number of Windows	1	1
			Total Window	66	66

			Area (ft2)		
			Frame Type	Aluminum	Aluminum
			Glazing Type	Standard	Standard
		2.1.9 Wall_Cast-In-Place_08Thick_500Height			
			Length (ft)	1039	1039
			Height (ft)	5	5
			Thickness (in)	8	8
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#4	#5
		2.1.10 Wall_Cast-In-Place_08Thick_600Height			
			Length (ft)	21	21
			Height (ft)	6	6
			Thickness (in)	8	8
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#4	#5
		2.1.11 Wall_Cast-In-Place_08Thick_700Height			
			Length (ft)	56	56
			Height (ft)	7	7
			Thickness (in)	8	8
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#4	#5
		2.1.12 Wall_Cast-In-Place_08Thick_708Height			
			Length (ft)	72	72
			Height (ft)	7.67	7.67
			Thickness (in)	8	8
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#4	#5
		Door Opening	Number of Doors	1	1
			Door Type	Steel Exterior Door	Steel Exterior Door
		2.1.13 Wall_Cast-In-Place_10Thick_1000Height			
			Length (ft)	354	442.5
			Height (ft)	10	10
			Thickness (in)	10	8
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#4	#5
		Window Opening	Number of Windows	5	5
			Total Window	280	280

			Area (ft2)		
			Frame Type	Aluminum	Aluminum
			Glazing Type	Standard	Standard
		2.1.14 Wall_Cast-In-Place_10Thick_1500Height			
			Length (ft)	411	513.75
			Height (ft)	15	15
			Thickness (in)	10	8
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#4	#5
		Window Opening	Number of Windows	21	21
			Total Window Area (ft2)	1110.375	1110.375
			Frame Type	Aluminum	Aluminum
			Glazing Type	Standard	Standard
		Door Opening	Number of Doors	2	2
			Door Type	Solid Wood Door	Solid Wood Door
		2.1.15 Wall_Cast-In-Place_10Thick_500Height			
			Length (ft)	110	137.5
			Height (ft)	5	5
			Thickness (in)	10	8
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#4	#5
		2.1.16 Wall_Cast-In-Place_10Thick_600Height			
			Length (ft)	62	77.5
			Height (ft)	6	6
			Thickness (in)	10	8
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#4	#5
		2.1.17 Wall_Cast-In-Place_10Thick_800Height			
			Length (ft)	133	166.25
			Height (ft)	8	8
			Thickness (in)	10	8
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#4	#5
		2.1.18 Wall_Cast-In-Place_10Thick_803Height			
			Length (ft)	83	103.75
			Height (ft)	8.25	8.25
			Thickness (in)	10	8
			Concrete (psi)	2500	3000

			Concrete flyash %	-	average
			Rebar	#4	#5
		2.1.18 Wall_Cast-In-Place_12Thick_1000Height			
			Length (ft)	90	90
			Height (ft)	10	10
			Thickness (in)	12	12
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#4	#5
		2.1.19 Wall_Cast-In-Place_12Thick_1300Height			
			Length (ft)	728	728
			Height (ft)	13	13
			Thickness (in)	12	12
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#4	#5
		Window Opening	Number of Windows	9	9
			Total Window Area (ft2)	5064.34	5064.34
			Frame Type	Aluminum	Aluminum
			Glazing Type	Standard	Standard
		Door Opening	Number of Doors	1	1
			Door Type	Solid Wood Door	Solid Wood Door
		2.1.20 Wall_Cast-In-Place_12Thick_1400Height			
			Length (ft)	640	640
			Height (ft)	14	14
			Thickness (in)	12	12
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#4	#5
		Window Opening	Number of Windows	8	8
			Total Window Area (ft2)	7350.6	7350.6
			Frame Type	Aluminum	Aluminum
			Glazing Type	Standard	Standard
		2.1.21 Wall_Cast-In-Place_12Thick_1500Height			
			Length (ft)	638	638
			Height (ft)	15	15
			Thickness (in)	12	12
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#4	#5
		Window Opening	Number of Windows	8	8

			Total Window Area (ft2)	7350.6	7350.6
			Frame Type	Aluminum	Aluminum
			Glazing Type	Standard	Standard
		2.1.22 Wall_Cast-In-Place_12Thick_800Height			
			Length (ft)	42	42
			Height (ft)	8	8
			Thickness (in)	12	12
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#4	#5
		2.1.23 Wall_Cast-In-Place_12Thick_803Height			
			Length (ft)	211	211
			Height (ft)	8.25	8.25
			Thickness (in)	12	12
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#4	#5
		Window Opening	Number of Windows	1	1
			Total Window Area (ft2)	56	56
			Frame Type	Aluminum	Aluminum
			Glazing Type	Standard	Standard
		2.1.24 Wall_Cast-In-Place_14Thick_1000Height			
			Length (ft)	27	31.5
			Height (ft)	10	10
			Thickness (in)	14	12
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#4	#5
		2.1.25 Wall_Cast-In-Place_16Thick_1000Height			
			Length (ft)	43	57.33
			Height (ft)	10	10
			Thickness (in)	16	12
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#4	#5
		2.1.26 Wall_Cast-In-Place_18Thick_1000Height			
			Length (ft)	258	387
			Height (ft)	10	10
			Thickness (in)	18	12
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#4	#5

		2.1.27 Wall_Cast-In-Place_18Thick_1500Height			
		Window Opening	Length (ft)	61	91.5
			Height (ft)	15	15
			Thickness (in)	18	12
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#4	#5
			Number of Windows	5	5
			Total Window Area (ft2)	90	90
			Frame Type	Aluminum	Aluminum
			Glazing Type	Standard	Standard
		2.1.28 Wall_Cast-In-Place_24Thick_1300Height			
			Length (ft)	46	92
			Height (ft)	13	13
			Thickness (in)	24	12
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#4	#5
		2.1.29 Wall_Cast-In-Place_24Thick_1500Height			
			Length (ft)	12	24
			Height (ft)	15	15
			Thickness (in)	24	12
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#4	#5
		2.1.30 Wall_Cast-In-Place_24Thick_600Height			
			Length (ft)	59	118
			Height (ft)	6	6
			Thickness (in)	24	12
			Concrete (psi)	2500	3000
			Concrete flyash %	-	average
			Rebar	#4	#5
	2.2 Steel Stud				
		2.4.1 Wall_SteelStud_Partition_FirstFloor			
		Envelope	Length (ft)	1123	1123
			Height (ft)	15	15
			Sheathing Type	-	None
			Stud Spacing	-	16
			Stud Weight	-	Light (25Ga)
			Stud Thickness	1 5/8 x 6	1 5/8 x 6
			Category	Gypsum Board	Gypsum Board
			Material	-	Gypsum Regular 5/8"

			Thickness	-	-
			Category	Gypsum Board	Gypsum Board
			Material	-	Gypsum Regular 5/8"
			Thickness	-	-
		Door Opening	Number of Doors	32	32
			Door Type	Solid Wood Door	Solid Wood Door
		2.4.2 Wall_SteelStud_Partition_Fourth Floor			
			Length (ft)	1008	1008
			Height (ft)	12	12
			Sheathing Type	-	None
			Stud Spacing	-	16
			Stud Weight	-	Light (25Ga)
			Stud Thickness	1 5/8 x 6	1 5/8 x 6
		Envelope	Category	Gypsum Board	Gypsum Board
			Material	-	Gypsum Regular 5/8"
			Thickness	-	-
			Category	Gypsum Board	Gypsum Board
			Material	-	Gypsum Regular 5/8"
			Thickness	-	-
		Door Opening	Number of Doors	50	50
			Door Type	Solid Wood Door	Solid Wood Door
		2.4.3 Wall_SteelStud_Partition_Second Floor			
			Length (ft)	1221	1221
			Height (ft)	12	12
			Sheathing Type	-	None
			Stud Spacing	-	16
			Stud Weight	-	Light (25Ga)
			Stud Thickness	1 5/8 x 6	1 5/8 x 6
		Envelope	Category	Gypsum Board	Gypsum Board
			Material	-	Gypsum Regular 5/8"
			Thickness	-	-
			Category	Gypsum Board	Gypsum Board
			Material	-	Gypsum Regular 5/8"
			Thickness	-	-
		Door Opening	Number of Doors	39	39
			Door Type	Solid Wood Door	Solid Wood Door
		2.4.4 Wall_SteelStud_Partition_ThirdFloor			
			Length (ft)	1262	1262
			Height (ft)	12	12
			Sheathing Type	-	None

		Envelope	Stud Spacing	-	16
			Stud Weight	-	Light (25Ga)
			Stud Thickness	1 5/8 x 6	1 5/8 x 6
			Category	Gypsum Board	Gypsum Board
			Material	-	Gypsum Regular 5/8"
			Thickness	-	-
			Category	Gypsum Board	Gypsum Board
			Material	-	Gypsum Regular 5/8"
			Thickness	-	-
		Door Opening	Number of Doors	20	20
			Door Type	Solid Wood Door	Solid Wood Door
3 Columns and Beams					
	3.1 Concrete Column				
		3.1.1 Column_Concrete_Basement_1000Height			
			Number of Beams	0	0
			Number of Columns	45	45
			Floor to floor height (ft)	10	10
			Bay sizes (ft)	16.37	16.37
			Supported span (ft)	16.37	16.37
			Live load (psf)	-	75
		3.1.2 Column_Concrete_Basement_300 Height			
			Number of Beams	0	0
			Number of Columns	56	56
			Floor to floor height (ft)	3	3
			Bay sizes (ft)	14.3	14.3
			Supported span (ft)	14.3	14.3
			Live load (psf)	-	75
		3.1.3 Column_Concrete_Basement_800 Height			
			Number of Beams	0	0
			Number of Columns	12	12
			Floor to floor height (ft)	8	8
			Bay sizes (ft)	12.86	12.86
			Supported span (ft)	12.86	12.86
			Live load (psf)	-	75
		3.1.4 Column_Concrete_Basement_803 Height			
			Number of	0	0

	Beams		
	Number of Columns	7	7
	Floor to floor height (ft)	8.25	8.25
	Bay sizes (ft)	10.42	10.42
	Supported span (ft)	10.42	10.42
	Live load (psf)	-	75
3.1.5 Column_Concrete_FirstFloor_1500Height			
	Number of Beams	0	0
	Number of Columns	35	35
	Floor to floor height (ft)	15	15
	Bay sizes (ft)	14.29	14.29
	Supported span (ft)	14.29	14.29
	Live load (psf)	-	75
3.1.6 Column_Concrete_FirstFloor_600Height			
	Number of Beams	0	0
	Number of Columns	53	53
	Floor to floor height (ft)	6	6
	Bay sizes (ft)	17.57	17.57
	Supported span (ft)	17.57	17.57
	Live load (psf)	-	75
3.1.7 Column_Concrete_FirstFloor_800Height			
	Number of Beams	0	0
	Number of Columns	11	11
	Floor to floor height (ft)	8	8
	Bay sizes (ft)	13.36	13.36
	Supported span (ft)	13.36	13.36
	Live load (psf)	-	75
3.1.8 Column_Concrete_Beam_Concrete_SecondFloor_SouthEast_1300Height			
	Number of Beams	4	4
	Number of Columns	8	8
	Floor to floor height (ft)	13	13
	Bay sizes (ft)	26.5	26.5
	Supported span (ft)	20	20
	Live load (psf)	-	75
3.1.9 Column_Concrete_Beam_Concrete_SecondFloor_Sou			

thLecture_1300Height			
	Number of Beams	12	12
	Number of Columns	16	16
	Floor to floor height (ft)	13	13
	Bay sizes (ft)	26	26
	Supported span (ft)	20.25	20.25
	Live load (psf)	-	75
3.1.10 Column_Concrete_Beam_Concrete_SecondFloor_NorthLecture_1300Height			
	Number of Beams	12	12
	Number of Columns	14	14
	Floor to floor height (ft)	13	13
	Bay sizes (ft)	20.42	20.42
	Supported span (ft)	15.67	15.67
	Live load (psf)	-	75
3.1.11 Column_Concrete_Beam_Concrete_SecondFloor_SouthWest_1300Height			
	Number of Beams	9	9
	Number of Columns	9	9
	Floor to floor height (ft)	13	13
	Bay sizes (ft)	32.58	32.58
	Supported span (ft)	10.08	10.08
	Live load (psf)	-	75
3.1.12 Column_Concrete_Beam_Concrete_SecondFloor_NorthWest_1300Height			
	Number of Beams	15	15
	Number of Columns	15	15
	Floor to floor height (ft)	13	13
	Bay sizes (ft)	20	20
	Supported span (ft)	20.42	20.42
	Live load (psf)	-	75
3.1.13 Column_Concrete_Beam_Concrete_ThirdFloor_Driveway_1500Height			
	Number of Beams	6	6
	Number of Columns	8	8
	Floor to floor height (ft)	15	15
	Bay sizes (ft)	30.17	30.17
	Supported span (ft)	19.75	19.75
	Live load (psf)	-	75

		3.1.14 Column_Concrete_Beam_Concrete_ThirdFloor_Center_1500Height			
			Number of Beams	12	12
			Number of Columns	15	15
			Floor to floor height (ft)	15	15
			Bay sizes (ft)	37.42	37.42
			Supported span (ft)	20	20
			Live load (psf)	-	75
		3.1.15 Column_Concrete_Beam_Concrete_ThirdFloor_West_1500Height			
			Number of Beams	15	15
			Number of Columns	20	20
			Floor to floor height (ft)	15	15
			Bay sizes (ft)	29.42	29.42
			Supported span (ft)	20.25	20.25
			Live load (psf)	-	75
		3.1.16 Column_Concrete_Beam_Concrete_FourthFloor_Driveway_1400Height			
			Number of Beams	6	6
			Number of Columns	8	8
			Floor to floor height (ft)	14	14
			Bay sizes (ft)	29.67	29.67
			Supported span (ft)	20.25	20.25
			Live load (psf)	-	75
		3.1.17 Column_Concrete_Beam_Concrete_FourthFloor_Center_1400Height			
			Number of Beams	12	12
			Number of Columns	15	15
			Floor to floor height (ft)	14	14
			Bay sizes (ft)	37.33	37.33
			Supported span (ft)	19.58	19.58
			Live load (psf)	-	75
		3.1.18 Column_Concrete_Beam_Concrete_FourthFloor_West_1400Height			
			Number of Beams	15	15
			Number of Columns	19	19
			Floor to floor height (ft)	14	14
			Bay sizes (ft)	29.42	29.42
			Supported span	20.25	20.25

			(ft)		
			Live load (psf)	-	75
4 Floor					
	4.1 Concrete Suspended Slab				
		4.1.1 Floor_Concrete_SuspendedSlab_15"			
			Floor Width (ft)	56.75	116.34
			Span (ft)	61.5	30
			Concrete (psi)	3000	3000
			Concrete flyash %	-	average
			Live load (psf)	-	75
		4.1.2 Floor_Concrete_SuspendedSlab_4"			
			Floor Width (ft)	233.72	765.4
			Span (ft)	98.25	30
			Concrete (psi)	3000	3000
			Concrete flyash %	-	average
			Live load (psf)	-	75
		4.1.3 Floor_Concrete_SuspendedSlab_5"			
			Floor Width (ft)	32.79	110.12
			Span (ft)	100.75	30
			Concrete (psi)	3000	3000
			Concrete flyash %	-	average
			Live load (psf)	-	75
		4.1.4 Floor_Concrete_SuspendedSlab_6"			
			Floor Width (ft)	74.53	356.92
			Span (ft)	143.67	30
			Concrete (psi)	3000	3000
			Concrete flyash %	-	average
			Live load (psf)	-	75
	4.2 Steel Joist Floor				
		4.2.1 Floor_Steel_Joist_FirstFloor_4"			
			Floor Width (ft)	18.93	22.61
			Floor Length (ft)	21.50	18.00
			Decking Type	-	None
			Decking Thickness (in)	-	5/8
			Steel Gauge	-	18
			Joist Type	1 5/8 x 6	1 5/8 x6
			Joist Spacing	16	16
		4.2.2 Floor_Steel_Joist_FirstFloor_5"			
			Floor Width (ft)	18.2	20.2

			Floor Length (ft)	20	18
			Decking Type	-	None
			Decking Thickness	-	5/8
			Steel Gauge	-	18
			Joist Type	1 5/8 x 6	1 5/8 x6
			Joist Spacing	24	24
		4.2.3 Floor_Steel_Joist_FourthFloor_4"			
			Floor Width (ft)	56.36	323.04
			Floor Length (ft)	103.17	18
			Decking Type	-	None
			Decking Thickness	-	5/8
			Steel Gauge	-	18
			Joist Type	1 5/8 x 6	1 5/8 x6
			Joist Spacing	16	16
		4.2.4 Floor_Steel_Joist_FourthFloor_5"			
			Floor Width (ft)	54.13	272.15
			Floor Length (ft)	90.5	18
			Decking Type	-	None
			Decking Thickness	-	5/8
			Steel Gauge	-	18
			Joist Type	1 5/8 x 6	1 5/8 x6
			Joist Spacing	24	24
		4.2.5 Floor_Steel_Joist_SecondFloor_4 "			
			Floor Width (ft)	53.86	340.37
			Floor Length (ft)	113.75	18
			Decking Type	-	None
			Decking Thickness	-	5/8
			Steel Gauge	-	18
			Joist Type	1 5/8 x 6	1 5/8 x6
			Joist Spacing	16	16
		4.2.6 Floor_Steel_Joist_SecondFloor_5 "			
			Floor Width (ft)	23.76	54.34
			Floor Length (ft)	41.17	18
			Decking Type	-	None
			Decking Thickness	-	5/8
			Steel Gauge	-	18
			Joist Type	1 5/8 x 6	1 5/8 x6
			Joist Spacing	16	16
		4.2.7 Floor_Steel_Joist_ThirdFloor_4"			
			Floor Width (ft)	49.19	268.5
			Floor Length (ft)	98.25	18
			Decking Type	-	None

			Decking Thickness	-	5/8
			Steel Gauge	-	18
			Joist Type	1 5/8 x 6	1 5/8 x6
			Joist Spacing	16	16
		4.2.8 Floor_Steel_Joist_ThirdFloor_5"			
			Floor Width (ft)	55.65	324.16
			Floor Length (ft)	103	18
			Decking Type	-	None
			Decking Thickness	-	5/8
			Steel Gauge	-	18
			Joist Type	1 5/8 x 6	1 5/8 x6
			Joist Spacing	24	24
5 Roof					
	5.1 Concrete Suspended Slab				
		5.1.1 Roof_Concrete_SuspendedSlab_4 "			
		Envelope	Roof Width (ft)	55.98	327.33
			Span (ft)	175.42	30
			Concrete (psi)	3000	3000
			Concrete flyash %	-	average
			Live load (psf)	-	75
			Category	Insulation	Insulation
			Material	-	Fiberglass Batt
			Thickness	-	6"
			Category	Vapour Barrier	Vapour Barrier
			Material	-	Polyethylene 6 mil
			Thickness	-	-
			Category	-	Roof Envelopes
			Material	-	Standard Modified Bitumen Membrane 2 ply
			Thickness	-	-
		5.1.2 Roof_Concrete_SuspendedSlab_5 "			
		Envelope	Roof Width (ft)	21.49	74.32
			Span (ft)	103.75	30
			Concrete (psi)	3000	3000
			Concrete flyash %	-	average
			Live load (psf)	-	75
			Category	Insulation	Insulation
			Material	-	Fiberglass Batt
			Thickness	-	6"
			Category	Vapour Barrier	Vapour Barrier
			Material	-	Polyethylene 6 mil
			Thickness	-	-
			Category	-	Roof Envelopes

			Material	-	Standard Modified Bitumen Membrane 2 ply
			Thickness	-	-
		5.1.3 Roof_Concrete_SuspendedSlab_7"			
		Envelope	Roof Width (ft)	17.14	17.14
			Span (ft)	20.83	20.83
			Concrete (psi)	3000	3000
			Concrete flyash %	-	average
			Live load (psf)	-	75
			Category	Insulation	Insulation
			Material	-	Fiberglass Batt
			Thickness	-	6"
			Category	Vapour Barrier	Vapour Barrier
			Material	-	Polyethylene 6 mil
			Thickness	-	-
			Category	-	Roof Envelopes
			Material	-	Standard Modified Bitumen Membrane 2 ply
			Thickness	-	-
	5.2 Steel Joist Roof				
		5.2.1 Roof_Steel_Joist_Roof_4"			
		Envelope	Roof Width (ft)	54.07	270.35
			Roof Length (ft)	90	18
			Decking Type	-	None
			Decking Thickness	-	5/8
			Steel Gauge	-	18
			Joist Type	1 5/8 x 6	1 5/8 x 6
			Joist Spacing	16	16
			Category	Insulation	Insulation
			Material	-	Fiberglass Batt
			Thickness	-	6"
			Category	Vapour Barrier	Vapour Barrier
			Material	-	Polyethylene 6 mil
			Thickness	-	-
			Category	-	Roof Envelopes
			Material	-	Standard Modified Bitumen Membrane 2 ply
			Thickness	-	-
		5.2.1 Roof_Steel_Joist_Roof_5"			
			Roof Width (ft)	55.14	320.12
			Roof Length (ft)	104.50	18.00
			Decking Type	-	None
			Decking Thickness	-	5/8
			Steel Gauge	-	18
			Joist Type	1 5/8 x 6	1 5/8 x 6
			Joist Spacing	24	24

		Envelope	Category	Insulation	Insulation
			Material	-	Fiberglass Batt
			Thickness	-	6"
			Category	Vapour Barrier	Vapour Barrier
			Material	-	Polyethylene 6 mil
			Thickness	-	-
			Category	-	Roof Envelopes
			Material	-	Standard Modified Bitumen Membrane 2 ply
			Thickness	-	-
6 Extra Basic Materials					
	6.1				
		6.1.1 XBM_Skylight_Glazing			
			Standard Glazing (sf)	2339.11	2339.11

Appendix B – IE Input Assumptions Document

Assembly Group	Assembly Type	Assembly Name	Specific Assumptions
1 Foundation	The Impact Estimator, SOG inputs are limited to being either a 4” or 8” thickness. Since the actual SOG thicknesses for the LSK building were not exactly 4” or 8” thick, the areas measured in OnScreen required calculations to adjust the areas to accommodate this limitation. The Impact Estimator is limited to inputs of 3000 psi, 4000 psi, or 9000 psi. Where the concrete was found to have a different value than those accepted inputs, the closest value was substituted. The Impact Estimator limits the thickness of footings to be between 7.5” and 19.7” thick. As there are a number of cases where footing thicknesses exceed 19”, their widths were increased accordingly to maintain the same volume of footing while accommodating this limitation. Lastly, the concrete stairs were modelled as footings (ie. Stairs_Concrete_Total). All stairs had the same thickness and width, so the total length of stair was measured and were combined into a single input.		
	1.1 Concrete Slab-on-Grade		
		1.1.1 SOG_3"_3000psi	The area of this slab had to be adjusted so that the thickness fit into the 4" thickness specified in the Impact Estimator. The following calculation was done in order to determine appropriate Length and Width (in feet) inputs for this slab; = sqrt[((Measured Slab Area) x (Actual Slab Thickness))/(4”)] = sqrt[(983 x (3”))/(4”)] = 27.15 feet
		1.1.2 SOG_4"_2000psi	For this slab, 3000 psi was substituted for 2000 psi. The following calculation was done in order to determine appropriate Length and Width (in feet) inputs for this slab; = sqrt(Measured Slab Area) = sqrt(2933) = 54.16 feet
		1.1.3 SOG_4"_3000psi	The following calculation was done in order to determine appropriate Length and Width (in feet) inputs for this slab; = sqrt(Measured Slab Area) = sqrt(17952) = 133.99 feet

		1.1.4 SOG_5"_3000psi	The area of this slab had to be adjusted so that the thickness fit into the 4" thickness specified in the Impact Estimator. The following calculation was done in order to determine appropriate Length and Width (in feet) inputs for this slab; = sqrt[((Measured Slab Area) x (Actual Slab Thickness))/(4”)] = sqrt[(4529 x (5”))/(4”)] = 75.24 feet
		1.1.5 SOG_6"_3000psi	The area of this slab had to be adjusted so that the thickness fit into the 4" thickness specified in the Impact Estimator. The following calculation was done in order to determine appropriate Length and Width (in feet) inputs for this slab; = sqrt[((Measured Slab Area) x (Actual Slab Thickness))/(4”)] = sqrt[(333' x (6”))/(4”)] = 22.35 feet
		1.1.6 SOG_Driveway	Gravel driveway was modeled instead with a slab on grade. Thickness of 4" and 3000 psi concrete assumed. The following calculation was done in order to determine appropriate Length and Width (in feet) inputs for this slab; = sqrt(Measured Slab Area) = sqrt(4421) = 66.49 feet
	1.2 Concrete Footing		
		1.2.1 Footing_1-5	The width of this slab was adjusted to accommodate the Impact Estimator limitation of footing thicknesses to be under 19.7”. The measured length was maintain, thicknesses were set at 19” and the widths were increased using the following calculations; = [(Cited Width) x (Cited Thickness)] / (19”/12) = [(3’) x (21”/12)] / (19”/12) = 3.32 feet

		1.2.4 Footing_109	The width of this slab was adjusted to accommodate the Impact Estimator limitation of footing thicknesses to be under 19.7”. The measured length was maintain, thicknesses were set at 19” and the widths were increased using the following calculations; = [(Cited Width) x (Cited Thickness)] / (19”/12) = [(7’) x (33”/12)] / (19”/12) = 12.16 feet
		1.2.7 Footing_117_118	The width of this slab was adjusted to accommodate the Impact Estimator limitation of footing thicknesses to be under 19.7”. The measured length was maintain, thicknesses were set at 19” and the widths were increased using the following calculations; = [(Cited Width) x (Cited Thickness)] / (19”/12) = [(4.5’) x (20”/12)] / (19”/12) = 4.74 feet
		1.2.9 Footing_15-19	The width of this slab was adjusted to accommodate the Impact Estimator limitation of footing thicknesses to be under 19.7”. The measured length was maintain, thicknesses were set at 19” and the widths were increased using the following calculations; = [(Cited Width) x (Cited Thickness)] / (19”/12) = [(4’) x (21”/12)] / (19”/12) = 4.42 feet
		1.2.10 Footing_16_17_20_21	The width of this slab was adjusted to accommodate the Impact Estimator limitation of footing thicknesses to be under 19.7”. The measured length was maintain, thicknesses were set at 19” and the widths were increased using the following calculations; = [(Cited Width) x (Cited Thickness)] / (19”/12) = [(5’) x (24”/12)] / (19”/12) = 6.32 feet

		1.2.13 Footing_18-22	The width of this slab was adjusted to accommodate the Impact Estimator limitation of footing thicknesses to be under 19.7”. The measured length was maintain, thicknesses were set at 19” and the widths were increased using the following calculations; = [(Cited Width) x (Cited Thickness)] / (19”/12) = [(3.5’) x (21”/12)] / (19”/12) = 3.87 feet
		1.2.14 Footing_2	The width of this slab was adjusted to accommodate the Impact Estimator limitation of footing thicknesses to be under 19.7”. The measured length was maintain, thicknesses were set at 19” and the widths were increased using the following calculations; = [(Cited Width) x (Cited Thickness)] / (19”/12) = [(3.67’) x (21”/12)] / (19”/12) = 4.06 feet
		1.2.17 Footing_29-34	The width of this slab was adjusted to accommodate the Impact Estimator limitation of footing thicknesses to be under 19.7”. The measured length was maintain, thicknesses were set at 19” and the widths were increased using the following calculations; = [(Cited Width) x (Cited Thickness)] / (19”/12) = [(3’) x (21”/12)] / (19”/12) = 3.32 feet
		1.2.18 Footing_3	The width of this slab was adjusted to accommodate the Impact Estimator limitation of footing thicknesses to be under 19.7”. The measured length was maintain, thicknesses were set at 19” and the widths were increased using the following calculations; = [(Cited Width) x (Cited Thickness)] / (19”/12) = [(3.5’) x (21”/12)] / (19”/12) = 3.87 feet

		1.2.22 Footing_32_39	The width of this slab was adjusted to accommodate the Impact Estimator limitation of footing thicknesses to be under 19.7”. The measured length was maintain, thicknesses were set at 19” and the widths were increased using the following calculations; = [(Cited Width) x (Cited Thickness)] / (19”/12) = [(4.5’) x (20”/12)] / (19”/12) = 4.74 feet
		1.2.23 Footing_36	The width of this slab was adjusted to accommodate the Impact Estimator limitation of footing thicknesses to be under 19.7”. The measured length was maintain, thicknesses were set at 19” and the widths were increased using the following calculations; = [(Cited Width) x (Cited Thickness)] / (19”/12) = [(4.75’) x (22”/12)] / (19”/12) = 5.5 feet
		1.2.24 Footing_38	The width of this slab was adjusted to accommodate the Impact Estimator limitation of footing thicknesses to be under 19.7”. The measured length was maintain, thicknesses were set at 19” and the widths were increased using the following calculations; = [(Cited Width) x (Cited Thickness)] / (19”/12) = [(5.25’) x (24”/12)] / (19”/12) = 6.63 feet
		1.2.25 Footing_4-8	The width of this slab was adjusted to accommodate the Impact Estimator limitation of footing thicknesses to be under 19.7”. The measured length was maintain, thicknesses were set at 19” and the widths were increased using the following calculations; = [(Cited Width) x (Cited Thickness)] / (19”/12) = [(2.75’) x (21”/12)] / (19”/12) = 3.04 feet

		1.2.29 Footing_51_60	The width of this slab was adjusted to accommodate the Impact Estimator limitation of footing thicknesses to be under 19.7”. The measured length was maintain, thicknesses were set at 19” and the widths were increased using the following calculations; = [(Cited Width) x (Cited Thickness)] / (19”/12) = [(8.5’) x (30”/12)] / (19”/12) = 13.42 feet
		1.2.30 Footing_52	The width of this slab was adjusted to accommodate the Impact Estimator limitation of footing thicknesses to be under 19.7”. The measured length was maintain, thicknesses were set at 19” and the widths were increased using the following calculations; = [(Cited Width) x (Cited Thickness)] / (19”/12) = [(8.75’) x (37”/12)] / (19”/12) = 17.04 feet
		1.2.32 Footing_54	The width of this slab was adjusted to accommodate the Impact Estimator limitation of footing thicknesses to be under 19.7”. The measured length was maintain, thicknesses were set at 19” and the widths were increased using the following calculations; = [(Cited Width) x (Cited Thickness)] / (19”/12) = [(8’) x (35”/12)] / (19”/12) = 14.74 feet
		1.2.33 Footing_55	The width of this slab was adjusted to accommodate the Impact Estimator limitation of footing thicknesses to be under 19.7”. The measured length was maintain, thicknesses were set at 19” and the widths were increased using the following calculations; = [(Cited Width) x (Cited Thickness)] / (19”/12) = [(5.25’) x (24”/12)] / (19”/12) = 6.63 feet

		1.2.34 Footing_61	The width of this slab was adjusted to accommodate the Impact Estimator limitation of footing thicknesses to be under 19.7”. The measured length was maintain, thicknesses were set at 19” and the widths were increased using the following calculations; = [(Cited Width) x (Cited Thickness)] / (19”/12) = [(8’) x (35”/12)] / (19”/12) = 14.74 feet
		1.2.36 Footing_63	The width of this slab was adjusted to accommodate the Impact Estimator limitation of footing thicknesses to be under 19.7”. The measured length was maintain, thicknesses were set at 19” and the widths were increased using the following calculations; = [(Cited Width) x (Cited Thickness)] / (19”/12) = [(8’) x (35”/12)] / (19”/12) = 14.74 feet
		1.2.37 Footing_64	The width of this slab was adjusted to accommodate the Impact Estimator limitation of footing thicknesses to be under 19.7”. The measured length was maintain, thicknesses were set at 19” and the widths were increased using the following calculations; = [(Cited Width) x (Cited Thickness)] / (19”/12) = [(5.25’) x (24”/12)] / (19”/12) = 6.63 feet
		1.2.40 Footing_71	The width of this slab was adjusted to accommodate the Impact Estimator limitation of footing thicknesses to be under 19.7”. The measured length was maintain, thicknesses were set at 19” and the widths were increased using the following calculations; = [(Cited Width) x (Cited Thickness)] / (19”/12) = [(8’) x (35”/12)] / (19”/12) = 14.74 feet

		1.2.41 Footing_72	The width of this slab was adjusted to accommodate the Impact Estimator limitation of footing thicknesses to be under 19.7”. The measured length was maintain, thicknesses were set at 19” and the widths were increased using the following calculations; = [(Cited Width) x (Cited Thickness)] / (19”/12) = [(7.5’) x (34”/12)] / (19”/12) = 13.42 feet
		1.2.43 Footing_74	The width of this slab was adjusted to accommodate the Impact Estimator limitation of footing thicknesses to be under 19.7”. The measured length was maintain, thicknesses were set at 19” and the widths were increased using the following calculations; = [(Cited Width) x (Cited Thickness)] / (19”/12) = [(7.5’) x (34”/12)] / (19”/12) = 13.42 feet
		1.2.44 Footing_75	The width of this slab was adjusted to accommodate the Impact Estimator limitation of footing thicknesses to be under 19.7”. The measured length was maintain, thicknesses were set at 19” and the widths were increased using the following calculations; = [(Cited Width) x (Cited Thickness)] / (19”/12) = [(5’) x (24”/12)] / (19”/12) = 6.32 feet
		1.2.46 Footing_78_79	The width of this slab was adjusted to accommodate the Impact Estimator limitation of footing thicknesses to be under 19.7”. The measured length was maintain, thicknesses were set at 19” and the widths were increased using the following calculations; = [(Cited Width) x (Cited Thickness)] / (19”/12) = [(7’) x (33”/12)] / (19”/12) = 12.16 feet

		1.2.47 Footing_80_89	The width of this slab was adjusted to accommodate the Impact Estimator limitation of footing thicknesses to be under 19.7”. The measured length was maintain, thicknesses were set at 19” and the widths were increased using the following calculations; = [(Cited Width) x (Cited Thickness)] / (19”/12) = [(7’) x (33”/12)] / (19”/12) = 12.16 feet
		1.2.49 Footing_87	The width of this slab was adjusted to accommodate the Impact Estimator limitation of footing thicknesses to be under 19.7”. The measured length was maintain, thicknesses were set at 19” and the widths were increased using the following calculations; = [(Cited Width) x (Cited Thickness)] / (19”/12) = [(7.5’) x (34”/12)] / (19”/12) = 13.42 feet
		1.2.50 Footing_88_96_103_110	The width of this slab was adjusted to accommodate the Impact Estimator limitation of footing thicknesses to be under 19.7”. The measured length was maintain, thicknesses were set at 19” and the widths were increased using the following calculations; = [(Cited Width) x (Cited Thickness)] / (19”/12) = [(7.75’) x (34”/12)] / (19”/12) = 13.87 feet
		1.2.51 Footing_95_102	The width of this slab was adjusted to accommodate the Impact Estimator limitation of footing thicknesses to be under 19.7”. The measured length was maintain, thicknesses were set at 19” and the widths were increased using the following calculations; = [(Cited Width) x (Cited Thickness)] / (19”/12) = [(7.5’) x (34”/12)] / (19”/12) = 13.42 feet

		1.2.52 Stairs_Concrete_Total	The thickness of the stairs was estimateded to be 15 inches based on the cross-section structural drawings. The following calculation was done in order to determine appropriate Length and Width (in feet) inputs for this footing; = sqrt(Measured Stairs Area) = sqrt(3210) = 56.66 feet
2 Walls	The length of the concrete cast-in-place walls needed adjusting to accommodate the wall thickness limitation in the Impact Estimator. The Impact Estimator is limited to inputs of 3000 psi, 4000 psi, or 9000 psi. Where the concrete was found to have a different value than those accepted inputs, the closest value was substituted. Flyash content was assumed to be average. #5 Rebar was substituted for #4 Rebar since the Impact Estimator for Cast-In-Place Wall assemblies was limited to #5 or #6 rebar. Since interior partition data was not available, the partitions were assumed to be metal stud, with light gauge (25Ga) steel studs at 16" O.C., with a 5/8" Gypsum board on both sides completing the assembly.		
	2.1 Cast In Place		
		2.1.1 Wall_Cast-In-Place_06Thick_1000Height	This wall was reduced by a factor in order to fit the 8” thickness limitation of the Impact Estimator. This was done by reducing the length of the wall using the following equation; = (Measured Length) * [(Cited Thickness)/8”] = (132’) * [(6”)/8”] = 99 feet
		2.1.2 Wall_Cast-In-Place_06Thick_300Height	This wall was reduced by a factor in order to fit the 8” thickness limitation of the Impact Estimator. This was done by reducing the length of the wall using the following equation; = (Measured Length) * [(Cited Thickness)/8”] = (201’) * [(6”)/8”] = 150.75 feet
		2.1.3 Wall_Cast-In-Place_06Thick_700Height	This wall was reduced by a factor in order to fit the 8” thickness limitation of the Impact Estimator. This was done by reducing the length of the wall using the following equation; = (Measured Length) * [(Cited Thickness)/8”] = (22’) * [(6”)/8”] = 16.5 feet

		2.1.13 Wall_Cast-In-Place_10Thick_1000Height	This wall was increased by a factor in order to fit the 8” thickness limitation of the Impact Estimator. This was done by increasing the length of the wall using the following equation; = (Measured Length) * [(Cited Thickness)/8”] = (354’) * [(10”)/8”] = 442.5 feet
		2.1.14 Wall_Cast-In-Place_10Thick_1500Height	This wall was increased by a factor in order to fit the 8” thickness limitation of the Impact Estimator. This was done by increasing the length of the wall using the following equation; = (Measured Length) * [(Cited Thickness)/8”] = (411’) * [(10”)/8”] = 513.75 feet
		2.1.15 Wall_Cast-In-Place_10Thick_500Height	This wall was increased by a factor in order to fit the 8” thickness limitation of the Impact Estimator. This was done by increasing the length of the wall using the following equation; = (Measured Length) * [(Cited Thickness)/8”] = (110’) * [(10”)/8”] = 137.5 feet
		2.1.16 Wall_Cast-In-Place_10Thick_600Height	This wall was increased by a factor in order to fit the 8” thickness limitation of the Impact Estimator. This was done by increasing the length of the wall using the following equation; = (Measured Length) * [(Cited Thickness)/8”] = (62’) * [(10”)/8”] = 77.5 feet
		2.1.17 Wall_Cast-In-Place_10Thick_800Height	This wall was increased by a factor in order to fit the 8” thickness limitation of the Impact Estimator. This was done by increasing the length of the wall using the following equation; = (Measured Length) * [(Cited Thickness)/8”] = (133’) * [(10”)/8”] = 166.25 feet

		2.1.18 Wall_Cast-In-Place_10Thick_803Height	This wall was increased by a factor in order to fit the 8” thickness limitation of the Impact Estimator. This was done by increasing the length of the wall using the following equation; = (Measured Length) * [(Cited Thickness)/8”] = (83’) * [(10”)/8”] = 103.75 feet
		2.1.24 Wall_Cast-In-Place_14Thick_1000Height	This wall was increased by a factor in order to fit the 12” thickness limitation of the Impact Estimator. This was done by increasing the length of the wall using the following equation; = (Measured Length) * [(Cited Thickness)/12”] = (27’) * [(14”)/12”] = 31.5 feet
		2.1.25 Wall_Cast-In-Place_16Thick_1000Height	This wall was increased by a factor in order to fit the 12” thickness limitation of the Impact Estimator. This was done by increasing the length of the wall using the following equation; = (Measured Length) * [(Cited Thickness)/12”] = (43’) * [(16”)/12”] = 57.33 feet
		2.1.26 Wall_Cast-In-Place_18Thick_1000Height	This wall was increased by a factor in order to fit the 12” thickness limitation of the Impact Estimator. This was done by increasing the length of the wall using the following equation; = (Measured Length) * [(Cited Thickness)/12”] = (258’) * [(18”)/12”] = 387 feet
		2.1.27 Wall_Cast-In-Place_18Thick_1500Height	This wall was increased by a factor in order to fit the 12” thickness limitation of the Impact Estimator. This was done by increasing the length of the wall using the following equation; = (Measured Length) * [(Cited Thickness)/12”] = (61’) * [(18”)/12”] = 91.5 feet

		2.1.28 Wall_Cast-In-Place_24Thick_1300Height	This wall was increased by a factor in order to fit the 12” thickness limitation of the Impact Estimator. This was done by increasing the length of the wall using the following equation; = (Measured Length) * [(Cited Thickness)/12”] = (46’) * [(24”)/12”] = 92 feet
		2.1.29 Wall_Cast-In-Place_24Thick_1500Height	This wall was increased by a factor in order to fit the 12” thickness limitation of the Impact Estimator. This was done by increasing the length of the wall using the following equation; = (Measured Length) * [(Cited Thickness)/12”] = (12’) * [(24”)/12”] = 24 feet
		2.1.30 Wall_Cast-In-Place_24Thick_600Height	This wall was increased by a factor in order to fit the 12” thickness limitation of the Impact Estimator. This was done by increasing the length of the wall using the following equation; = (Measured Length) * [(Cited Thickness)/12”] = (59’) * [(24”)/12”] = 118 feet
3 Columns and Beams	The method used to measure column sizing was completely depended upon the metrics built into the Impact Estimator. That is, the Impact Estimator calculates the sizing of beams and columns based on the following inputs; number of beams, number of columns, floor to floor height, bay size, supported span and live load. This being the case, in OnScreen, where no beams were present in the plans, concrete columns were accounted for on each floor, while each floor’s area was measured. The number of beams supporting each floor were assigned an average bay and span size in order to cover the measured area, as seen assumption details below for each input. Since the live loading was not located within the provided building information, a live load of 75psf on all four floors and the basement level were assumed. Where beams were present but of varying length, the bay size was averaged.		
	3.1 Concrete Column		
		3.1.1 Column_Concrete_Basement_1000Height	Because of the variability of bay and span sizes, they were calculated using the following calculation; = sqrt[(Measured Supported Floor Area) / (Counted Number of Columns)] = sqrt[(12066 ft2) / (45)] = 16.37 feet

		3.1.2 Column_Concrete_Basement_300Height	Because of the variability of bay and span sizes, they were calculated using the following calculation; = sqrt[(Measured Supported Floor Area) / (Counted Number of Columns)] = sqrt[(11446 ft2) / (56)] = 14.30 feet
		3.1.3 Column_Concrete_Basement_800Height	Because of the variability of bay and span sizes, they were calculated using the following calculation; = sqrt[(Measured Supported Floor Area) / (Counted Number of Columns)] = sqrt[(1986 ft2) / (12)] = 12.86 feet
		3.1.4 Column_Concrete_Basement_803Height	Because of the variability of bay and span sizes, they were calculated using the following calculation; = sqrt[(Measured Supported Floor Area) / (Counted Number of Columns)] = sqrt[(760 ft2) / (7)] = 10.42 feet
		3.1.5 Column_Concrete_FirstFloor_1500Height	Because of the variability of bay and span sizes, they were calculated using the following calculation; = sqrt[(Measured Supported Floor Area) / (Counted Number of Columns)] = sqrt[(7145 ft2) / (35)] = 14.29 feet
		3.1.6 Column_Concrete_FirstFloor_600Height	Because of the variability of bay and span sizes, they were calculated using the following calculation; = sqrt[(Measured Supported Floor Area) / (Counted Number of Columns)] = sqrt[(16354 ft2) / (53)] = 17.57 feet
		3.1.7 Column_Concrete_FirstFloor_800Height	Because of the variability of bay and span sizes, they were calculated using the following calculation; = sqrt[(Measured Supported Floor Area) / (Counted Number of Columns)] = sqrt[(1963 ft2) / (11)] = 13.36 feet

4 Floors	The Impact Estimator calculated the thickness of the material based on floor width, span, concrete strength, concrete flyash content and live load. The Concrete Suspended Slab group was assumed to have a live load of 75psf. Since the maximum span input for the Impact Estimator for Concrete Suspended Slabs was limited to 30 ft, the width was adjusted accordingly to maintain the same measured area. The Steel Joist Floor was assumed to have a decking thickness of 5/8" (Type: None) and Steel Gauge of 18. Since the maximum length input for the Impact Estimator for Steel Joist Floors was limited to 18 ft, the width was adjusted accordingly to maintain the same measured area.		
	4.1 Concrete Suspended Slab		
		4.1.1 Floor_Concrete_SuspendedSlab_15"	The width of this slab was adjusted to accommodate the Impact Estimator limitation of maximum span to be under 30'. The measured area was maintained, and the width increased with the following calculations; = [(Cited Width) x (Cited Span)] / (30') = [(56.75') x (61.5')] / (30') = 116.34 feet
		4.1.2 Floor_Concrete_SuspendedSlab_4"	The width of this slab was adjusted to accommodate the Impact Estimator limitation of maximum span to be under 30'. The measured area was maintained, and the width increased with the following calculations; = [(Cited Width) x (Cited Span)] / (30') = [(233.72') x (98.25')] / (30') = 765.4 feet
		4.1.3 Floor_Concrete_SuspendedSlab_5"	The width of this slab was adjusted to accommodate the Impact Estimator limitation of maximum span to be under 30'. The measured area was maintained, and the width increased with the following calculations; = [(Cited Width) x (Cited Span)] / (30') = [(32.79') x (100.75')] / (30') = 110.12 feet
		4.1.4 Floor_Concrete_SuspendedSlab_6"	The width of this slab was adjusted to accommodate the Impact Estimator limitation of maximum span to be under 30'. The measured area was maintained, and the width increased with the following calculations; = [(Cited Width) x (Cited Span)] / (30') = [(74.53') x (143.67')] / (30') = 356.92 feet
	4.2 Steel Joist Floor		

		4.2.1 Floor_Steel_Joist_FirstFloor_4"	The width of this slab was adjusted to accommodate the Impact Estimator limitation of maximum length to be under 18'. The measured area was maintained, and the width increased with the following calculations; = [(Cited Width) x (Cited Length)] / (18') = [(18.93') x (21.5')] / (18') = 22.61 feet
		4.2.2 Floor_Steel_Joist_FirstFloor_5"	The width of this slab was adjusted to accommodate the Impact Estimator limitation of maximum length to be under 18'. The measured area was maintained, and the width increased with the following calculations; = [(Cited Width) x (Cited Length)] / (18') = [(18.2') x (20')] / (18') = 22.61 feet
		4.2.3 Floor_Steel_Joist_FourthFloor_4"	The width of this slab was adjusted to accommodate the Impact Estimator limitation of maximum length to be under 18'. The measured area was maintained, and the width increased with the following calculations; = [(Cited Width) x (Cited Length)] / (18') = [(56.36') x (103.17')] / (18') = 323.04 feet
		4.2.4 Floor_Steel_Joist_FourthFloor_5"	The width of this slab was adjusted to accommodate the Impact Estimator limitation of maximum length to be under 18'. The measured area was maintained, and the width increased with the following calculations; = [(Cited Width) x (Cited Length)] / (18') = [(54.13') x (90.5')] / (18') = 272.15 feet

		4.2.5 Floor_Steel_Joist_SecondFloor_4"	The width of this slab was adjusted to accommodate the Impact Estimator limitation of maximum length to be under 18'. The measured area was maintained, and the width increased with the following calculations; = [(Cited Width) x (Cited Length)] / (18') = [(53.86’) x (113.75')] / (18') = 340.37 feet
		4.2.6 Floor_Steel_Joist_SecondFloor_5"	The width of this slab was adjusted to accommodate the Impact Estimator limitation of maximum length to be under 18'. The measured area was maintained, and the width increased with the following calculations; = [(Cited Width) x (Cited Length)] / (18') = [(23.76’) x (41.17')] / (18') = 54.34 feet
		4.2.7 Floor_Steel_Joist_ThirdFloor_4"	The width of this slab was adjusted to accommodate the Impact Estimator limitation of maximum length to be under 18'. The measured area was maintained, and the width increased with the following calculations; = [(Cited Width) x (Cited Length)] / (18') = [(49.19’) x (98.25')] / (18') = 268.5 feet
		4.2.8 Floor_Steel_Joist_ThirdFloor_5"	The width of this slab was adjusted to accommodate the Impact Estimator limitation of maximum length to be under 18'. The measured area was maintained, and the width increased with the following calculations; = [(Cited Width) x (Cited Length)] / (18') = [(56.65’) x (103')] / (18') = 324.16 feet
5 Roof	The live load for the Concrete Suspended Slabs was assumed to be 75 psf. Since the maximum span input for the Impact Estimator for Concrete Suspended Slabs was limited to 30 ft, the width was adjusted accordingly to maintain the same measured area. Roof assembly data was unavailable but insulation was known to be present, so a generic roof assembly was created and used for each roof type. The Roof Envelope was assumed to be Standard Modified Bitumen Membrane 2 ply, the Insulation assumed to be 6" Fiberglass Batt, and the Vapour Barrier assumed to be 6 mil Polyethylene. The assumptions made for the Steel Joist Roof were a decking thickness of 5/8" (Type: None) and Steel Gauge of 18. Since the maximum length input for the Impact Estimator for Steel Joist Roofs was limited to 18 ft, the width was adjusted accordingly to maintain the same measured area.		
	5.1 Concrete Suspended Slab		

		5.1.1 Roof_Concrete_SuspendedSlab_4"	The width of this slab was adjusted to accommodate the Impact Estimator limitation of maximum span to be under 30'. The measured area was maintained, and the width increased with the following calculations; = [(Cited Width) x (Cited Span)] / (30') = [(55.98') x (175.42')] / (30') = 327.33 feet
		5.1.2 Roof_Concrete_SuspendedSlab_5"	The width of this slab was adjusted to accommodate the Impact Estimator limitation of maximum span to be under 30'. The measured area was maintained, and the width increased with the following calculations; = [(Cited Width) x (Cited Span)] / (30') = [(21.49') x (103.75')] / (30') = 74.32 feet
	5.2 Steel Joist Roof		
		5.2.1 Roof_Steel_Joist_Roof_4"	The width of this slab was adjusted to accommodate the Impact Estimator limitation of maximum length to be under 18'. The measured area was maintained, and the width increased with the following calculations; = [(Cited Width) x (Cited Length)] / (18') = [(54.07') x (90')] / (18') = 270.35 feet
		5.2.1 Roof_Steel_Joist_Roof_5"	The width of this slab was adjusted to accommodate the Impact Estimator limitation of maximum length to be under 18'. The measured area was maintained, and the width increased with the following calculations; = [(Cited Width) x (Cited Length)] / (18') = [(55.14') x (104.5')] / (18') = 320.12 feet
6 Extra Basic Materials	Skylight glazing was modeled separately as an extra basic material due to the glazing being angled and not flat against the roof surface. The angle of inclination was estimated to be 45 degrees; thus the measured base area of the glazing multiplied by the square root of 2 (1.41) to account for this.		