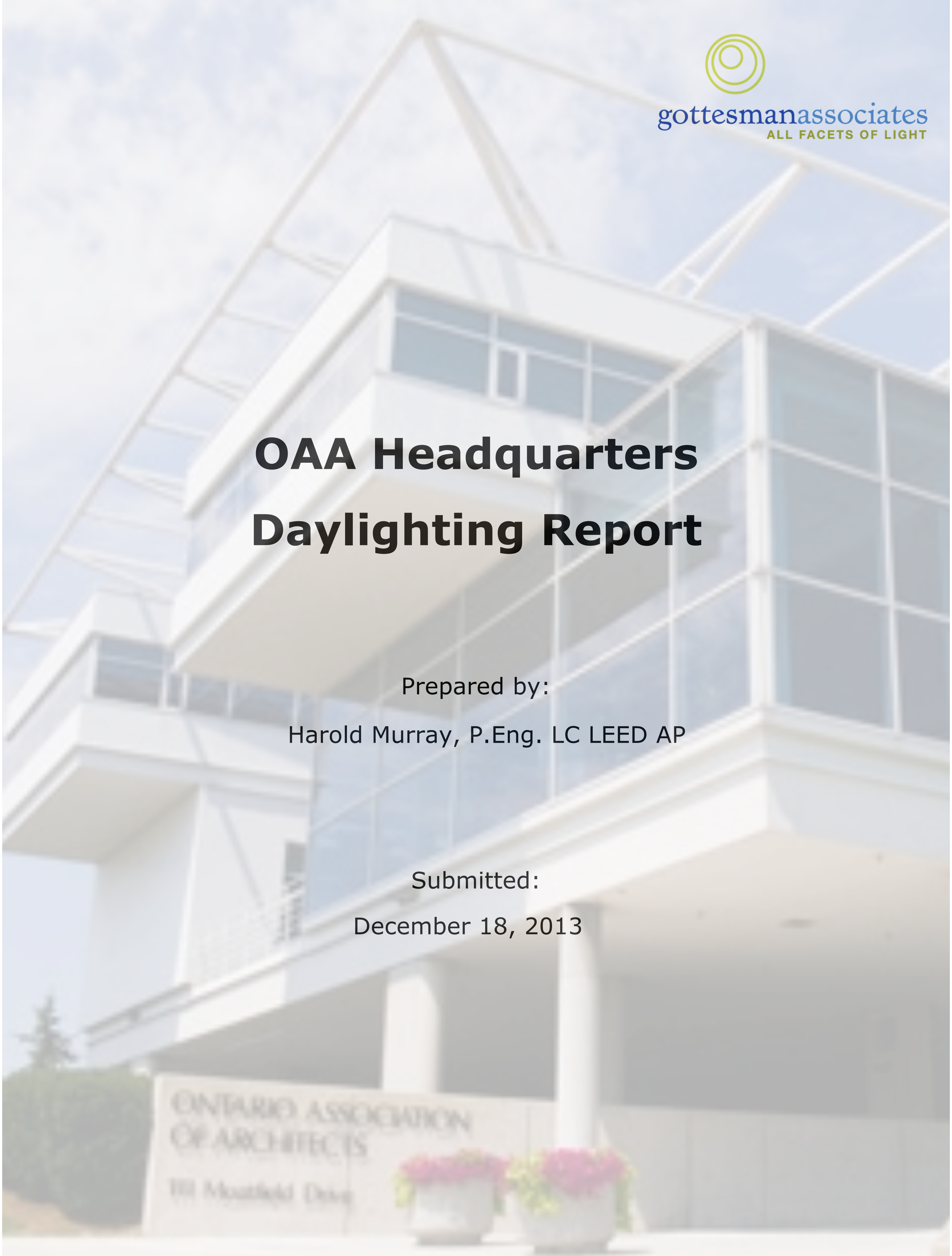
gottesmanassociates
ALL FACETS OF LIGHT



OAA Headquarters Daylighting Report

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Submitted:

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ALL FACETS OF LIGHT

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Executive Summary

The Ontario Association of Architects has undertaken an ambitious project in putting their Headquarters at 111 Moatfield Drive to the 2030 Challenge. Substantial renovations would be required to achieve the goal of net-zero energy use. To this end, a study was undertaken by the OAA Building Committee, and overseen by David Fujiwara, Architect. Sustainable Edge was hired to co-ordinate the mechanical feasibility study with Transsolar Klima Engineering providing the energy and thermal modeling. Gottesman Associates was hired as lighting and daylighting consultant. The study reviewed all potential building improvements and their impact on overall energy consumption. Maintaining the architectural integrity of the building and its appearance was identified as a parallel high priority.

This report covers the Daylighting Study and its conclusions, which have formed an integral part of the overall feasibility study and preliminary design process. There was considerable co-ordination between the disciplines as the daylight, electric light, thermal and energy models were concurrently developed. Details of the daylight modeling and electric lighting and controls design were provided as input to the thermal modeling. There were discussions regarding shading systems options, as required for both daylighting and thermal control. The new electric lighting system was designed with dimming controls to take full advantage of the excellent daylight harvesting potential. The result will be lighting energy use far below current NRCAN and ASHRAE guidelines, and Building Code requirements.

As a part of the Daylighting Study, first the existing building and then six progressively refined whole building renovations were modeled and evaluated with input from the OAA Building Committee, David Fujiwara Architect, Sustainable Edge, and Transsolar Klima Engineering. The results and analyses of these daylight models illustrate the superb daylighting potential of the building as well as its challenges with glare from direct sunlight. Variations on proposed arrays of PV panels on the roof were included in the models. Alternatives for new glazing were modeled. Proposed changes to the floor layouts, with new interior walls reflecting changes to the use and occupancy of the building were also incorporated.

This Daylighting Study concludes that the proposed changes to the glazing and the new exterior shading systems, which will allow the building to meet net-zero energy goals, will still provide good quality interior daylight. The remaining challenge will be controlling glare, particularly around the atrium on the third floor, which is currently used as open concept office space. Given the alternatives, the preferred approach to solving this will be a redesign of the furniture systems and the introduction of additional interior architectural elements.

These renovations when completed will be a major contributor to meeting the 2030 Challenge.

What is Daylighting?

Figure 1: *Daylighting Considerations*

Throughout history daylight has been one of the most powerful forces in human existence. Our ancestors worshipped the sun and with good reason; it provided warmth, allowed our highly evolved visual systems to work effectively, and gave us a sense of time and place. Humans depended upon the sun and solar eclipses were considered a most serious sign of displeasure from the gods.

The human body evolved in a diurnal cycle of light and dark, and is tuned to the daily cycle of the sun. We respond to natural light in many ways; it affects our health and our moods, our interactions with others and is key to performing visual tasks. Most of all daylight is dynamic, varying with time and place.

For those whose living environment has moved predominantly to building interiors, the importance of daylight has not diminished but has sometimes been neglected. For almost all buildings, daylight plays a significant role in the utilitarian as well as aesthetic success of the designed environment. Good design for the introduction of daylight to our interiors is essential to successful architecture. Studies have demonstrated that productivity increases for building occupants who work in daylit areas.

Daylight comes to us in the form of both direct sunlight and diffused skylight, and it is the integration of these two elements that is critical to good daylighting design. Diffuse skylight offers the most effective source of daylighting in buildings as it generally provides more even illumination in the range of light levels ideal for visual tasks. Direct sunlight provides visual and aesthetic interest, but is also often a source of glare which can be both uncomfortable and visually debilitating. Daylighting design becomes then a challenge of letting the right light in, at the right time, and controlling the direct sunlight effectively. Preserving the natural variability of daylight is also important.

Associated with daylighting design is the concept of providing occupants of interior environments with views to the outdoors. Research indicates that visual connections to the outdoors are important factors in occupant satisfaction, productivity and health. Windows and views are highly valued in the workplace. Views to natural vegetation have been found to reduce stress and improve focus and attention. Allowing individuals to control their own lighting and particularly daylighting systems has also proved to be very important to full occupant satisfaction with their working and living environments.

Well-designed daylighting systems can also significantly reduce the need for artificial light and the electrical energy to operate it. Again the key is effective control of the natural and electric lighting such that they are well integrated. Daylight harvesting and the associated dimming of unnecessary electric light, when well executed and combined with occupancy sensing has proven to achieve lighting energy savings of up to 75% and more.

Daylighting Definitions

Light: Electromagnetic radiation which is sensed by the human eye. Scientifically known as *luminous flux*.

Lumens: The measurement used for *luminous flux*, or *light*.

Illuminance: The amount of *light* or *luminous flux* per square meter falling on a surface, measured in *lux* (or per square foot, measured in *footcandles*). This is informally known as "light level".

Sunlight: Direct light from the sun.

Skylight: Light from the sun that has been scattered by the atmosphere. (Also, a window in the roof)

Daylight: The combination of *Sunlight* and *Skylight*. Also called natural light in this report.

Daylight Factor: The daylight illuminance on a surface expressed as a percentage of the external horizontal illumination which would be measured at that same point in space with an unobstructed view of the sky and in the complete absence of the building. Daylight factor excludes direct sunlight and is based on the assumption that the sky is overcast. It does include the effects of ground reflections, interactions with neighbouring buildings and the effects of inter-reflection within the building. Daylight factor provides no measure of how well a system performs in clear sky conditions, particularly with respect to direct sun penetration and glare.

Daylight Autonomy: The portion or fraction of the solar day in which there is adequate daylight in a given space for the required tasks, and hence no supplementary electric light is necessary. The threshold or target light level for daylight autonomy is thus dependent upon the light level required for the given task and will vary from one area to another. *Full daylight autonomy* would thus come from a daylight system that delivers enough natural light to perform the required tasks in the space from dawn to dusk, and no electric lighting would be required during daylight hours. *Partial daylight autonomy* would describe a system that delivers daylight such that some electric light would likely be required for a portion of the solar day.

Continuous Daylight Autonomy: A more sophisticated measure of *Daylight Autonomy* which gives credit for daylight that only partially meets the light level target. It is a useful measure for electric lighting systems that include dimming as it then becomes a good measure of the electrical energy savings possible with *Daylight Harvesting*.

Daylight Harvesting: The dimming of the electric lighting systems in response to the presence of daylight. Typically, dimming begins when light levels exceed the target or threshold set for the required tasks.

Visual Light Transmission (*VLT*): The fraction of the visible portion of the solar spectrum (*Light*) which is transmitted through a window or glazing. Values are a function of glazing properties, thickness, tints and coatings.

Solar Heat Gain Coefficient (*SHGC*): The fraction of solar energy incident on a window that becomes interior heat gain.

An extensive list of references for the daylighting studies and terms quoted above are available in The Lighting Handbook, 10th Edition, published by the Illuminating Engineering Society of North America. ISBN #978-0-87995-241-9

Project Introduction

The Head Office of the Ontario Association of Architects located at 111 Moatfield Drive is an iconic building and represents both a great opportunity and some challenges for effective daylighting and daylighting control. Its site location and orientation allows almost full access to direct sunlight for the entire solar day, for almost the entire calendar year. Natural light provides a unique, invigorating and open atmosphere throughout the building. There are also excellent opportunities for occupant views and connection to the outdoors from most of the interior areas. Given its orientation, extensive glazing, skylighting, layout and openness there is also an excellent opportunity to deliver quality daylight to most of the offices, meeting spaces and critical task areas requiring good lighting.

There are however some real challenges, centered mostly around the control of this ample natural light, which currently creates significant glare conditions in some locations at specific times of day and certain times of the year. This may be the result of spaces being used for purposes not originally as intended and has created some interesting current conditions as illustrated in Figure 2.

There is also an opportunity for more effective control of the electric lighting to maximize energy efficiency, given the ample natural light available.

Figure 2: *Existing 3rd Floor Glare Control Devices*

These opportunities have been analyzed and addressed through daylight modeling and careful collaboration with the architectural and lighting design teams. There are a number of options available for better control of the daylighting through adding interior or exterior architectural/design components. These measures need to be designed to better control both unwanted glare and natural light levels.

As this building is also to be substantially renovated toward a goal of net-zero energy use, all architectural changes proposed for the building (such as PV panels mounted on the steel framework above the roof) were incorporated in to the daylight modeling process.

Good concept design co-ordination with the electric lighting design insures that the entire system and the building are as energy efficient as possible. This project was undertaken knowing the importance of including the daylighting design considerations and simulations very early in the process of considering any proposed building renovations.

Lastly and most importantly, over-riding the entire design process were considerations respecting the original architectural intent of the building. This created constraints and challenges as no structural modifications were to be made unless absolutely necessary and above all the exterior appearance should be kept as close as possible to the original. Adding daylight controlling elements such as light shelves would be difficult for these reasons.

Modeling Phase 1: Daylight Models 1, 2 and 3

Following a Design Charrette with the entire team, the naturally lit portions of the existing building (which represents most of the floor area) were built and modeled with AGi32, using one whole building model as illustrated in Figure 3.

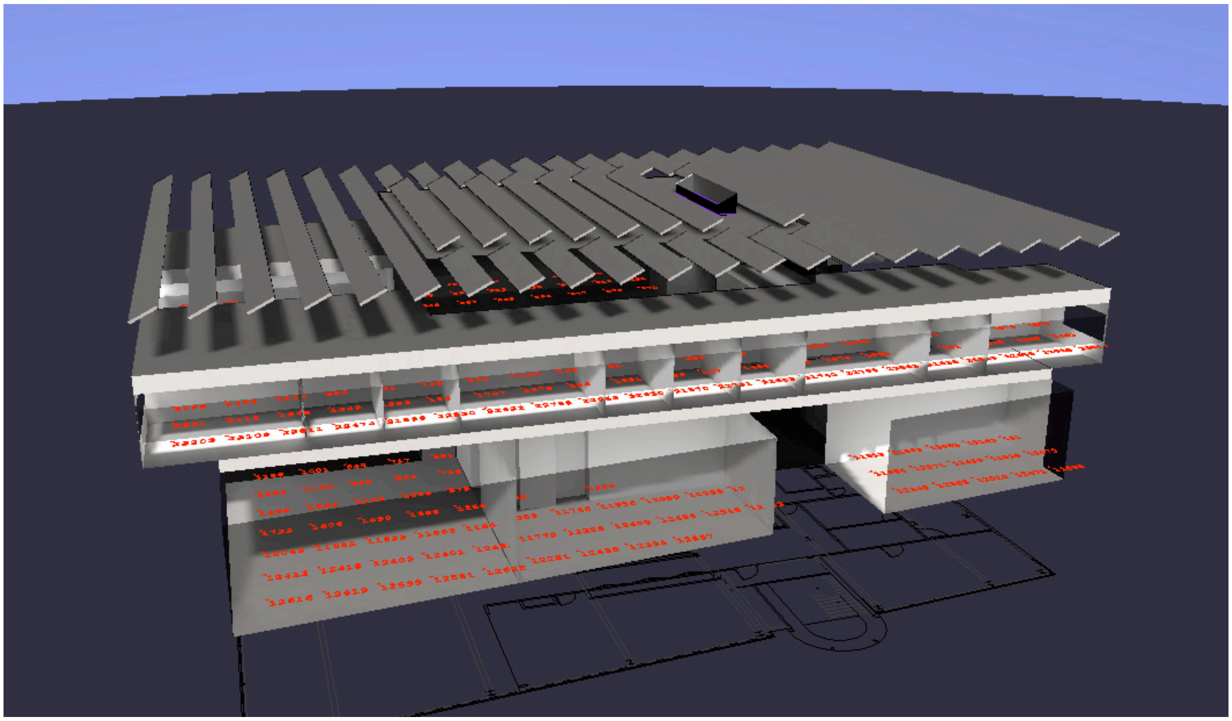


Figure 3: *OAA Head Office with Proposed PV Panels. AGi32 Model with Clear Sky, View from East*

Existing building glazing consisted of four basic types: skylight, clerestory, curtain wall and strip windows, each with distinct transmission features and visual light transmittance values. The strip windows were original to the building (1991) but the other glazing had all been more recently replaced. Assumptions about visual light transmittances were made based on data provided by the architectural and mechanical consultants and the model built accordingly.

The models assume no shading systems for any of the windows, curtain wall, clerestories or skylights and thus represent both the best case for daylight factor and the worst case for glare.

Overcast sky models were simulated and daylight factors were calculated over workplane grids covering all naturally lit spaces. Illumination levels from natural light were also calculated, and renderings created to illustrate a variety of overcast and clear sky conditions.

Clear sky renderings were done for times of the day and year that ray tracing analysis suggested would pose direct glare problems. It was clear from these models that the building has excellent daylight penetration, high daylight factors and considerable daylight autonomy in many areas, but also specific challenges with glare from direct sunlight.

As part of the net zero renovation goals PV panels were proposed for the roof. Based on the preliminary models for the PV panel layouts, two additional daylight models were created and analyzed in the same way as the existing building model, as described above. Several forms for the PV system had been discussed during the design charrette. PV Panels layouts have been included as Appendix 2. The first version of the model (Model #2) with PV panels had gaps between the rows. The Second PV Model (Model #3) had no gaps.

These three models, each with associated daylight simulations for a variety of sky conditions, daylight factor and illumination point arrays were presented to the design team. A summary of the daylight factors calculated and modeling assumptions is included as Figure 4. The following was evident:

- Daylight Autonomy was significantly reduced with a fully opaque PV array.
- All three options would require some glare control.
- The gapped PV array provided the best balance of daylight factor and some glare control.
- Morning and afternoon direct light are a glare issue for the Atrium workspaces, particularly on the third floor.
- Because there are no overhangs or other daylight control features associated with the existing strip windows, daylight factors are very high near the windows and drop off quickly farther in to the building.

OAA Daylighting - Preliminary Model — Daylight Factor Calculations — 6-Aug-13

	Existing Building Conditions				With PV Panels Added (gaps between panels open)				With PV Panels Added (gaps between panels opaque)				
			Extent of Daylight Autonomy				Extent of Daylight Autonomy				Extent of Daylight Autonomy		notes
Space	Average DF	Overcast Sky, Annual Light Level Range	Ambient	Tasks	Average DF	Overcast Sky, Annual Light Level Range	Ambient	Tasks	Average DF	Overcast Sky, Annual Light Level Range	Ambient	Tasks	
Atrium (2nd floor only)	3.5	105 - 700 lux	Fully Autonomous	Partial	2.5	75 - 500 lux	Fully Autonomous	Partial	1.3	40 - 250 lux	Partially Autonomous	Never	
Lounge 211	5.8	175 - 1200 lux	Fully Autonomous	Partial	5.4	160 - 1100 lux	Fully Autonomous	Partial	4.9	150 - 1000 lux	Fully Autonomous	Partial	
Conference 207	4.3	125 - 900 lux	Fully Autonomous	Partial	4.3	125 - 900 lux	Fully Autonomous	Partial	4.3	125 - 900 lux	Fully Autonomous	Partial	
Boardroom 205	4.9	150 - 1000 lux	Fully Autonomous	Partial	4.9	150 - 1000 lux	Fully Autonomous	Partial	4.9	150 - 1000 lux	Fully Autonomous	Partial	
Second Floor West 213	7.2	210 - 1400 lux	Fully Autonomous	Partial	6.7	200 - 1300 lux	Fully Autonomous	Partial	6.4	190 - 1300 lux	Fully Autonomous	Partial	1
Third Floor Office Spaces	5.5	165 - 1100 lux	Fully Autonomous	Partial	4.7	140 - 900 lux	Fully Autonomous	Partial	3.9	120 - 800 lux	Fully Autonomous	Partial	2
Atrium (3rd floor only)	2.5	75 - 500 lux	Fully Autonomous	Partial	1.5	45 - 300 lux	Partially Autonomous	Rarely	1	30 - 200 lux	Partially Autonomous	Never	

Modelling Assumptions

	VLT per specification	Assummed VLT for Model	
Skylight	10.0%	8.0%	
Clerestory Windows	14.8%	13.0%	has 75% frit
Curtain Wall	26.0%	22.0%	
Strip Windows	70.0%	60.0% (typical for double glazed, low E)	

Toronto Overcast Outdoor Annual Illumination Range: 3000 - 20,000 Lux

Task Light Level for Daylight Autonomy: 300 Lux
Ambient Light Level Threshold for Autonomy: 50 to 75 lux

Note 1 windows assumed to be existing strip windows
Note 2 includes points in Atrium space on third floor

Figure 4: *OAA Daylighting - Daylight Factors for Models 1, 2 and 3 with notes on Daylight Autonomy Thresholds*

A copy of this first presentation is included as Appendix 3.

There was discussion about glare control and various options for interior or exterior shading. External roller shades and vegetative screens had been considered in the design charrette. The possibility of glare control for the atrium workspaces achieved through interior architectural features and furniture layout was discussed. For the enclosed offices around the perimeter, the existing interior roller blinds achieve the necessary glare control but do not exclude summer solar gains. For the purposes of personal glare control, it will be important to keep these blinds in place. There was also a discussion about possible changes to the second floor office layout with additional interior walls and partitions and their implications for the lighting and daylighting.

Exterior retractable venetian blinds were demonstrated and discussed. The favoured blinds had perforated aluminum fins and an overall visual light transmittance of 8% in the fully closed position. They fully retract along cables into a housing above the window. Control of the fin angle is automated and all blinds designed to fully retract in high wind conditions.

Modeling Phase 2: Daylight Models 4 through 7

Following this meeting and subsequent discussions centered around the mechanical system modeling, the following parameters were proposed for further daylight modeling:

- Strip Windows would be replaced, with two possible alternatives for SHGC and corresponding VLT, specifically 0.56 and 0.68 for the latter.
- Skylight, Clerestory and Curtain Wall glazing would remain as is.
- Exterior retractable venetian blinds would be used for the strip windows.
- Roller shades would be considered for the curtain wall glazing.
- Clerestory windows may not have shading control.

Based on these parameters, Daylight models 4 and 5 were created, representing the two possible strip window glazing specifications. These models both include the gapped PV panel array mounted on the roof structure, which was favoured following the first review. Refinements to the assumptions about the properties of the glazing that would not be replaced and reflectance properties of other new and existing building features including the PV panel arrays were also made. The new models incorporate these revised visual transmittance and reflectance parameters.

The new office layout was further defined and these changes were incorporated in to revised models #6 and 7. These revised plans have been included as Appendix 4. The revised office layout included new internal walls and partitions on the west side of the second floor. As such, these changes had a significant effect on daylight penetration in to this area and the lower atrium. Daylight factors were correspondingly reduced.

As with the earlier models, models 4 through 7 assume no shading systems for the windows, curtain wall, clerestories or skylight and thus represent both the best case for daylight factor and the worst case for glare. Daylight factors were again calculated over workplane grids covering all naturally lit spaces. Renderings were created to illustrate a variety of overcast sky situations around the building perimeter and in to the interior. Particular attention was again paid to the Atrium area.

The daylight factors of models 6 and 7, defined for each building zone, were then used in combination with the electric lighting loads estimated for the new lighting design and the lighting control system details, for the purposes of building energy modeling. The Thermal Building Modeling Consultants were thus able to estimate annual electrical lighting loads for the entire building. A summary of the daylight factors calculated for models 6 and 7 and used as input to the overall energy models is included as Figure 5. A table outlining the new electrical lighting energy density estimates and controls design is included as Figure 6.

OAA Daylighting - Models with revised 2nd floor office layout and new strip windows

Daylight Factor Calculations 21-Aug-13

		Model 6: Strip Window Spec VLT of 56%					Model 7: Strip Window Spec VLT of 68%					
Space/Zone	Room(s) Included	Average DF	Min DF	Max DF	# Points	% of points over 2% DF	Average DF	Min DF	Max DF	# Points	% of points over 2% DF	notes
Atrium - Second Floor	212	1.2	1	2	126	15%	1.2	1	2	126	15%	
Lounge	211	4.5	1	11	35	97%	4.5	1	11	35	97%	
Conference	207	4.4	1	9	17	94%	4.4	1	9	17	94%	
Boardroom	205	5.3	2	9	15	100%	5.3	2	9	15	100%	
Second Floor West	213, 214, 215, 216	3.3	0	14	281	58%	4.0	0	17	281	62%	
Third Floor East Office Spaces	303A, 303B, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, 340, 339A	3.9	0	19	314	60%	4.6	0	22	314	64%	1
Third Floor West Office Spaces	315, 316, 317, 318, 319, 320, 341, 321A, 321B, 322, 323, 324, 325, 326, 327, 328, 342A	3.9	0	19	314	62%	4.6	0	23	314	64%	1

Modelling Assumptions

	VLT per specification	VLT used for Model 6	VLT used for Model 7
Skylight	10.0%	8.5%	8.5%
Clerestory Windows	20.0%	17.0%	17.0%
Curtain Walls	25.8%	22.0%	22.0%
Second Floor Strip Windows	56% (Model 6), 68% (Model 7)	48.0%	58.0%
Third Floor Strip Windows	56% (Model 6), 68% (Model 7)	43.0%	52.0%

Note 1 includes points in Atrium space on third floor

General Notes
- model VLT values include a 5% depreciation factor and a 10% loss factor for the window and curtain wall mullions. Overall model window sizes are (approximately) actual. On the Third floor, the mullion factor has been increased to 20% for the strip windows because of their geometry and operability.
- no consideration has been made for the daylighting effects of external shading devices, other than the PV panels. These models assume that any external blinds on the strip windows and/or shades on the curtain walls would be in the retracted position.

Figure 5: *OAA Daylighting - Daylight Factors for Models 6 and 7*

OAA HEADQUARTERS
Electrical Lighting - Estimated connected load
August 29, 2013

Space/Zone	Rm. #s	Watts/Sq m. HI*	Watts/Sq m. LO	**Proposed Control Devices	**Proposed Control Strategy
Atrium 2nd and 3rd Floors	212	9.3	6.5	time clock, daylight sensor	daylight harvesting target of maximum 150 lux during business hours, otherwise OFF
Lounge	211	9.4	6.0	occupancy sensor, daylight sensor	daylight harvesting target of 100 lux during business hours, otherwise OFF
Conference	207	13.2	7.0	occupancy sensor, daylight sensor, keypad dimming & on/off control	Manual on. Automatic and Manual Off. Daylight harvesting to 300 lux on table top when occupied.
Boardroom	205	13.2	8.5	occupancy sensor, daylight sensor, keypad dimming & on/off control	Manual on. Automatic and Manual Off. Daylight harvesting to 300 lux on table top when occupied.
2nd Floor Private Offices (4.265m ceiling height)	214, 215, 216, New offices	11.9	7.0	occupancy sensor, daylight sensor, wallbox dimmer, desktop/PDA control	Manual on. Automatic and Manual Off. Daylight harvesting to 300 lux on desk top when occupied.
3rd Floor Private Offices (2.9m ceiling height)	302, 303A, 303B, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, 340, 339A, 315, 316, 317, 318, 319, 320, 341, 321A, 321B, 322, 323, 324, 325, 326, 327, 328, 342A	11.9	6.0	occupancy sensor, daylight sensor, wallbox dimmer, desktop/PDA control	Manual on. Automatic and Manual Off. Daylight harvesting to 300 lux on desk top when occupied.
3rd floor Open Offices (around Atrium)	339a, 342a, 342b	11.0	6.0	occupancy sensor, daylight sensor, desktop/PDA control	Daylight harvesting to 300 lux on desk when occupied, minimum level 50 lux when occupied.
Corridor/transition spaces	226, @ new Offices 2nd flr, 337, 338, 340, 341, 343, 345, 346	8.4	5.0	occupancy sensor, daylight sensor (where appropriate)	Min. level of 10 lux , daylight harvest to 50 lux when occupied.

***"HI" W/Sm is energy density limit as prescribed by the National Energy Code of Canada for Buildings 2011, NRC**
****Proposed control devices and strategies are for specific space. A building lighting control & dimming system is proposed to control the overall system.**

Figure 6: *Estimated Electrical Lighting Connected Loads*

Models 6 and 7 were also extensively evaluated under clear sky conditions. Clear sky illumination levels were calculated, and renderings created to illustrate a variety of clear sky situations. Further ray tracing analysis, continuing from what was started with the earlier models, was done and clear sky renderings were simulated for times of the day and year that direct glare problems would be expected. This analysis was then further refined for the areas with glare and hour by hour simulations done to illustrate the situation.

The results of Models 6 and 7 were presented to the design team, with particular emphasis on the clear sky simulations and renderings which illustrate the glare challenges for the proposed renovation, with the gapped PV array. The following was discussed:

- The Daylight factors for the second floor west offices were reduced with the new office layout.
- The high new performance windows would reduce the third floor perimeter office daylight factors slightly, but would still be very high overall.
- Focus on glare issues: primary concern is direct light coming through clerestory windows, secondary concern is direct light through south facing curtain wall.
- Summertime is worst case for direct sunlight slipping between PV panel arrays from east or west; there are two morning conditions where glare through the clerestories would reach the open offices on the third floor atrium.
- There are parallel conditions again in the afternoon with direct light now coming through the west facing clerestory.
- Analysis and simulations indicate that this situation will happen for several months over Spring and Summer, although the time of day will shift. This is not just a summer solstice "Stonehenge Event".
- There is a similar situation for the third floor perimeter offices looking out over the terrace, but these offices have internal blinds to eliminate the glare when necessary.
- There is also a short period of time in the morning when direct light coming through the east clerestories will reach the reconfigured spaces on the west side of the second floor.
- Analysis suggests that high angle midsummer direct light coming in between the PV panels and through the south facing clerestory and curtain wall will not cause significant glare problems.
- Winter mornings analysis illustrated a concern for low angle light coming under the PV panels and through south facing curtain wall, with conditions simulated through November and December.
- Simulations suggest that only around winter solstice and for a very limited time will this result in potential glare issues (a winter solstice "Stonehenge Event" only).
- The sun angle at this time is very low and glare for the atrium offices could be eliminated with good furniture design and layout.
- The gaps between the PV panels will create a striped effect on the second floor atrium floor for much of the year.

A copy of this presentation is included as Appendix 5.

Options for dealing with the glare conditions were discussed. The main issue will be direct sunlight coming through the east and west clerestory windows.

Alternatives, to be used alone or in combination, include:

1. External:
- Fixed metal louvers on underside of steel roof framework
- Roller blinds for clerestory windows
- Retractable venetian blinds for clerestory windows, as proposed for the strip windows

2. Internal:
- Roller blinds for clerestory windows
- Redesign of workstations on third floor atrium with additional architectural elements to block direct sunlight.

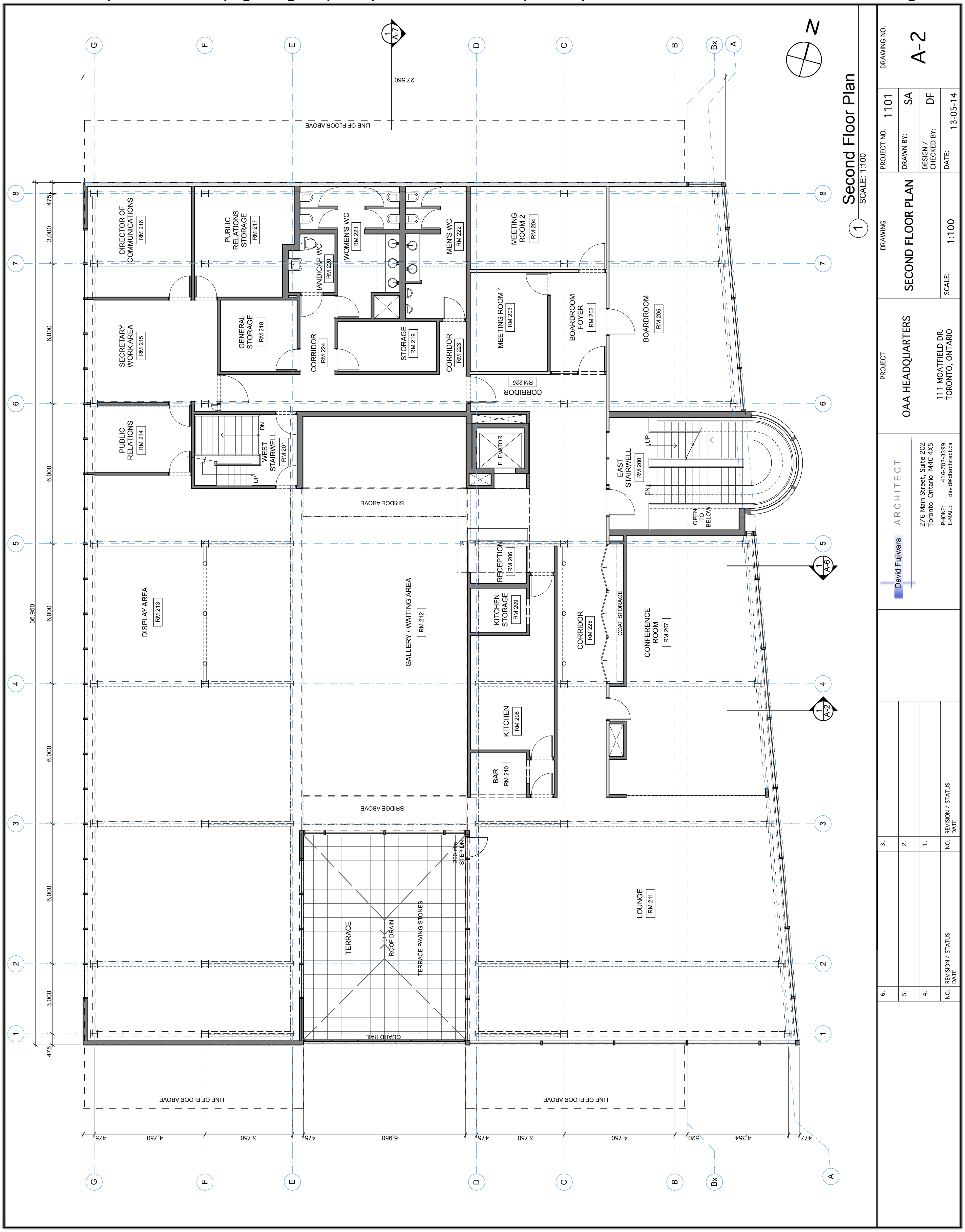
These alternatives represent a wide range of solutions. It has been noted that the original building model (currently on display at the bottom of the stairs, inside the parking level main entrance doorway) includes louvers mounted on the steel framework above the roof and this informed the suggestion to add similar panels, in harmony with the original architectural intent. Subsequent analysis of this concept however indicated that the louvers would have to be quite large and deep for full glare control at low sun angles.

Individual control of the shading system elements would be ideal. There are also thermal considerations; it is desirable to block the sunlight externally during the cooling season to reduce solar gains. A solution enabling individual control would favor an internal architectural/workstation design while the thermal considerations during the cooling season would favor exterior blinds or roller shades. Other factors to consider for managing glare include aesthetics, architectural integrity, cost and ease of maintenance. With the exception of the summer solar loading, carefully redesigned workstations with additional internal architectural elements would be attractive from the perspective of all of these considerations.

About the Modeling Tools

Daylight Models for this project were done with AGi32, a simulation program capable of modeling and rendering both natural and electric light sources in interior and exterior environments. It calculates point by point illumination values, based on the light properties of all architectural elements in the interior space and a sophisticated sky model for the daylight component. In can also model the effects of exterior and neighbouring building elements. The model requires that each and every architectural surface be specifically defined with both geometric and photometric properties in order to calculate lighting performance, and both direct and reflected light components are calculated. For daylight factor calculations, an overcast sky model is used. More information about the program is available at the Lighting Analysts Website: www.agi32.com

Appendix 1: Architectural Drawings


Second Floor Plan
SCALE: 1:100
SECOND FLOOR PLAN
A-2
PROJECT NO. 1101
DRAWN BY: SA
DESIGN / CHECKED BY: DF
DATE: 13-05-14
SCALE: 1:100
OAA HEADQUARTERS
111 MOATFIELD DR.
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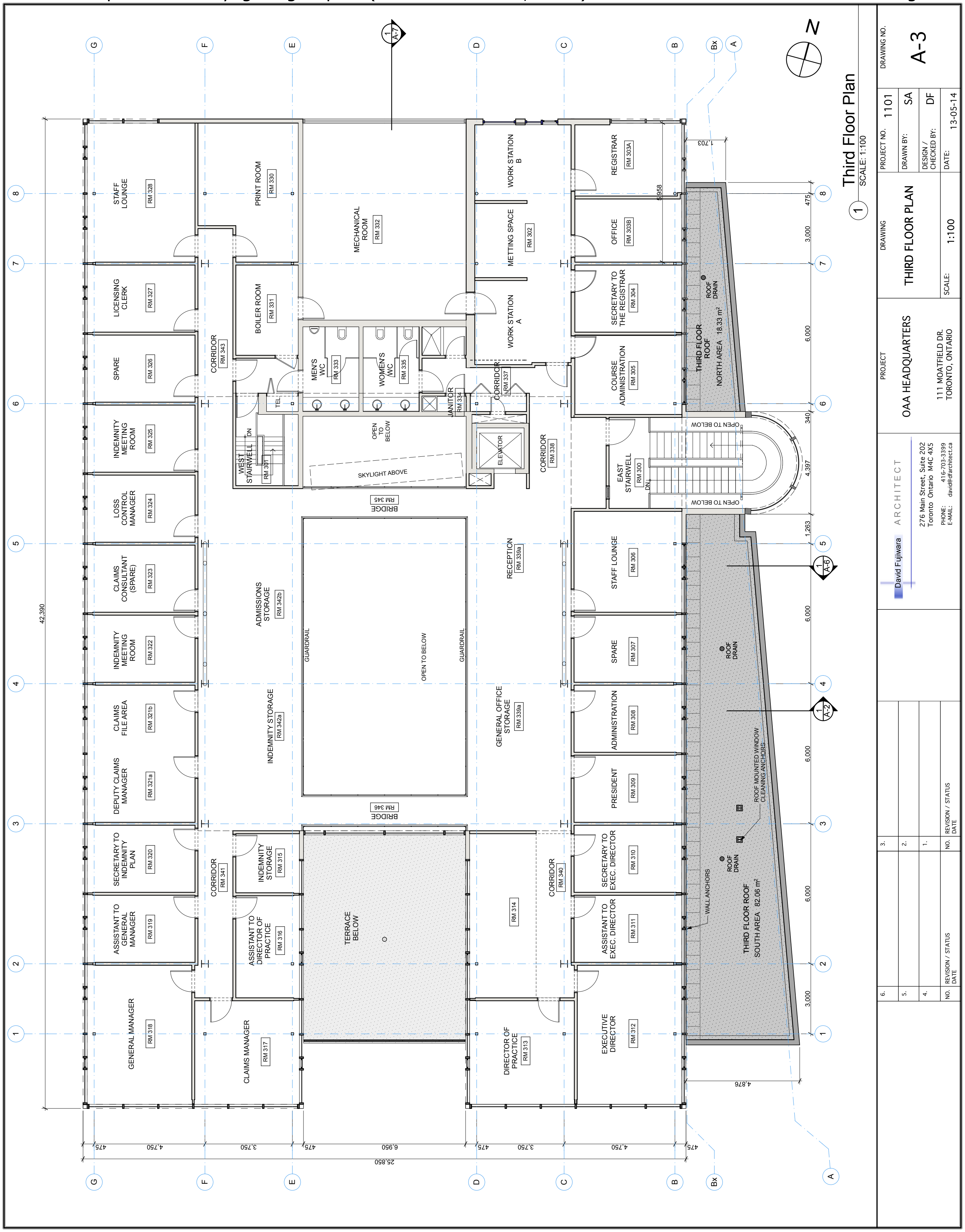
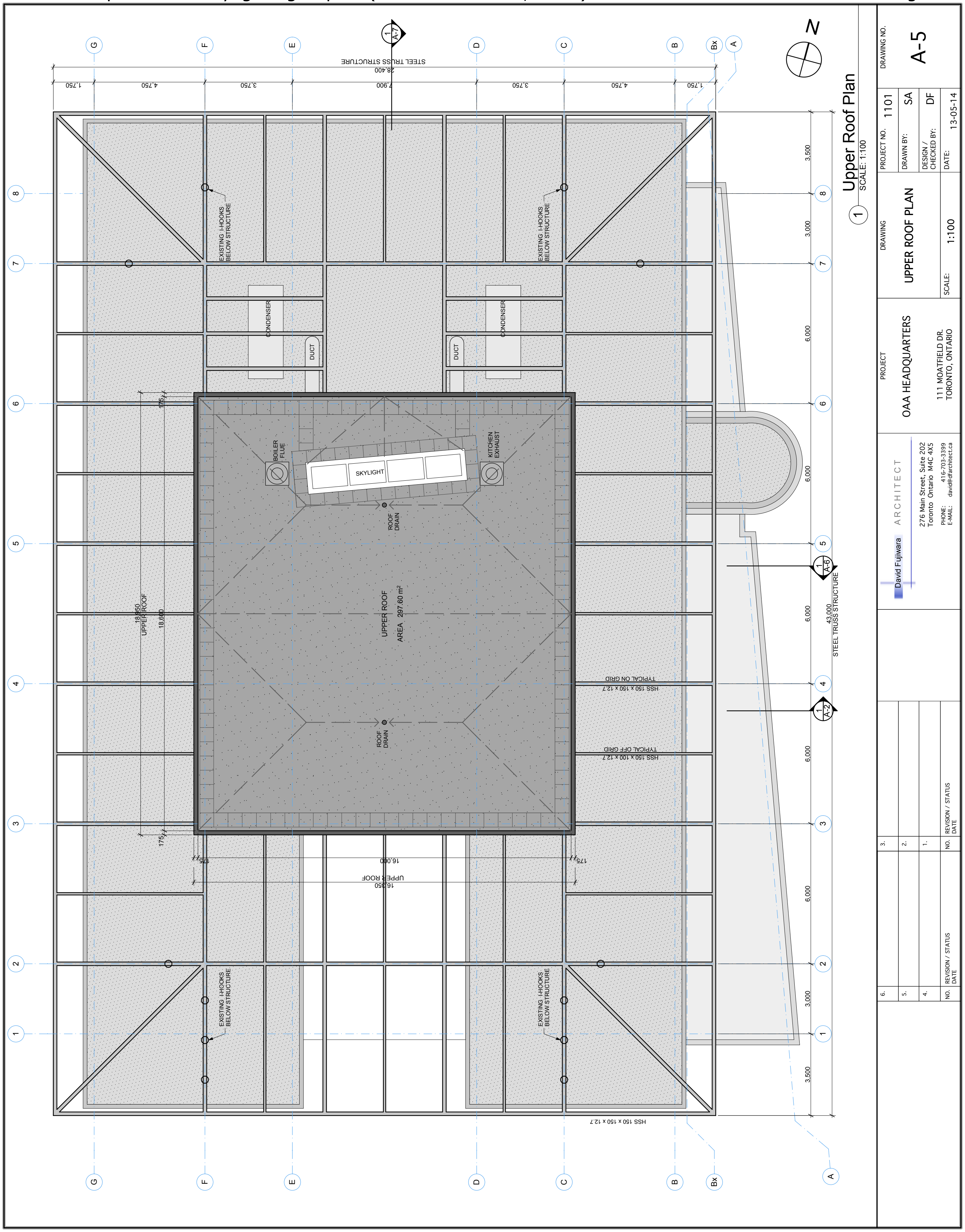
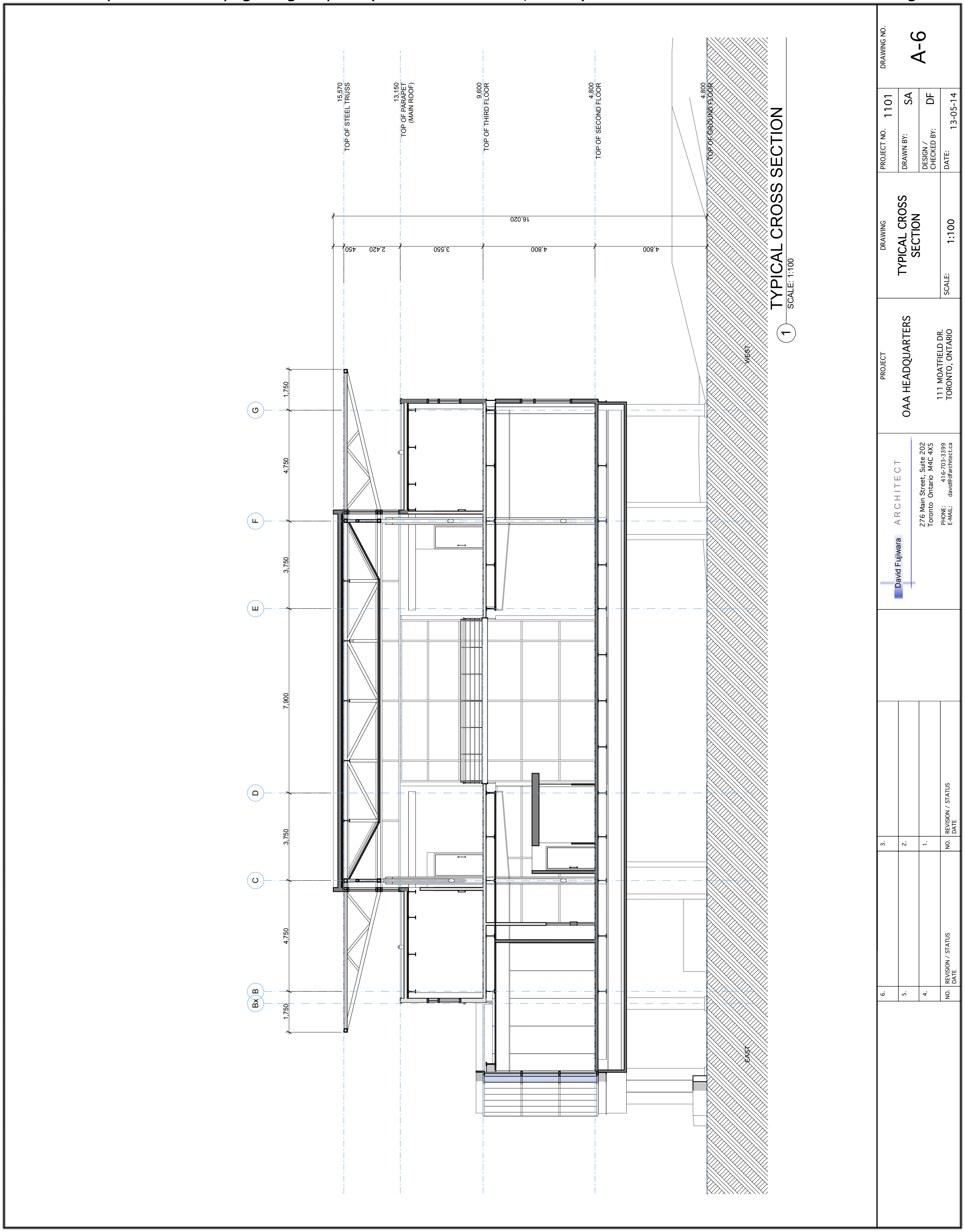
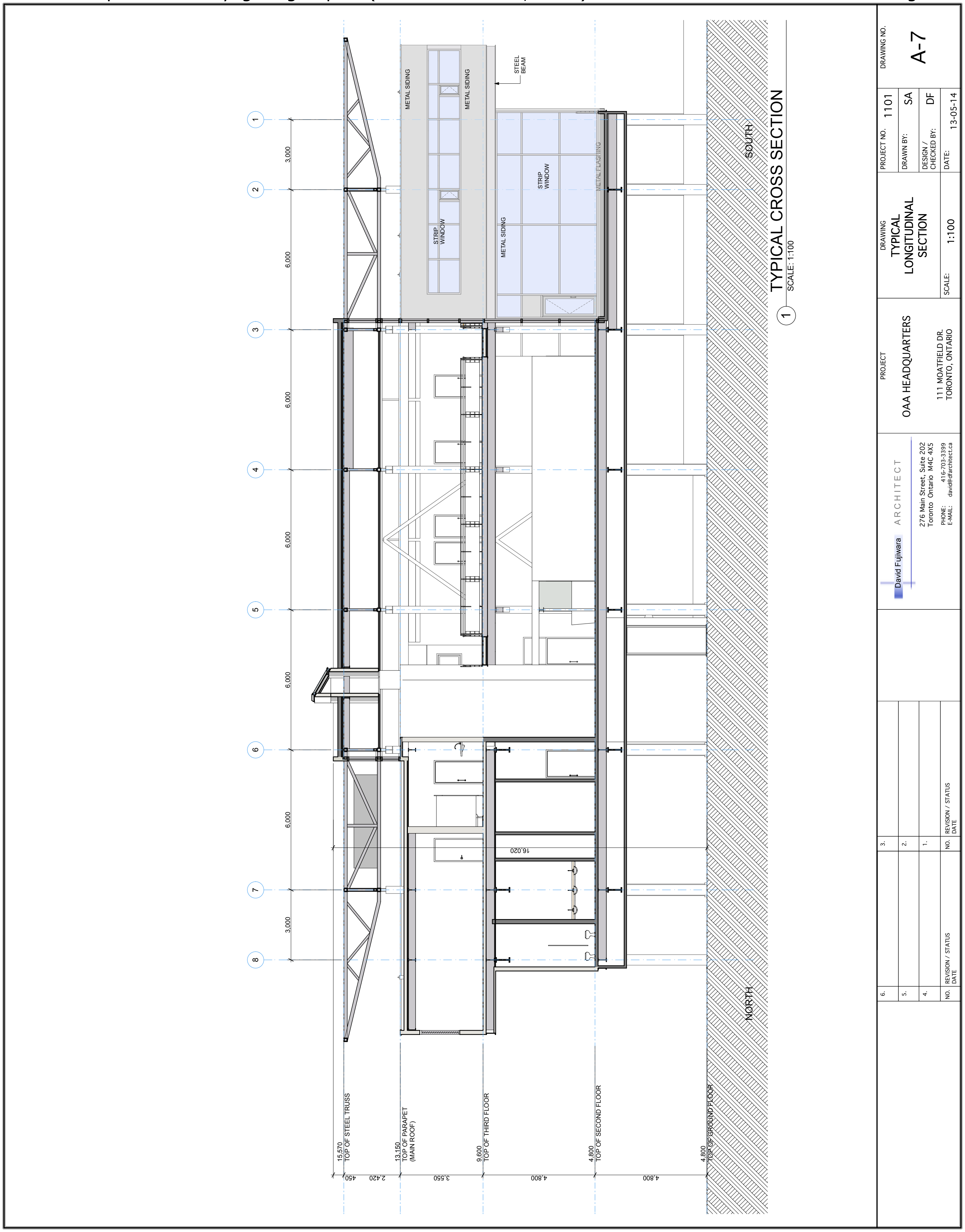
Toronto Ontario M4C 4X5
DISPLAY AREA RM 213
GALLERY / WAITING AREA RM 212
TERRACE
LOUNGE RM 211
CONFERENCE ROOM RM 207
BOARDROOM RM 205
EAST STAIRWELL RM 200
WEST STAIRWELL RM 201
KITCHEN RM 208
BAR RM 210
RECEPTION RM 206
KITCHEN STORAGE RM 209
CORRIDOR RM 226
COAT STORAGE
MEETING ROOM 1 RM 203
MEETING ROOM 2 RM 204
BOARDROOM FOYER RM 202
CORRIDOR RM 225
MEN'S WC RM 222
WOMEN'S WC RM 221
HANDICAP WC RM 220
STORAGE RM 219
CORRIDOR RM 223
CORRIDOR RM 224
GENERAL STORAGE RM 218
PUBLIC RELATIONS STORAGE RM 217
DIRECTOR OF COMMUNICATIONS RM 216
SECRETARY WORK AREA RM 215
PUBLIC RELATIONS RM 214
ELEVATOR
BRIDGE ABOVE
LINE OF FLOOR ABOVE
GUARD RAIL
ROOF DRAIN
TERRACE PAVING STONES

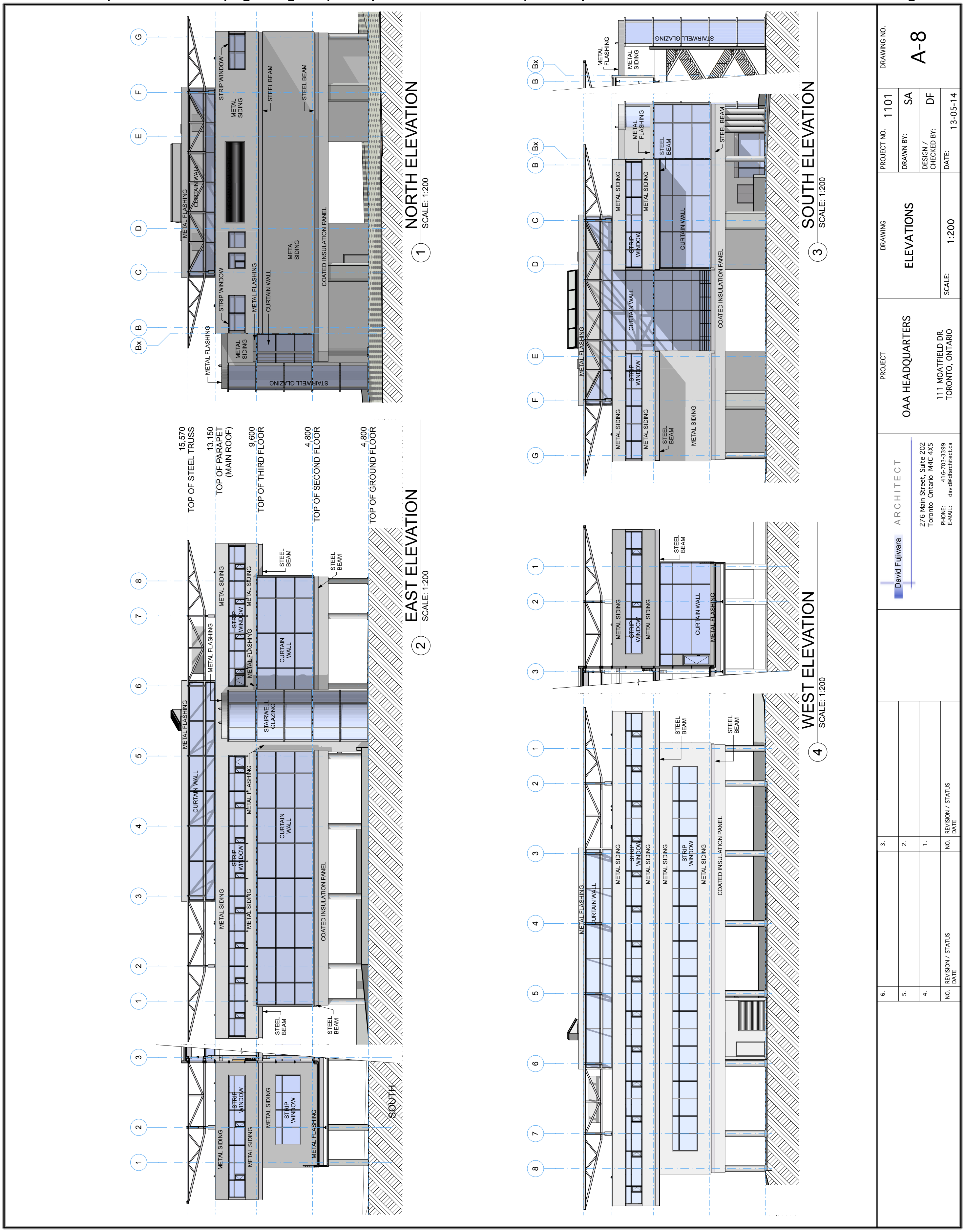

Third Floor Plan
SCALE: 1:100
THIRD FLOOR PLAN
OAA HEADQUARTERS
111 MOATFIELD DR.
TORONTO, ONTARIO
1:100
A-3


Upper Roof Plan
SCALE: 1:100
STEEL TRUSS STRUCTURE
28,400
1,750
4,750
3,750
7,900
43,000
STEEL TRUSS STRUCTURE
3,500
3,000
6,000
EXISTING I-HOOKS BELOW STRUCTURE
CONDENSER
DUCT
BOILER FLUE
KITCHEN EXHAUST
SKYLIGHT
ROOF DRAIN
UPPER ROOF
AREA 297.60 m²
18,950
UPPER ROOF
18,600
175
16,000
UPPER ROOF
16,350
TYPICAL ON GRID
HSS 150 x 150 x 12.7
TYPICAL OFF GRID
HSS 150 x 100 x 12.7
HSS 150 x 150 x 12.7
David Fujiwara
ARCHITECT
276 Main Street, Suite 202
Toronto Ontario M4C 4X5
PHONE: 416-703-3399
E-MAIL: david@dfarchitect.ca
PROJECT
OAA HEADQUARTERS
111 MOATFIELD DR.
TORONTO, ONTARIO
DRAWING
UPPER ROOF PLAN
SCALE: 1:100
PROJECT NO. 1101
DRAWN BY: SA
DESIGN / CHECKED BY: DF
DATE: 13-05-14
DRAWING NO.
A-5
NO. REVISION / STATUS DATE



TYPICAL CROSS SECTION
SCALE: 1:100
1
15,570 TOP OF STEEL TRUSS
13,150 TOP OF PARAPET (MAIN ROOF)
9,600 TOP OF THIRD FLOOR
4,800 TOP OF SECOND FLOOR
4,800 TOP OF GROUND FLOOR
16,020
450
2,420
3,550
4,800
4,800
WEST
EAST
G
F
E
D
C
B
Bx
1,750
4,750
3,750
7,900
3,750
4,750
1,750
DRAWING NO.
A-6
PROJECT NO. 1101
DRAWN BY: SA
DESIGN / CHECKED BY: DF
DATE: 13-05-14
DRAWING
TYPICAL CROSS SECTION
SCALE: 1:100
PROJECT
OAA HEADQUARTERS
111 MOATFIELD DR.
TORONTO, ONTARIO
David Fujiwara ARCHITECT
276 Main Street, Suite 202
Toronto Ontario M4C 4X5
PHONE: 416-703-3399
E-MAIL: david@dfarchitect.ca
NO. REVISION / STATUS DATE


TYPICAL CROSS SECTION
SCALE: 1:100
SOUTH
NORTH
METAL SIDING
STRIP WINDOW
METAL FLASHING
STEEL BEAM
15,570 TOP OF STEEL TRUSS
13,150 TOP OF PARAPET (MAIN ROOF)
9,600 TOP OF THIRD FLOOR
4,800 TOP OF SECOND FLOOR
4,800 TOP OF GROUND FLOOR
16,020
3,000
6,000
450
2,420
3,550
4,800
DRAWING NO.
A-7
PROJECT NO. 1101
DRAWN BY: SA
DESIGN / CHECKED BY: DF
DATE: 13-05-14
DRAWING
TYPICAL LONGITUDINAL SECTION
SCALE: 1:100
PROJECT
OAA HEADQUARTERS
111 MOATFIELD DR.
TORONTO, ONTARIO
David Fujiwara ARCHITECT
276 Main Street, Suite 202
Toronto Ontario M4C 4X5
PHONE: 416-703-3399
E-MAIL: david@dfarchitect.ca
NO. REVISION / STATUS DATE


1 NORTH ELEVATION
SCALE: 1:200
2 EAST ELEVATION
SCALE: 1:200
3 SOUTH ELEVATION
SCALE: 1:200
4 WEST ELEVATION
SCALE: 1:200
15,570 TOP OF STEEL TRUSS
13,150 TOP OF PARAPET (MAIN ROOF)
9,600 TOP OF THIRD FLOOR
4,800 TOP OF SECOND FLOOR
4,800 TOP OF GROUND FLOOR
METAL SIDING
METAL FLASHING
STRIP WINDOW
CURTAIN WALL
STEEL BEAM
STAIRWELL GLAZING
COATED INSULATION PANEL
MECHANICAL VENT
SOUTH
David Fujiwara ARCHITECT
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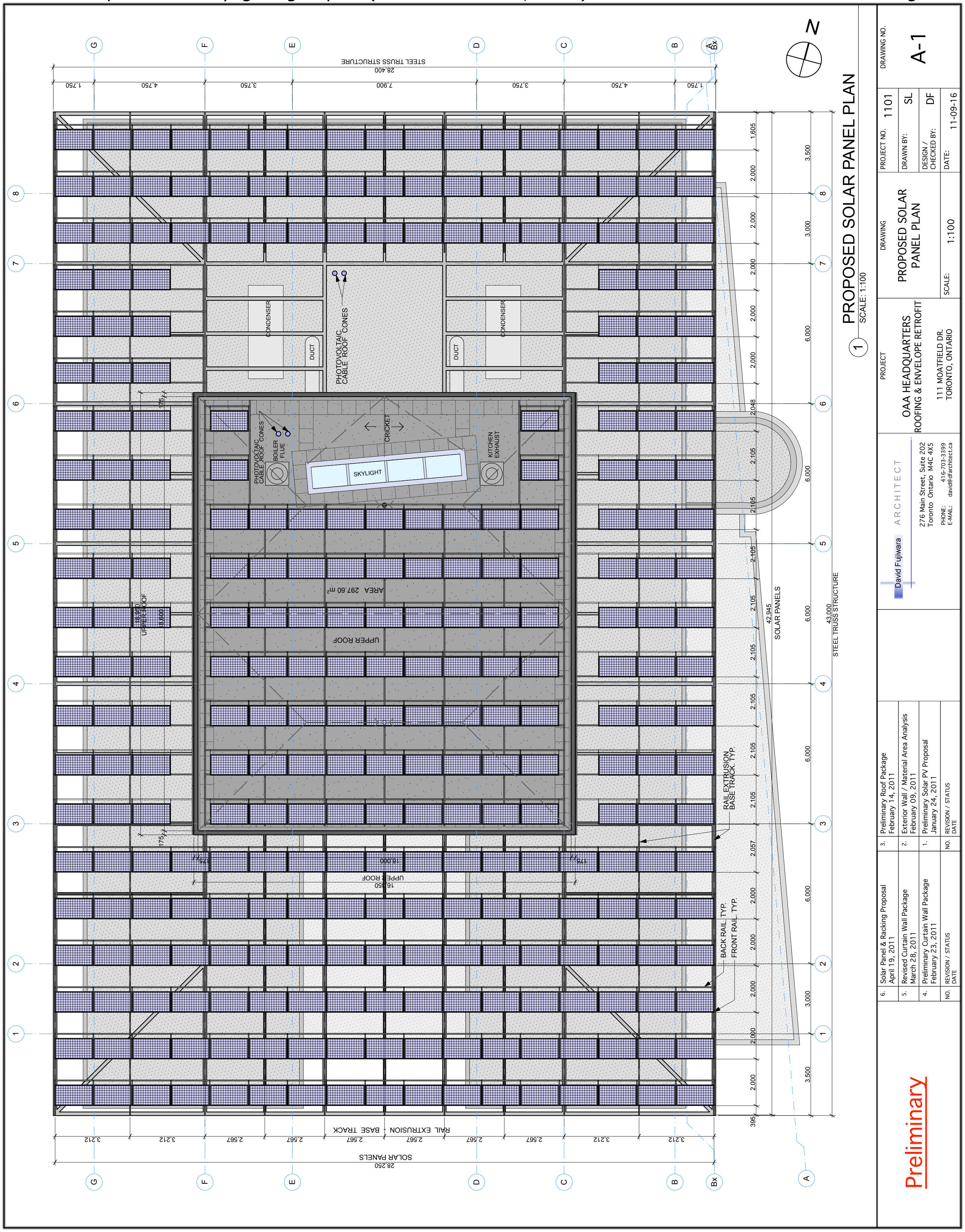
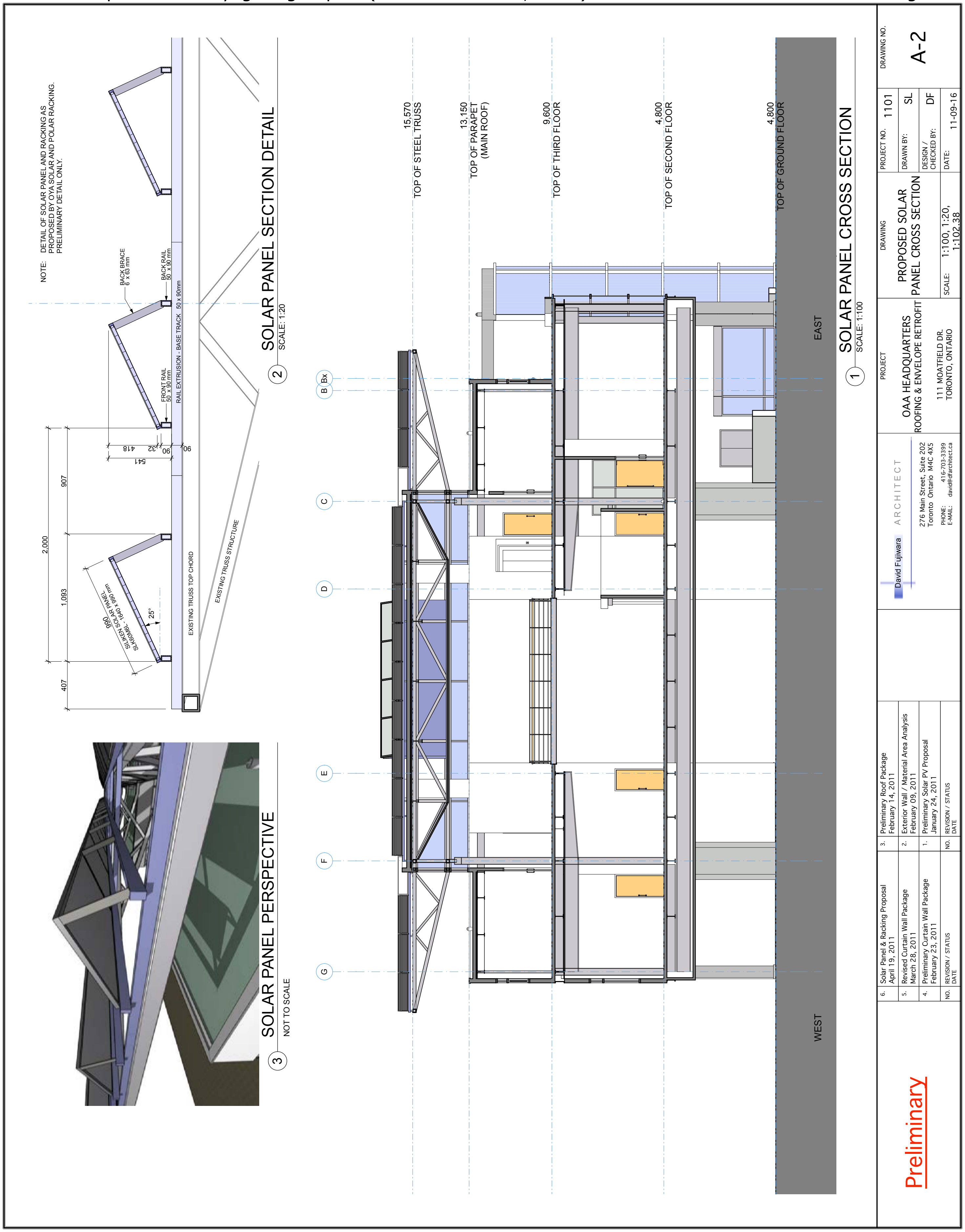
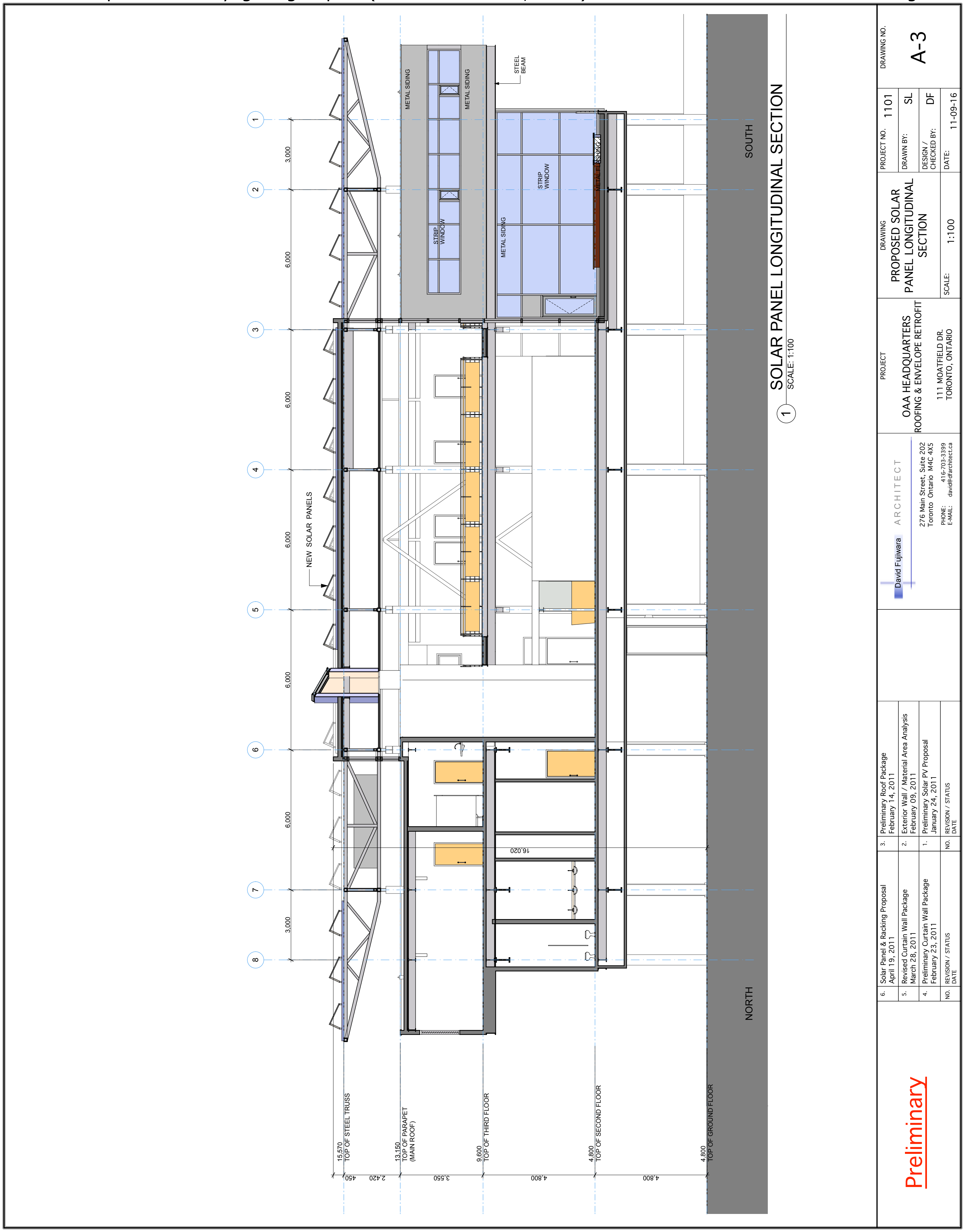
E-MAIL: david@dfarchitect.ca
PROJECT
OAA HEADQUARTERS
111 MOATFIELD DR.
TORONTO, ONTARIO
DRAWING
ELEVATIONS
SCALE: 1:200
PROJECT NO. 1101
DRAWN BY: SA
DESIGN / CHECKED BY: DF
DATE: 13-05-14
DRAWING NO.
A-8
NO. REVISION / STATUS DATE

Appendix 2: PV Panel Layouts


PROPOSED SOLAR PANEL PLAN
SCALE: 1:100
SKYLIGHT
CRICKET
UPPER ROOF
AREA 297.60 m²
CONDENSER
DUCT
PHOTOVOLTAIC CABLE ROOF CONES
BOILER FLUE
KITCHEN EXHAUST
RAIL EXTRUSION BASE TRACK, TYP.
BACK RAIL, TYP.
FRONT RAIL, TYP.
STEEL TRUSS STRUCTURE
SOLAR PANELS
RAIL EXTRUSION - BASE TRACK
PROJECT
OAA HEADQUARTERS
ROOFING & ENVELOPE RETROFIT
111 MOATFIELD DR.
TORONTO, ONTARIO
David Fujiwara
ARCHITECT
276 Main Street, Suite 202
Toronto Ontario M4C 4X5
PHONE: 416-703-3399
E-MAIL: david@dfarchitect.ca
DRAWING
PROPOSED SOLAR PANEL PLAN
SCALE: 1:100
PROJECT NO. 1101
DRAWN BY: SL
DESIGN / CHECKED BY: DF
DATE: 11-09-16
DRAWING NO. A-1
6. Solar Panel & Racking Proposal April 19, 2011
5. Revised Curtain Wall Package March 28, 2011
4. Preliminary Curtain Wall Package February 23, 2011
3. Preliminary Roof Package February 14, 2011
2. Exterior Wall / Material Area Analysis February 09, 2011
1. Preliminary Solar PV Proposal January 24, 2011
NO. REVISION / STATUS DATE
Preliminary


NOTE: DETAIL OF SOLAR PANEL AND RACKING AS PROPOSED BY OYA SOLAR AND POLAR RACKING. PRELIMINARY DETAIL ONLY.
SOLAR PANEL SECTION DETAIL
SCALE: 1:20
SOLAR PANEL PERSPECTIVE
NOT TO SCALE
SOLAR PANEL CROSS SECTION
SCALE: 1:100
15,570 TOP OF STEEL TRUSS
13,150 TOP OF PARAPET (MAIN ROOF)
9,600 TOP OF THIRD FLOOR
4,800 TOP OF SECOND FLOOR
TOP OF GROUND FLOOR
EAST
WEST
EXISTING TRUSS TOP CHORD
EXISTING TRUSS STRUCTURE
RAIL EXTRUSION - BASE TRACK 50 x 90mm
FRONT RAIL 50 x 90 mm
BACK RAIL 50 x 90 mm
BACK BRACE 6 x 63 mm
SILIKEN SOLAR PANEL SLK60M6L - 1640 x 990 mm
25°
David Fujiwara ARCHITECT
276 Main Street, Suite 202 Toronto Ontario M4C 4X5
PHONE: 416-703-3399
E-MAIL: david@dfarchitect.ca
PROJECT: OAA HEADQUARTERS ROOFING & ENVELOPE RETROFIT
111 MOATFIELD DR. TORONTO, ONTARIO
DRAWING: PROPOSED SOLAR PANEL CROSS SECTION
SCALE: 1:100, 1:20, 1:102.38
PROJECT NO. 1101
DRAWN BY: SL
DESIGN / CHECKED BY: DF
DATE: 11-09-16
DRAWING NO. A-2
6. Solar Panel & Racking Proposal April 19, 2011
5. Revised Curtain Wall Package March 28, 2011
4. Preliminary Curtain Wall Package February 23, 2011
3. Preliminary Roof Package February 14, 2011
2. Exterior Wall / Material Area Analysis February 09, 2011
1. Preliminary Solar PV Proposal January 24, 2011
Preliminary


SOLAR PANEL LONGITUDINAL SECTION
SCALE: 1:100
1
SOUTH
NORTH
NEW SOLAR PANELS
STEEL BEAM
METAL SIDING
STRIP WINDOW
METAL SIDING
METAL SIDING
STRIP WINDOW
1
2
3
4
5
6
7
8
3,000
6,000
6,000
6,000
6,000
6,000
3,000
16,020
15,570 TOP OF STEEL TRUSS
13,150 TOP OF PARAPET (MAIN ROOF)
9,600 TOP OF THIRD FLOOR
4,800 TOP OF SECOND FLOOR
4,800 TOP OF GROUND FLOOR
450
2,420
3,550
4,800
4,800
David Fujiwara ARCHITECT
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Toronto Ontario M4C 4X5
PHONE: 416-703-3399
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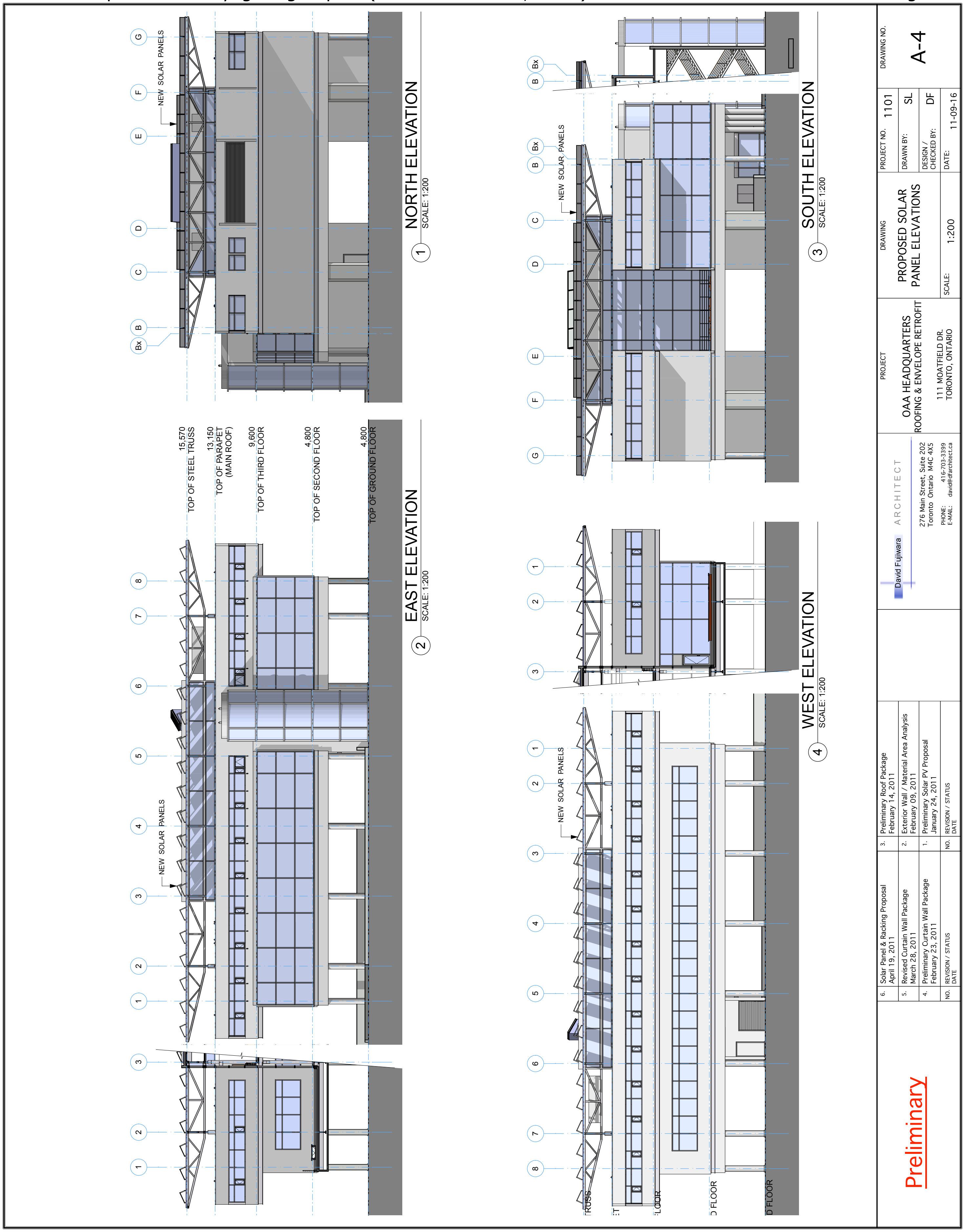
PROJECT
OAA HEADQUARTERS
ROOFING & ENVELOPE RETROFIT
111 MOATFIELD DR.
TORONTO, ONTARIO
DRAWING
PROPOSED SOLAR PANEL LONGITUDINAL SECTION
SCALE: 1:100
PROJECT NO. 1101
DRAWN BY: SL
DESIGN / CHECKED BY: DF
DATE: 11-09-16
DRAWING NO. A-3
6. Solar Panel & Racking Proposal April 19, 2011
5. Revised Curtain Wall Package March 28, 2011
4. Preliminary Curtain Wall Package February 23, 2011
3. Preliminary Roof Package February 14, 2011
2. Exterior Wall / Material Area Analysis February 09, 2011
1. Preliminary Solar PV Proposal January 24, 2011
NO. REVISION / STATUS DATE
Preliminary


NORTH ELEVATION
SCALE: 1:200
EAST ELEVATION
SCALE: 1:200
SOUTH ELEVATION
SCALE: 1:200
WEST ELEVATION
SCALE: 1:200
NEW SOLAR PANELS
15,570 TOP OF STEEL TRUSS
13,150 TOP OF PARAPET (MAIN ROOF)
9,600 TOP OF THIRD FLOOR
4,800 TOP OF SECOND FLOOR
4,800 TOP OF GROUND FLOOR
David Fujiwara ARCHITECT
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E-MAIL: david@dfarchitect.ca
PROJECT
OAA HEADQUARTERS ROOFING & ENVELOPE RETROFIT
111 MOATFIELD DR. TORONTO, ONTARIO
DRAWING
PROPOSED SOLAR PANEL ELEVATIONS
SCALE: 1:200
PROJECT NO. 1101
DRAWN BY: SL
DESIGN / CHECKED BY: DF
DATE: 11-09-16
DRAWING NO. A-4
6. Solar Panel & Racking Proposal April 19, 2011
5. Revised Curtain Wall Package March 28, 2011
4. Preliminary Curtain Wall Package February 23, 2011
3. Preliminary Roof Package February 14, 2011
2. Exterior Wall / Material Area Analysis February 09, 2011
1. Preliminary Solar PV Proposal January 24, 2011
NO. REVISION / STATUS DATE
Preliminary

Appendix 3: Presentation to OAA August 6, 2013

Daylight Models 1, 2 and 3


GOTTESMAN ASSOCIATES
OAA HQ: DAYLIGHT MODELLING
August 6, 2013
Page 1 of 23
PRELIMINARY
EXISTING

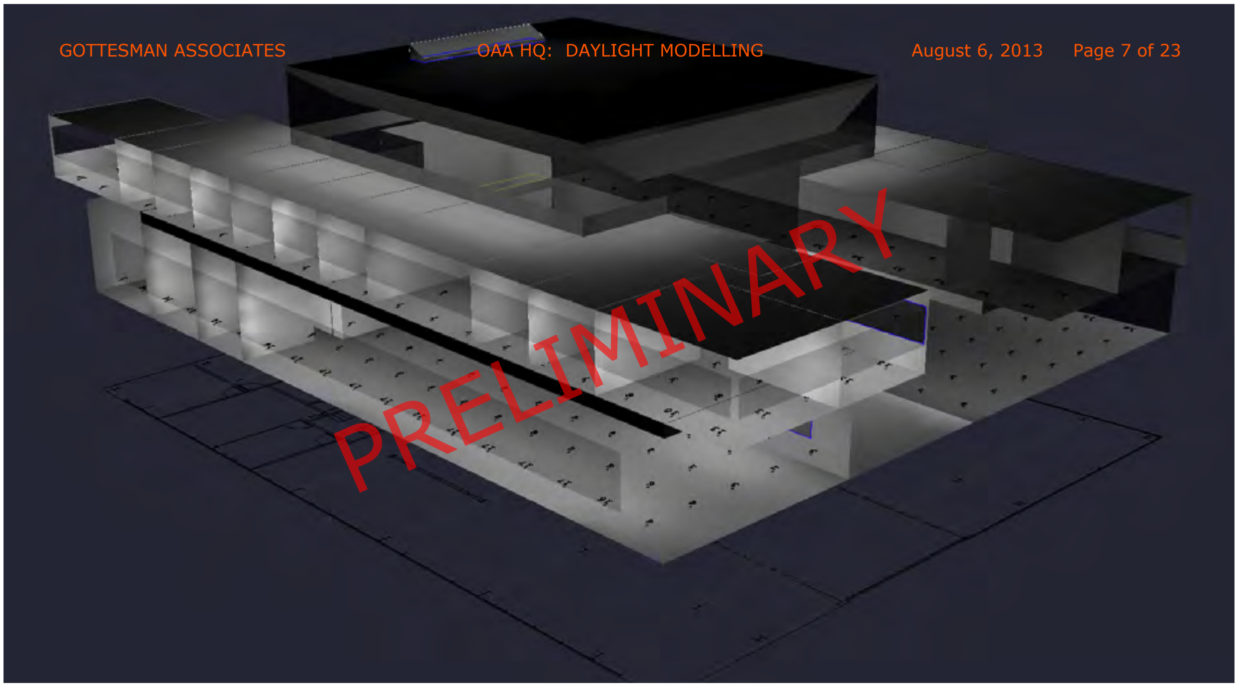

GOTTESMAN ASSOCIATES
OAA HQ: DAYLIGHT MODELLING
August 6, 2013
Page 2 of 23
PRELIMINARY


GOTTESMAN ASSOCIATES
OAA HQ: DAYLIGHT MODELLING
August 6, 2013
Page 3 of 23
PRELIMINARY


GOTTESMAN ASSOCIATES
OAA HQ: DAYLIGHT MODELLING
August 6, 2013
Page 4 of 23
PRELIMINARY

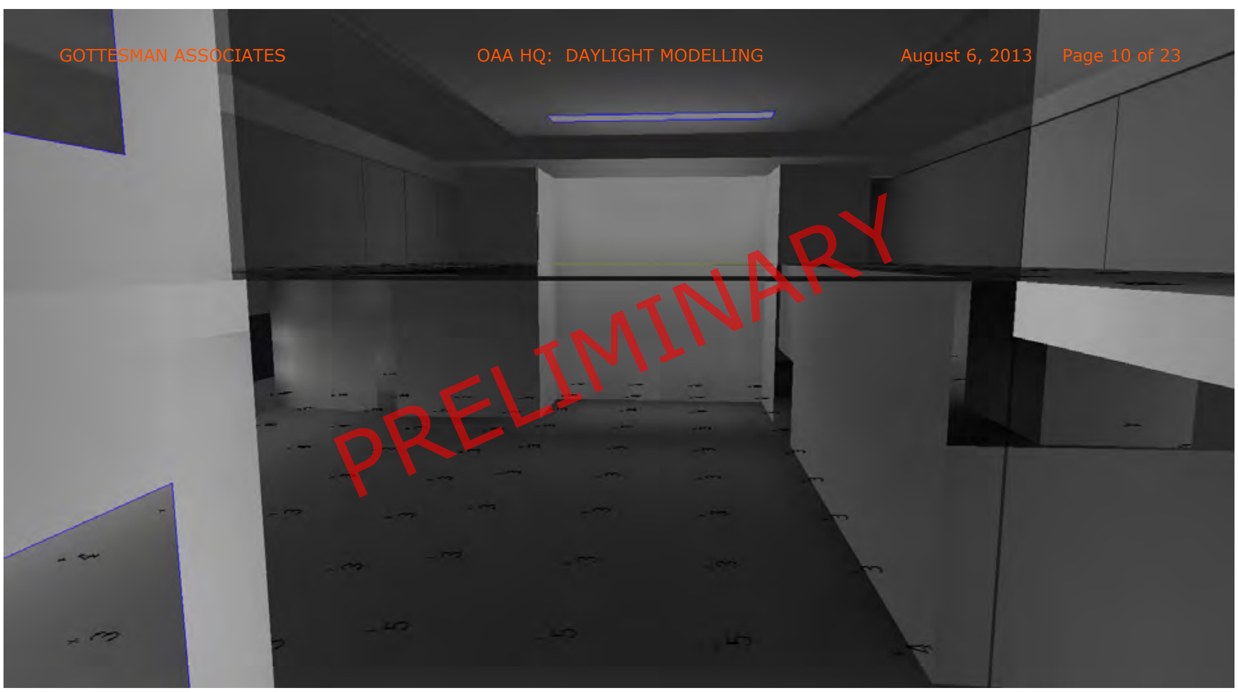

GOTTESMAN ASSOCIATES
OAA HQ: DAYLIGHT MODELLING
August 6, 2013
Page 5 of 23
PRELIMINARY
Daylight Factors Shown


GOTTESMAN ASSOCIATES
OAA HQ: DAYLIGHT MODELLING
August 6, 2013
Page 6 of 23
PRELIMINARY

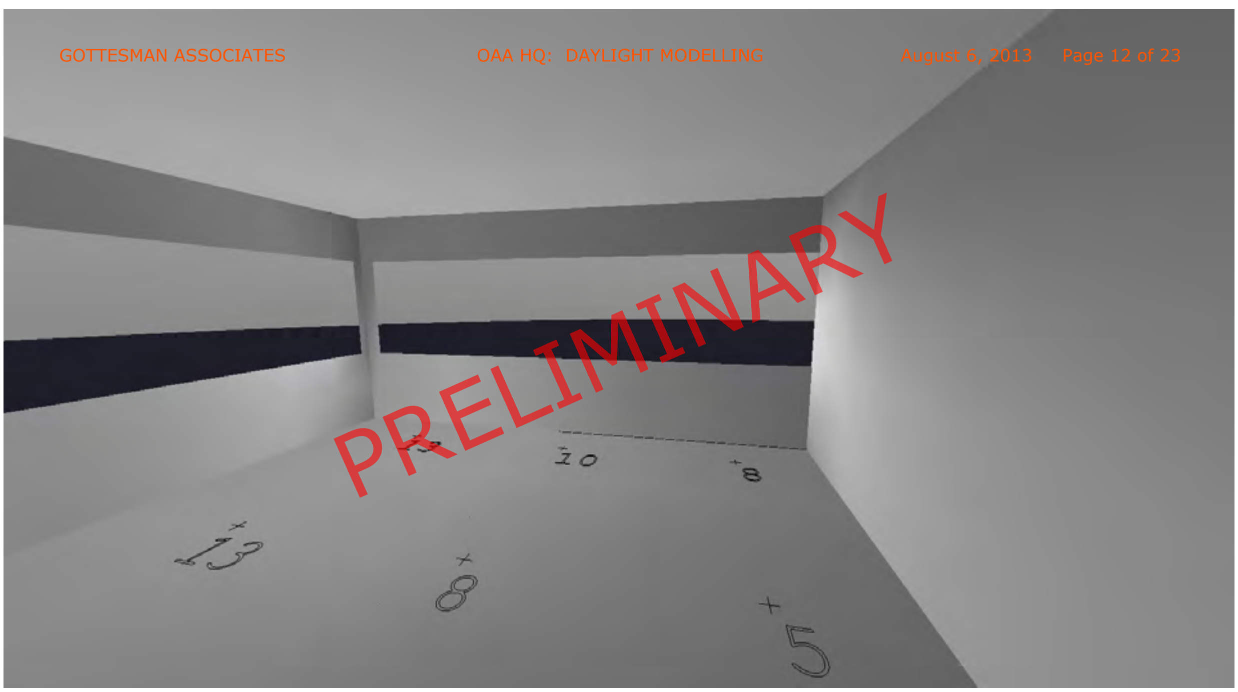

GOTTESMAN ASSOCIATES
OAA HQ: DAYLIGHT MODELLING
August 6, 2013
Page 7 of 23
PRELIMINARY

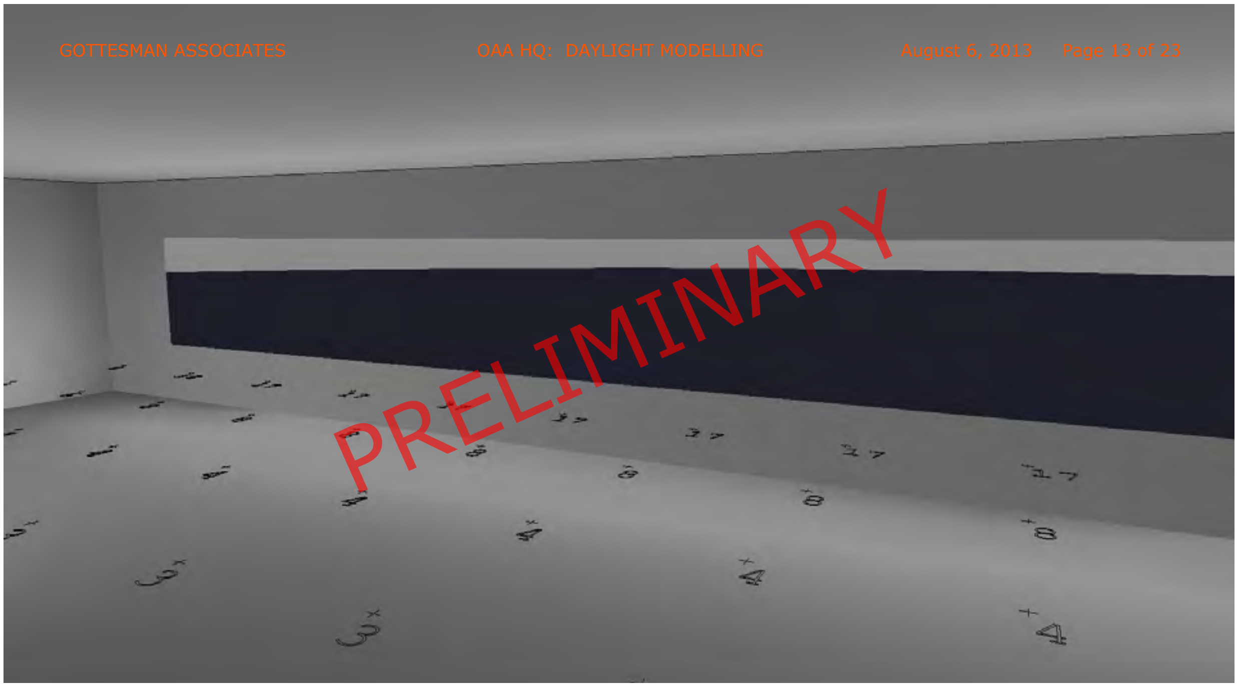

GOTTESMAN ASSOCIATES
OAA HQ: DAYLIGHT MODELLING
August 6, 2013
Page 8 of 23
PRELIMINARY


GOTTESMAN ASSOCIATES
OAA HQ: DAYLIGHT MODELLING
August 6, 2013
Page 9 of 23
PRELIMINARY

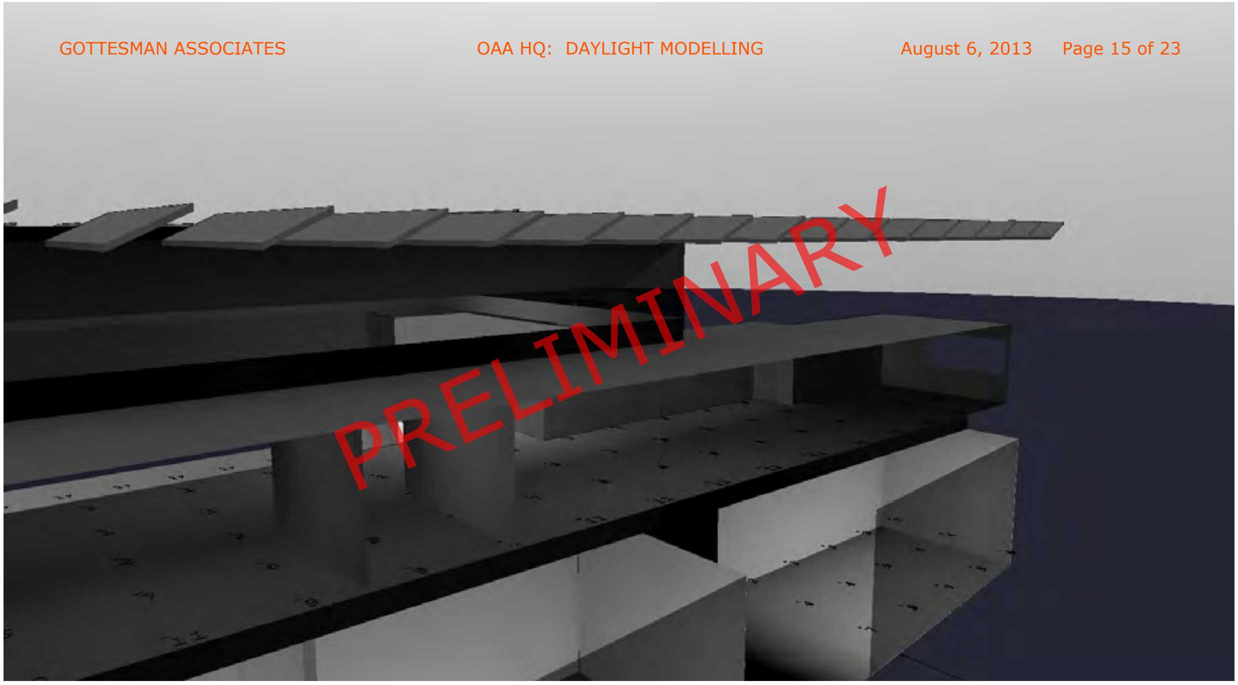

GOTTESMAN ASSOCIATES
OAA HQ: DAYLIGHT MODELLING
August 6, 2013
Page 10 of 23
PRELIMINARY


GOTTESMAN ASSOCIATES
OAA HQ: DAYLIGHT MODELLING
August 6, 2013
Page 11 of 23
PRELIMINARY


GOTTESMAN ASSOCIATES
OAA HQ: DAYLIGHT MODELLING
August 6, 2013
Page 12 of 23
PRELIMINARY
10
8
13
8
5


GOTTESMAN ASSOCIATES
OAA HQ: DAYLIGHT MODELLING
August 6, 2013
Page 13 of 23
PRELIMINARY


GOTTESMAN ASSOCIATES
OAA HQ: DAYLIGHT MODELLING
August 6, 2013
Page 14 of 23
PRELIMINARY
PV PANELS
-transparent gaps

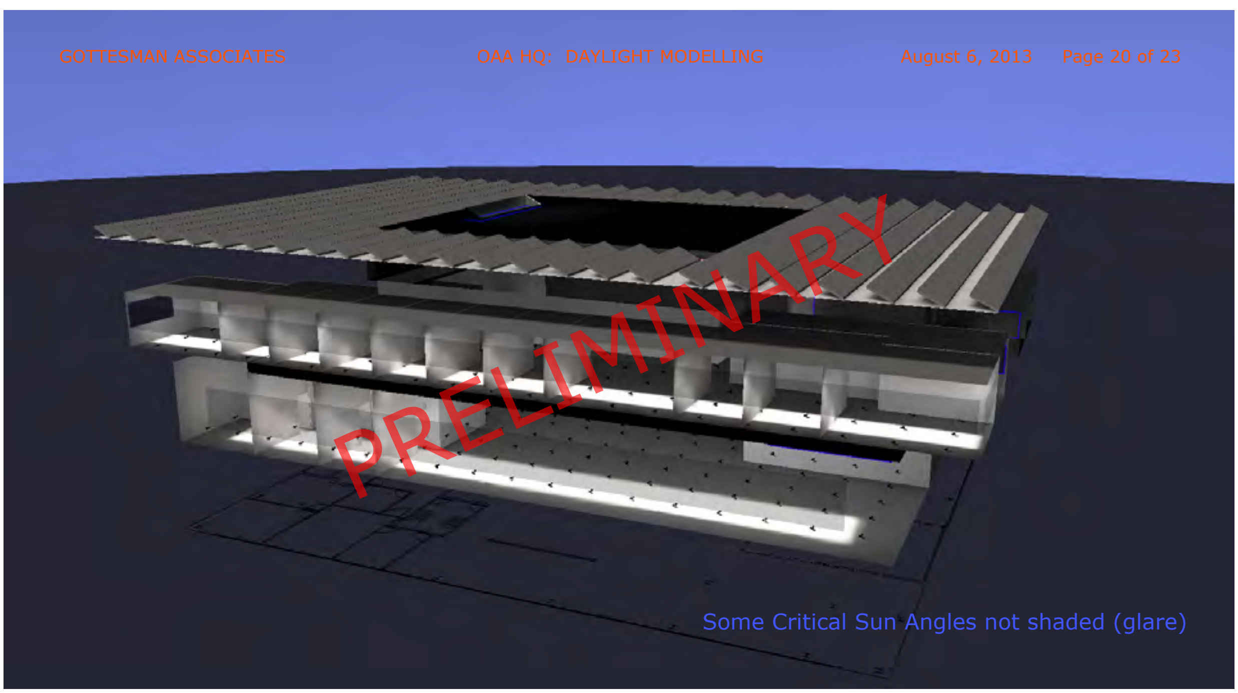

GOTTESMAN ASSOCIATES
OAA HQ: DAYLIGHT MODELLING
August 6, 2013
Page 15 of 23
PRELIMINARY

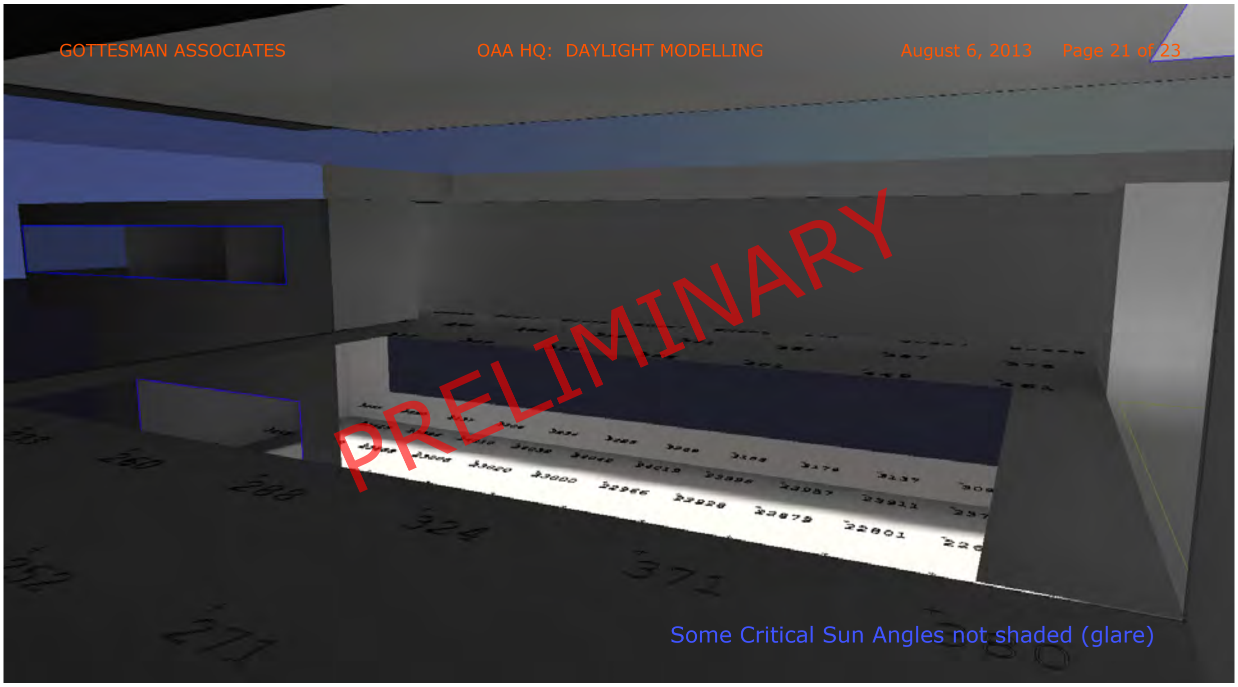

GOTTESMAN ASSOCIATES
OAA HQ: DAYLIGHT MODELLING
August 6, 2013
Page 16 of 23
PRELIMINARY

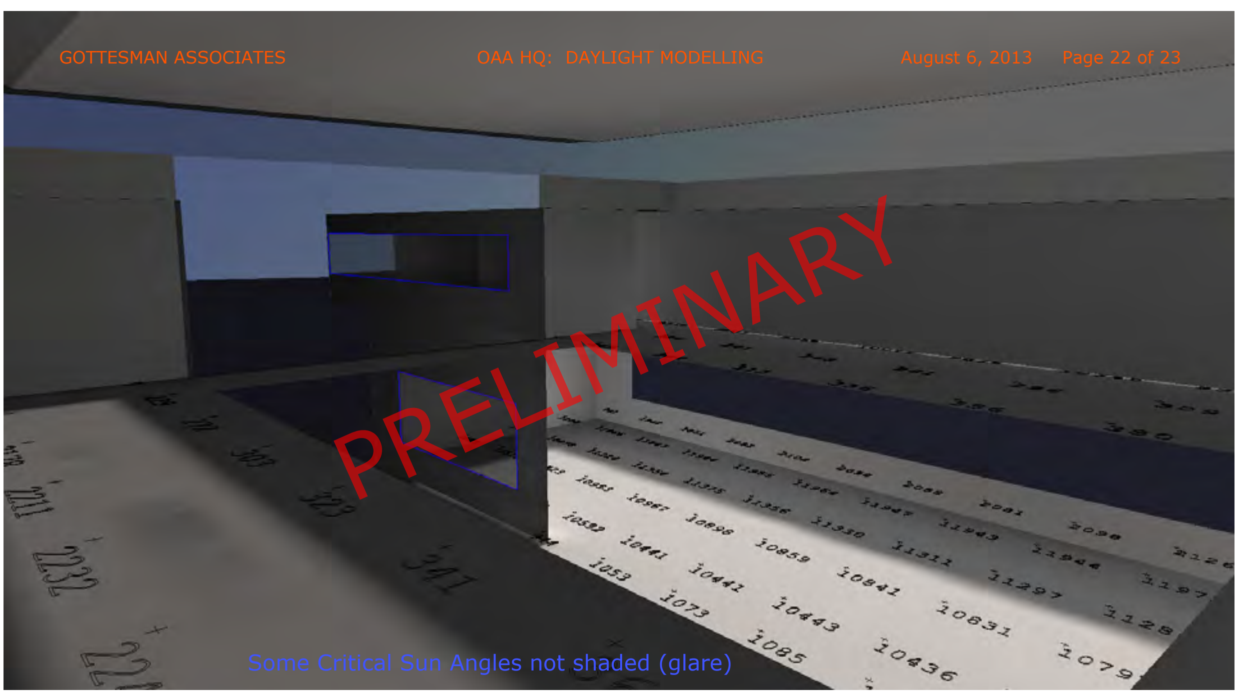

GOTTESMAN ASSOCIATES
OAA HQ: DAYLIGHT MODELLING
August 6, 2013
Page 17 of 23
PRELIMINARY
PV PANELS
-opaque gaps


GOTTESMAN ASSOCIATES
OAA HQ: DAYLIGHT MODELLING
August 6, 2013
Page 18 of 23
PRELIMINARY


GOTTESMAN ASSOCIATES
OAA HQ: DAYLIGHT MODELLING
August 6, 2013
Page 19 of 23
PRELIMINARY


GOTTESMAN ASSOCIATES
OAA HQ: DAYLIGHT MODELLING
August 6, 2013
Page 20 of 23
PRELIMINARY
Some Critical Sun Angles not shaded (glare)


GOTTESMAN ASSOCIATES
OAA HQ: DAYLIGHT MODELLING
August 6, 2013
Page 21 of 23
PRELIMINARY
Some Critical Sun Angles not shaded (glare)


GOTTESMAN ASSOCIATES
OAA HQ: DAYLIGHT MODELLING
August 6, 2013
Page 22 of 23
PRELIMINARY
Some Critical Sun Angles not shaded (glare)

OAA Daylighting - Preliminary Model

Daylight Factor Calculations

6-Aug-13

	Existing Building Conditions				With PV Panels Added (gaps between panels open)				With PV Panels Added (gaps between panels opaque)				
			Extent of Daylight Autonomy				Extent of Daylight Autonomy				Extent of Daylight Autonomy		notes
Space	Average DF	Overcast Sky, Annual Light Level Range	Ambient	Tasks	Average DF	Overcast Sky, Annual Light Level Range	Ambient	Tasks	Average DF	Overcast Sky, Annual Light Level Range	Ambient	Tasks	
Atrium (2nd floor only)	3.5	105 - 700 lux	Fully Autonomous	Partial	2.5	75 - 500 lux	Fully Autonomous	Partial	1.3	40 - 250 lux	Partially Autonomous	Never	
Lounge 211	5.8	175 - 1200 lux	Fully Autonomous	Partial	5.4	160 - 1100 lux	Fully Autonomous	Partial	4.9	150 - 1000 lux	Fully Autonomous	Partial	
Conference 207	4.3	125 - 900 lux	Fully Autonomous	Partial	4.3	125 - 900 lux	Fully Autonomous	Partial	4.3	125 - 900 lux	Fully Autonomous	Partial	
Boardroom 205	4.9	150 - 1000 lux	Fully Autonomous	Partial	4.9	150 - 1000 lux	Fully Autonomous	Partial	4.9	150 - 1000 lux	Fully Autonomous	Partial	
Second Floor West 213	7.2	210 - 1400 lux	Fully Autonomous	Partial	6.7	200 - 1300 lux	Fully Autonomous	Partial	6.4	190 - 1300 lux	Fully Autonomous	Partial	1
Third Floor Office Spaces	5.5	165 - 1100 lux	Fully Autonomous	Partial	4.7	140 - 900 lux	Fully Autonomous	Partial	3.9	120 - 800 lux	Fully Autonomous	Partial	2
Atrium (3rd floor only)	2.5	75 - 500 lux	Fully Autonomous	Partial	1.5	45 - 300 lux	Partially Autonomous	Rarely	1	30 - 200 lux	Partially Autonomous	Never	

Modelling Assumptions

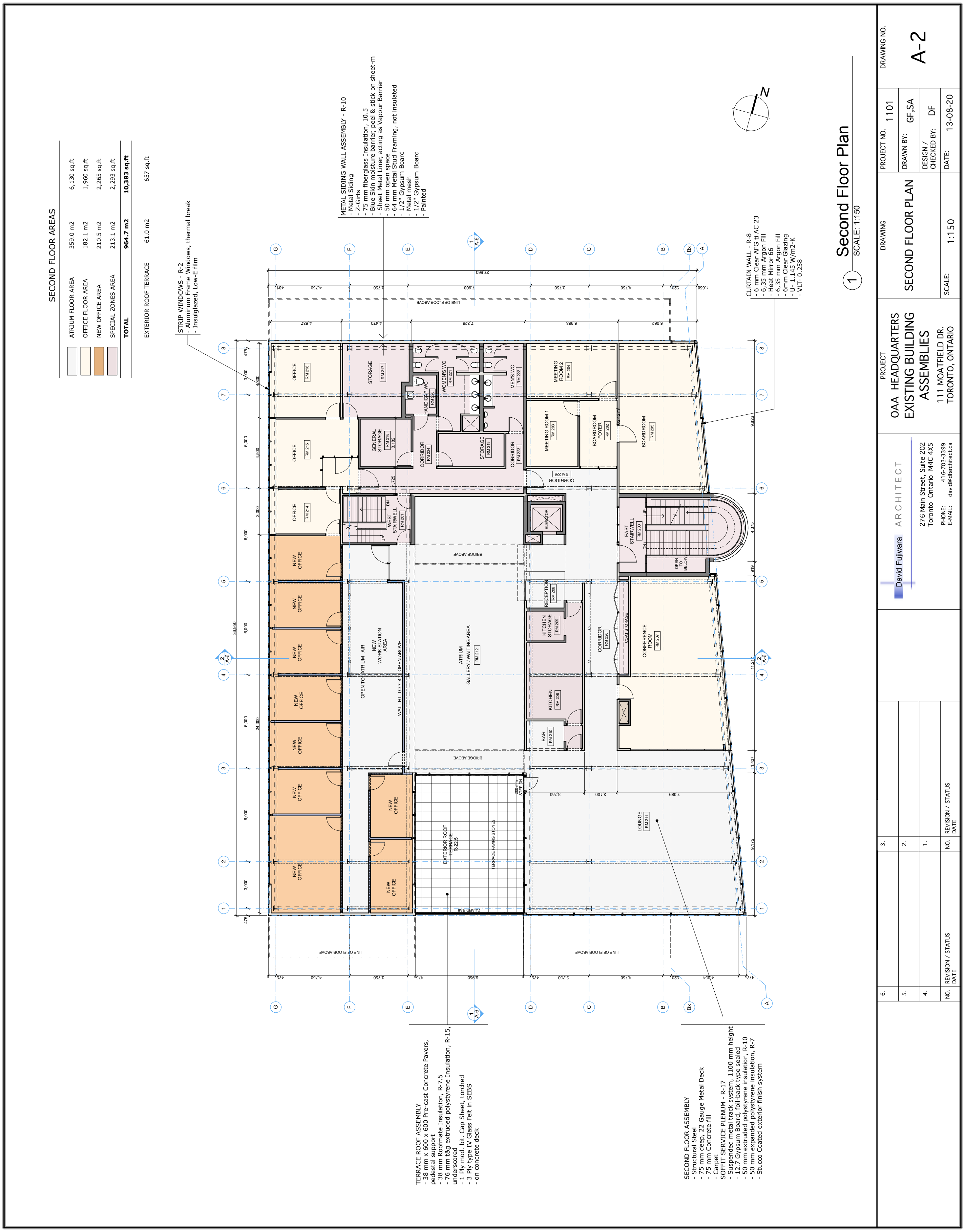
	VLT per specification	Assummed VLT for Model	
Skylight	10.0%	8.0%	
Clerestory Windows	14.8%	13.0%	has 75% frit
Curtain Wall	26.0%	22.0%	
Strip Windows	70.0%	60.0%	(typical for double glazed, low E)

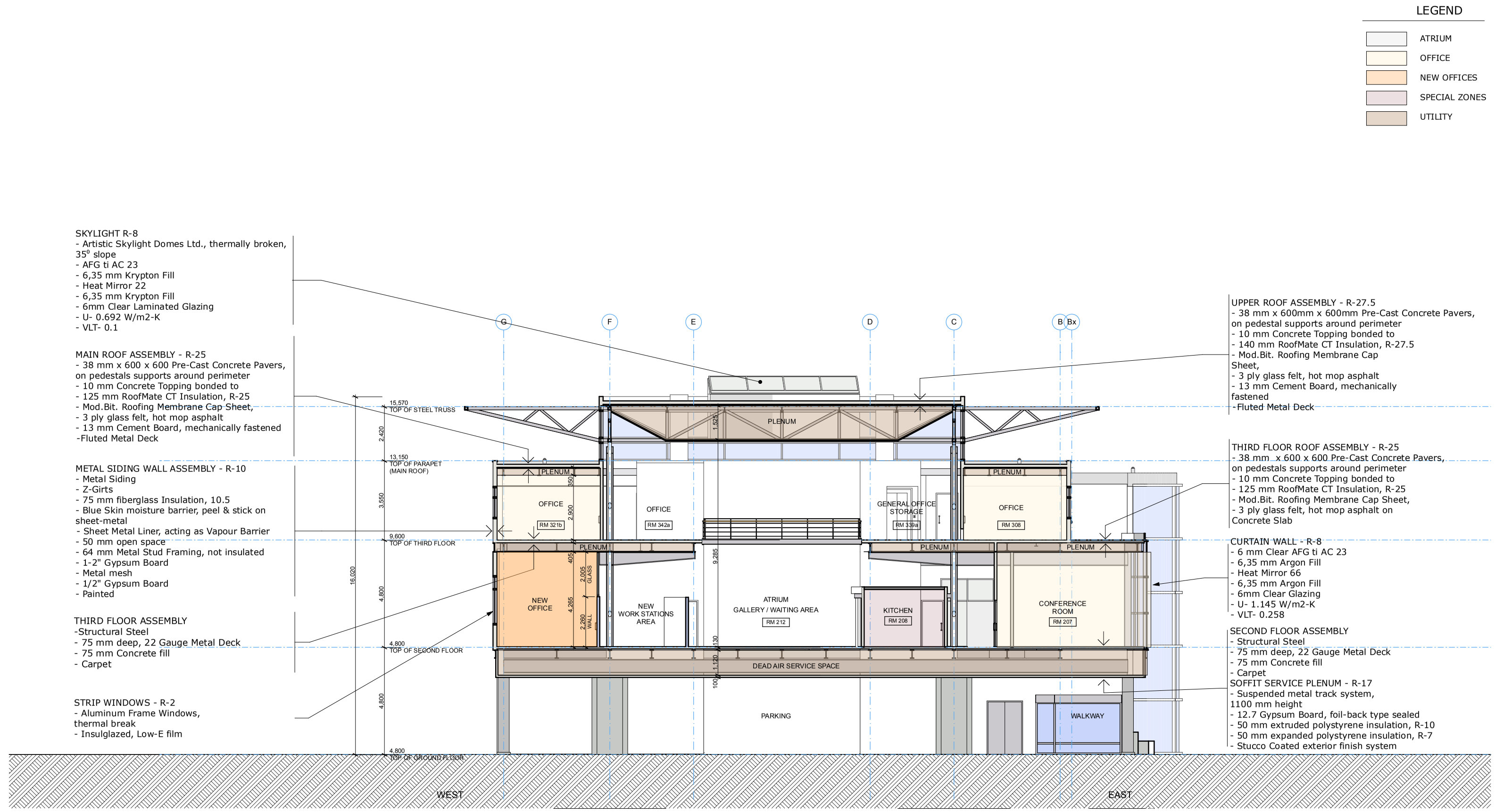
Toronto Overcast Outdoor Annual Illumination Range: 3000 - 20,000 Lux

Note 1 windows assumed to be existing strip windows

Note 2 includes points in Atrium space on third floor

Appendix 4: Revised Second Floor Plans


SECOND FLOOR AREAS
ATRIUM FLOOR AREA 359.0 m2 6,130 sq.ft
OFFICE FLOOR AREA 182.1 m2 1,960 sq.ft
NEW OFFICE AREA 210.5 m2 2,265 sq.ft
SPECIAL ZONES AREA 213.1 m2 2,293 sq.ft
TOTAL 964.7 m2 10,383 sq.ft
EXTERIOR ROOF TERRACE 61.0 m2 657 sq.ft
STRIP WINDOWS - R-2
- Aluminum Frame Windows, thermal break
- Insulglazed, Low-E film
METAL SIDING WALL ASSEMBLY - R-10
- Metal Siding
- Z-Girts
- 75 mm fiberglass Insulation, 10.5
- Blue Skin moisture barrier, peel & stick on sheet-m
- Sheet Metal Liner, acting as Vapour Barrier
- 50 mm open space
- 64 mm Metal Stud Framing, not insulated
- 1/2" Gypsum Board
- Metal mesh
- 1/2" Gypsum Board
- Painted
CURTAIN WALL - R-8
- 6 mm Clear AFG ti AC 23
- 6,35 mm Argon Fill
- Heat Mirror 66
- 6,35 mm Argon Fill
- 6mm Clear Glazing
- U- 1.145 W/m2-K
- VLT- 0.258
TERRACE ROOF ASSEMBLY
- 38 mm x 600 x 600 Pre-cast Concrete Pavers, pedestal support
- 38 mm Roofmate Insulation, R-7.5
- 76 mm t&g extruded polystyrene Insulation, R-15, underscored
- 1 Ply mod. bit. Cap Sheet, torched
- 3 Ply type IV Glass Felt in SEBS
- on concrete deck
SECOND FLOOR ASSEMBLY
- Structural Steel
- 75 mm deep, 22 Gauge Metal Deck
- 75 mm Concrete fill
- Carpet
SOFFIT SERVICE PLENUM - R-17
- Suspended metal track system, 1100 mm height
- 12.7 Gypsum Board, foil-back type sealed
- 50 mm extruded polystyrene insulation, R-10
- 50 mm expanded polystyrene insulation, R-7
- Stucco Coated exterior finish system
Second Floor Plan
SCALE: 1:150
PROJECT
OAA HEADQUARTERS
EXISTING BUILDING
ASSEMBLIES
111 MOATFIELD DR.
TORONTO, ONTARIO
David Fujiwara ARCHITECT
276 Main Street, Suite 202
Toronto Ontario M4C 4X5
PHONE: 416-703-3399
E-MAIL: david@dfarchitect.ca
DRAWING
SECOND FLOOR PLAN
SCALE: 1:150
PROJECT NO. 1101
DRAWN BY: GF,SA
DESIGN / CHECKED BY: DF
DATE: 13-08-20
DRAWING NO.
A-2



CROSS SECTION - LOOKING NORTH

1 SCALE: 1:150

NO.	REVISION / STATUS DATE	NO.	REVISION / STATUS DATE
6.		3.	
5.		2.	
4.		1.	

David Fujiwara ARCHITECT
276 Main Street, Suite 202
Toronto Ontario M4C 4X5
PHONE: 416-703-3399
E-MAIL: david@dfarchitect.ca

PROJECT: OAA HEADQUARTERS EXISTING BUILDING ASSEMBLIES
111 MOATFIELD DR. TORONTO, ONTARIO

DRAWING: SECTION LOOKING NORTH

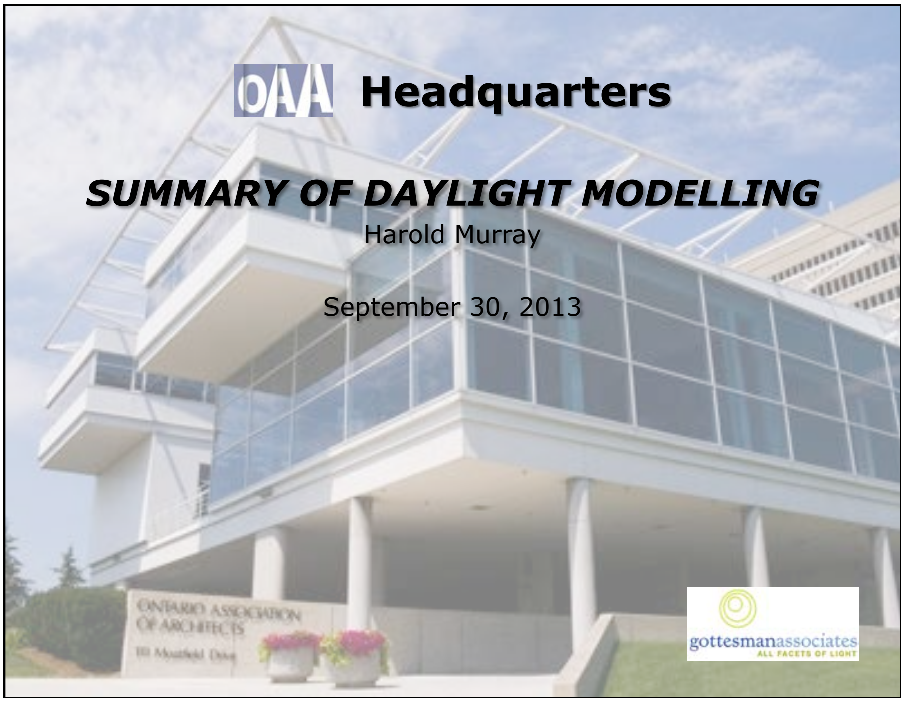
SCALE: 1:150

PROJECT NO. 1101
DRAWN BY: GF,SA
DESIGN / CHECKED BY: DF
DATE: 13-08-20

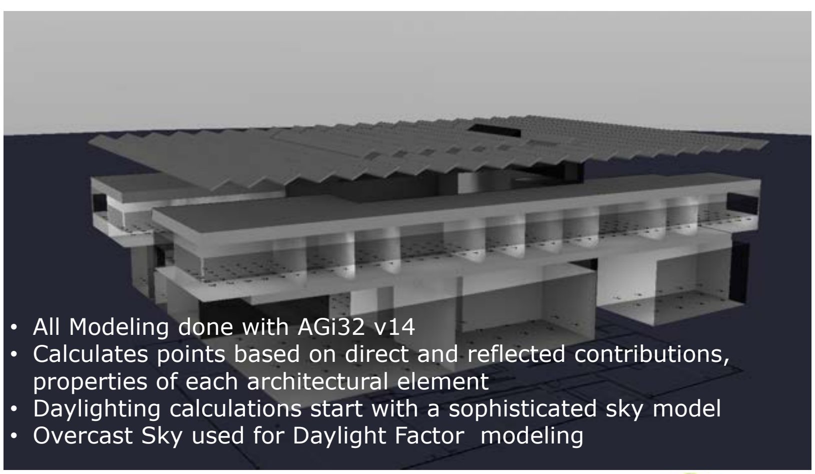
DRAWING NO. A-6.1

Appendix 5: Presentation to OAA Sept 30, 2013

Daylight Models 6 and 7



Chosen Model: PV Panels with gaps between



- All Modeling done with AGi32 v14
- Calculates points based on direct and reflected contributions, properties of each architectural element
- Daylighting calculations start with a sophisticated sky model
- Overcast Sky used for Daylight Factor modeling

View from SE

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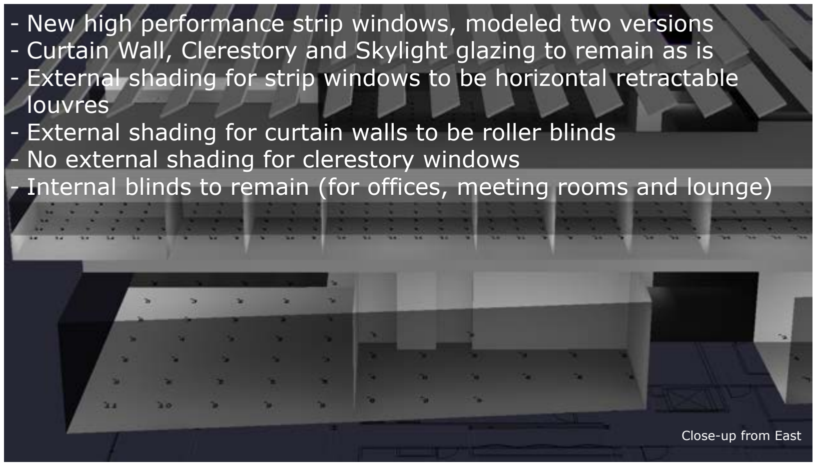
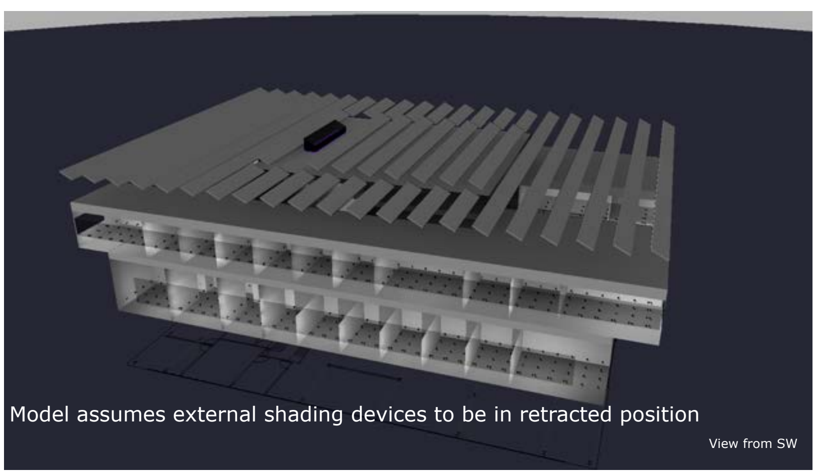
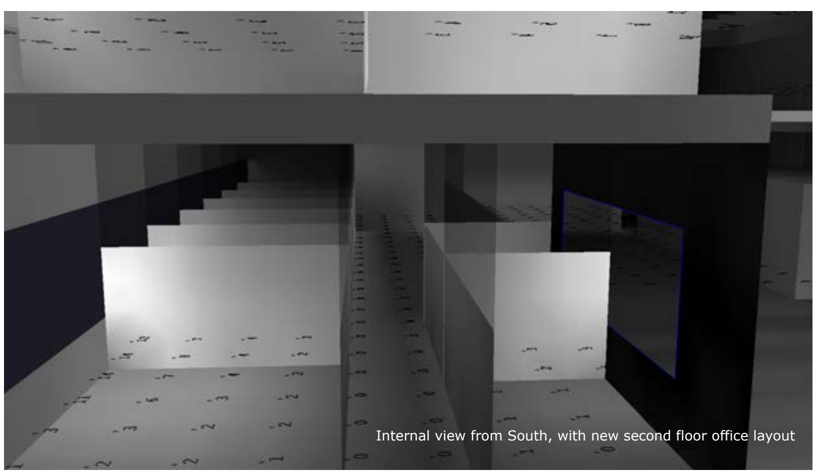
Daylight Models 6 and 7:

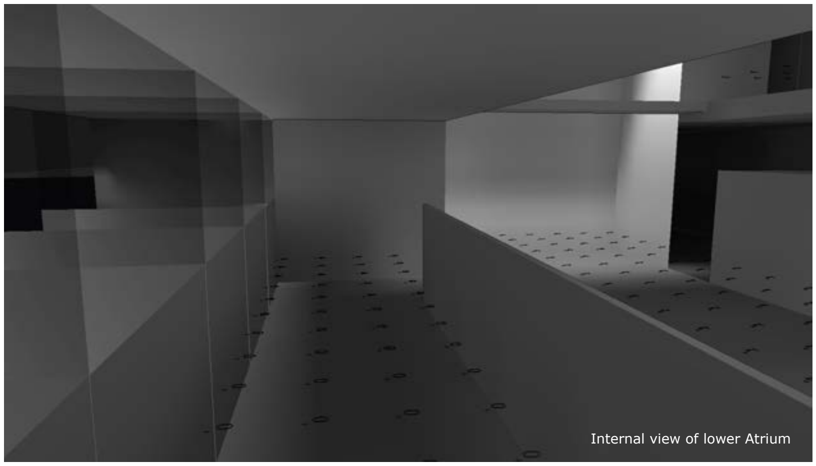




View from West



Internal view from South, with new second floor office layout



Internal view of lower Atrium

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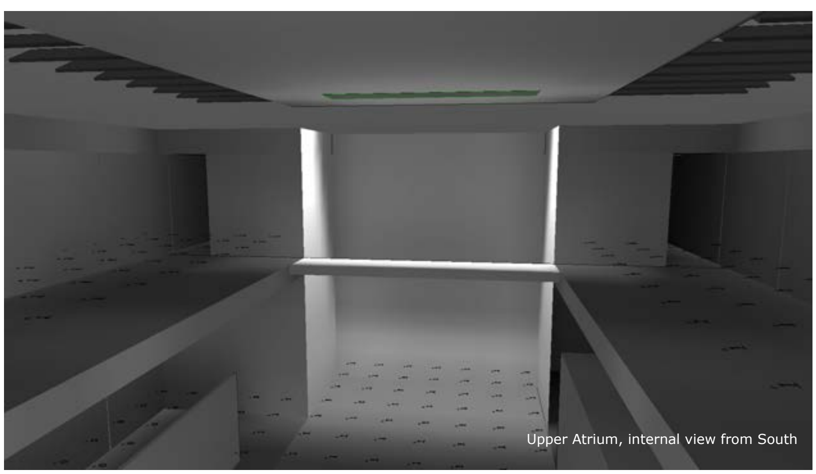

Upper Atrium, internal view from South

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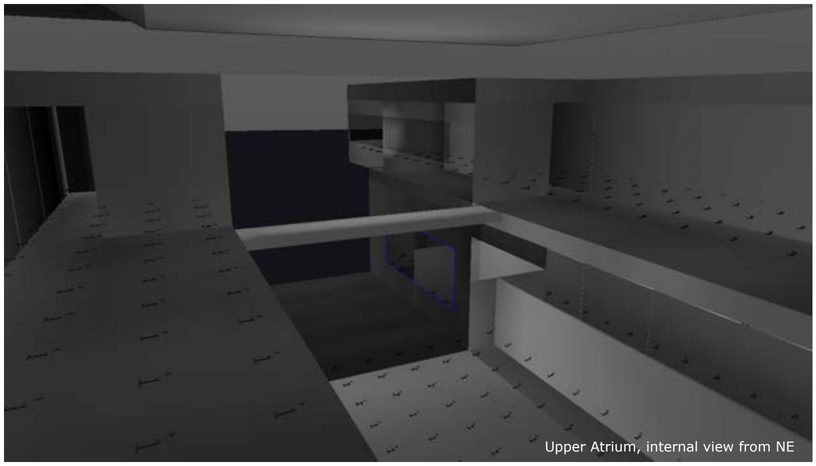
ALL FACETS OF LIGHT



Upper Atrium, internal view from NE

Daylight Model Data Summary

OAA Daylighting - Models with revised 2nd floor office layout and new strip windows — Daylight Factor Calculations — 21-Aug-13

Space/Zone	Room(s) Included	Model 6: Strip Window Spec VLT of 56% Average DF	Min DF	Max DF	# Points	% of points over 2% DF	Model 7: Strip Window Spec VLT of 68% Average DF	Min DF	Max DF	# Points	% of points over 2% DF	notes
Atrium - Second Floor	212	1.2	1	2	126	15%	1.2	1	2	126	15%	
Lounge	211	4.5	1	11	35	97%	4.5	1	11	35	97%	
Conference	207	4.4	1	9	17	94%	4.4	1	9	17	94%	
Boardroom	205	5.3	2	9	15	100%	5.3	2	9	15	100%	
Second Floor West	213, 214, 215, 216	3.3	0	14	281	58%	4.0	0	17	281	62%	
Third Floor East Office Spaces	303A, 303B, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, 340, 339A	3.9	0	19	314	60%	4.6	0	22	314	64%	1
Third Floor West Office Spaces	315, 316, 317, 318, 319, 320, 341, 321A, 321B, 322, 323, 324, 325, 326, 327, 328, 342A	3.9	0	19	314	62%	4.6	0	23	314	64%	1

Modelling Assumptions

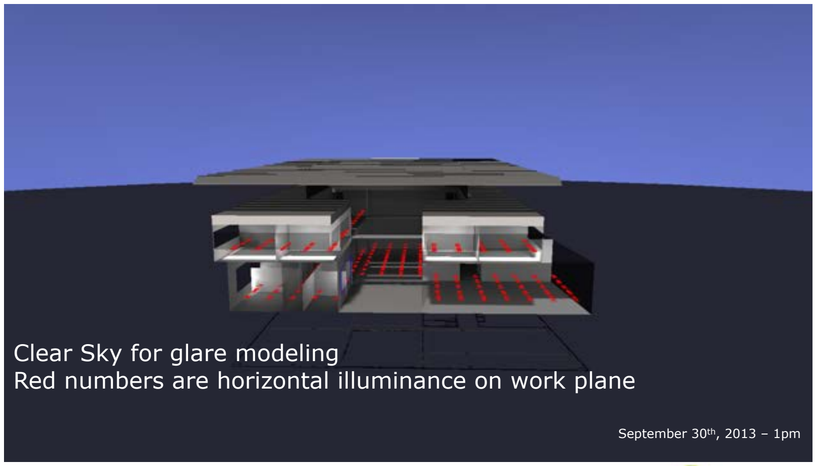
	VLT per specification	VLT used for Model 6	VLT used for Model 7
Skylight	10.0%	8.5%	8.5%
Clerestory Windows	20.0%	17.0%	17.0%
Curtain Walls	25.8%	22.0%	22.0%
Second Floor Strip Windows	56% (Model 6), 68% (Model 7)	48.0%	58.0%
Third Floor Strip Windows	56% (Model 6), 68% (Model 7)	43.0%	52.0%

Note 1: includes points in Atrium space on third floor

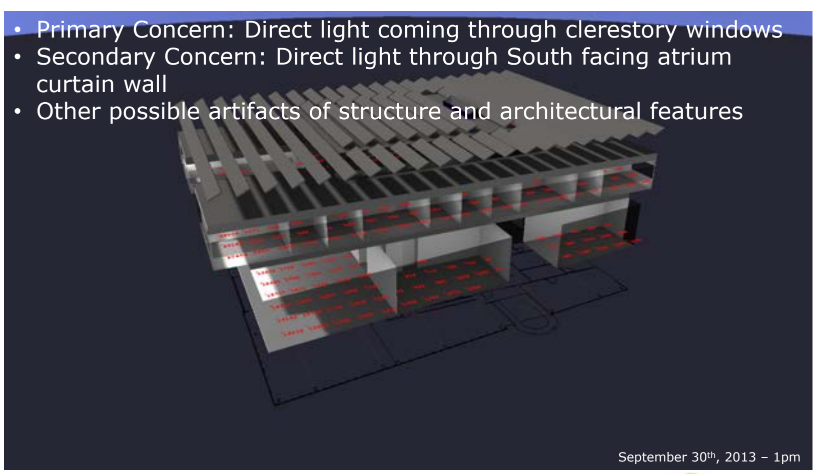
General Notes:
- model VLT values include a 5% depreciation factor and a 10% loss factor for the window and curtain wall mullions. Overall model window sizes are (approximately) actual. On the Third floor, the mullion factor has been increased to 20% for the strip windows because of their geometry and operability.
- no consideration has been made for the daylighting effects of external shading devices, other than the PV panels. These models assume that any external blinds on the strip windows and/or shades on the curtain walls would be in the retracted position.

- Used for Mechanical Building Model
- Atrium and second floor DF lower with new office layout
- Third floor DF reduced with high performance glazing but still high overall

More Modeling, this time for glare:

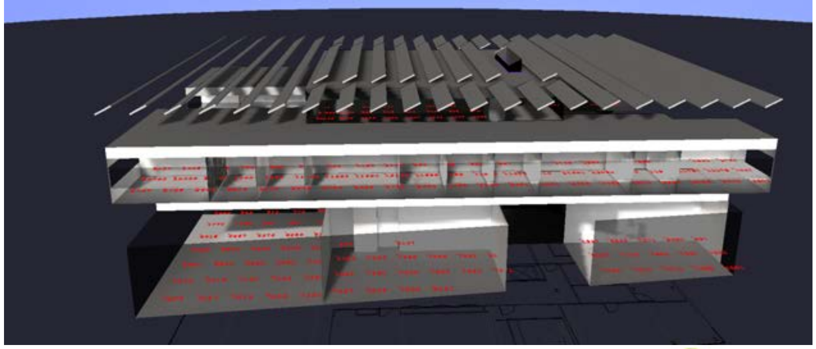


More Modeling, this time for glare:



Summer Mornings: View from East

- In summer: morning and afternoon light between PV panels comes through east and west clerestory windows
- Also midday high angle light would slip between PV panels and enter atrium through south face - clerestory and curtain wall



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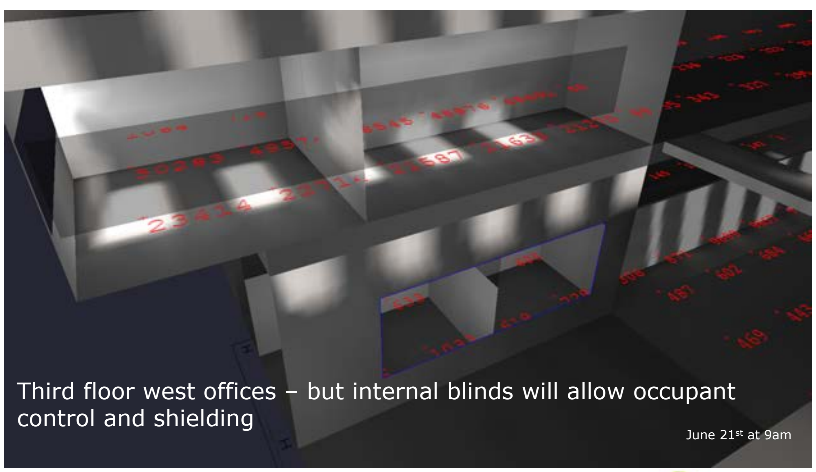
Summer Mornings:



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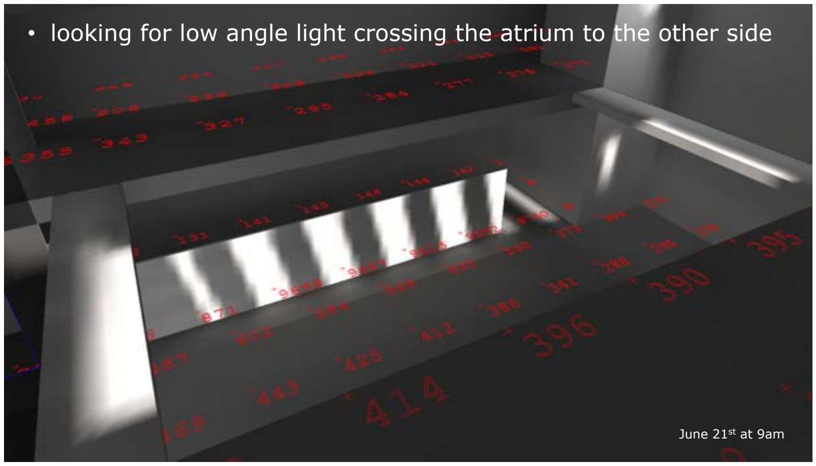
Summer Mornings:



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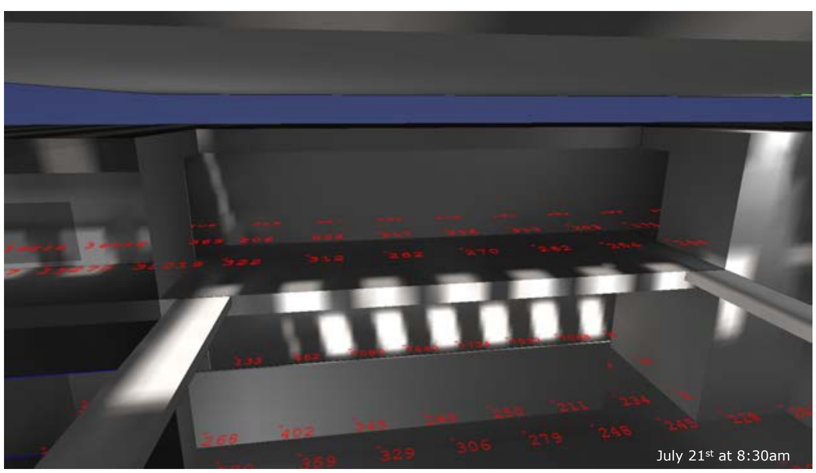
Summer Mornings:



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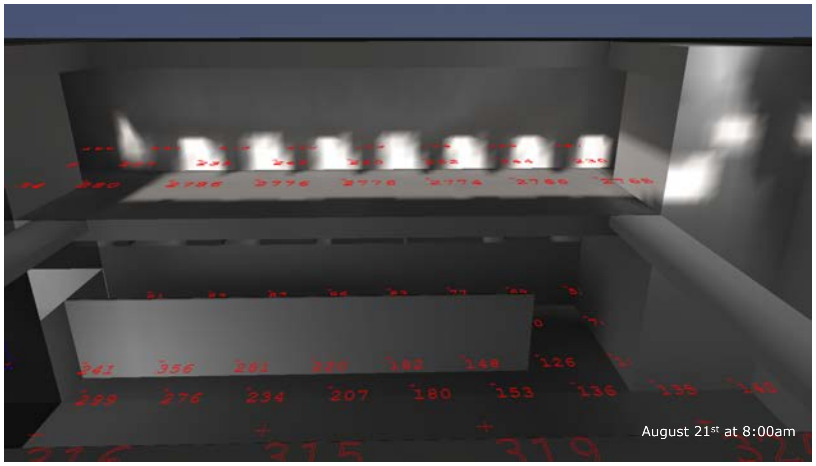
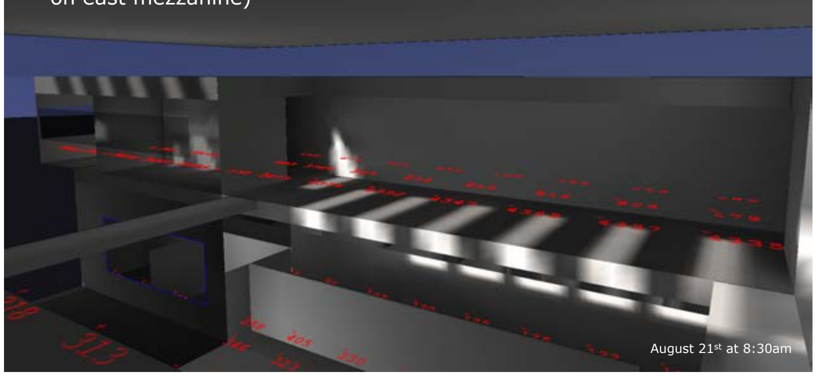
Summer Mornings:



August 21st at 8:00am

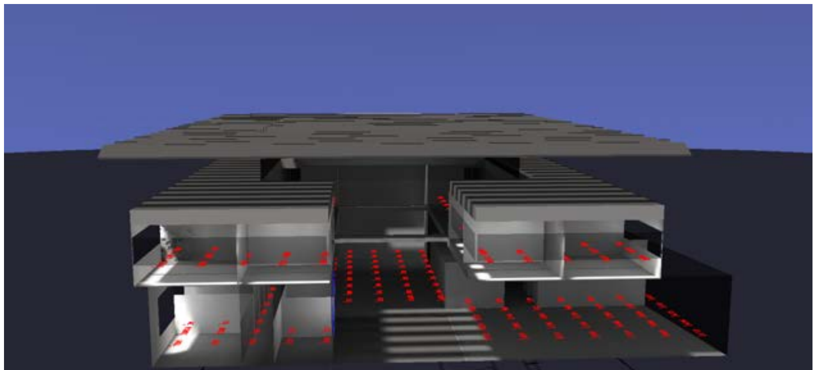
Summer Mornings:

- this will be a common situation throughout Spring and Summer
- and there will be an identical condition in the late afternoon (with glare on east mezzanine)



August 21st at 8:30am

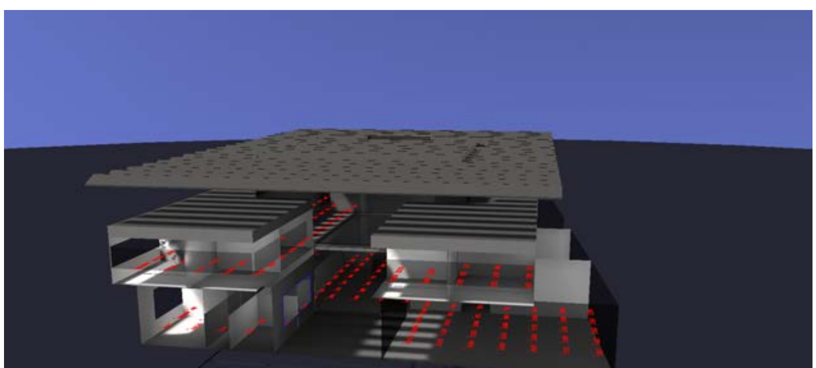
Summer Afternoons:



- looking for direct light coming through PV panels and clerestories to atrium mezzanine (same side)

June 21st at 2:30pm

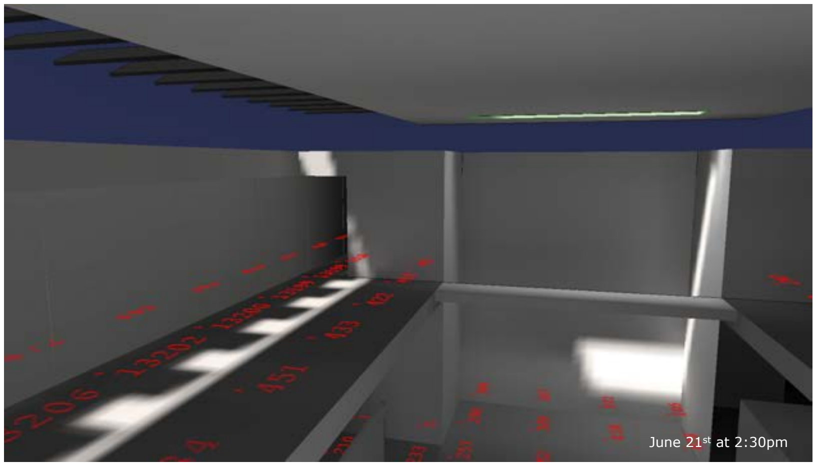
Summer Afternoons:



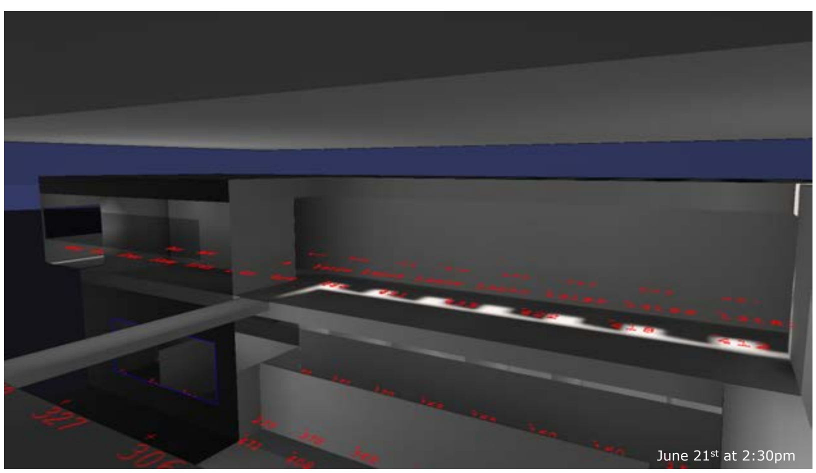
- looking for direct light coming through PV panels and clerestories to atrium mezzanine (same side)

June 21st at 3:30pm

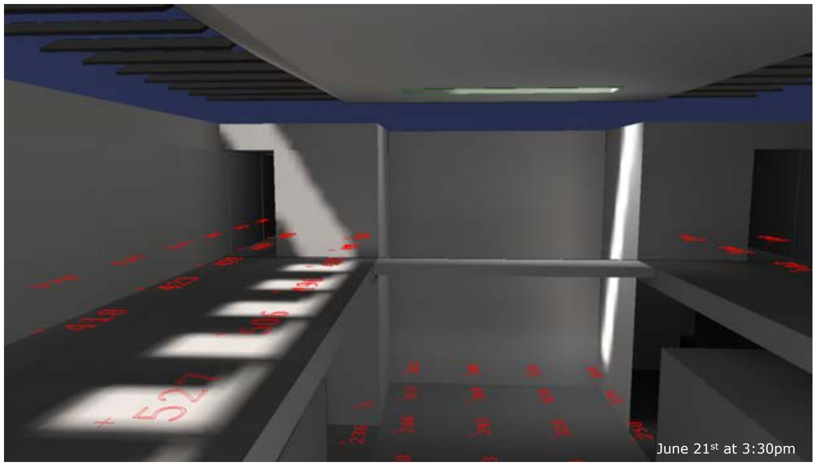
Summer Afternoons:



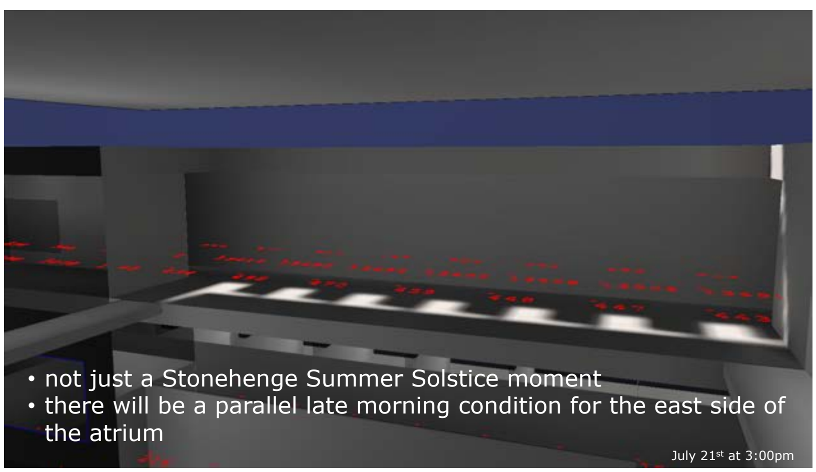
Summer Afternoons:



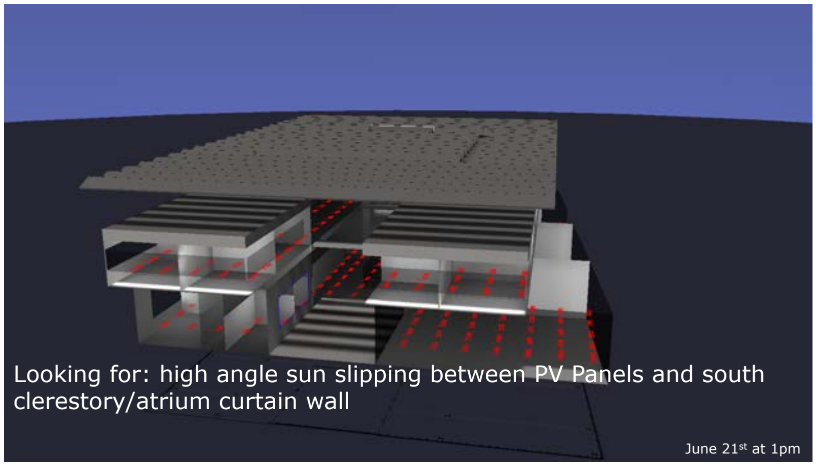
Summer Afternoons:



Summer Afternoons:



Summer Midday:



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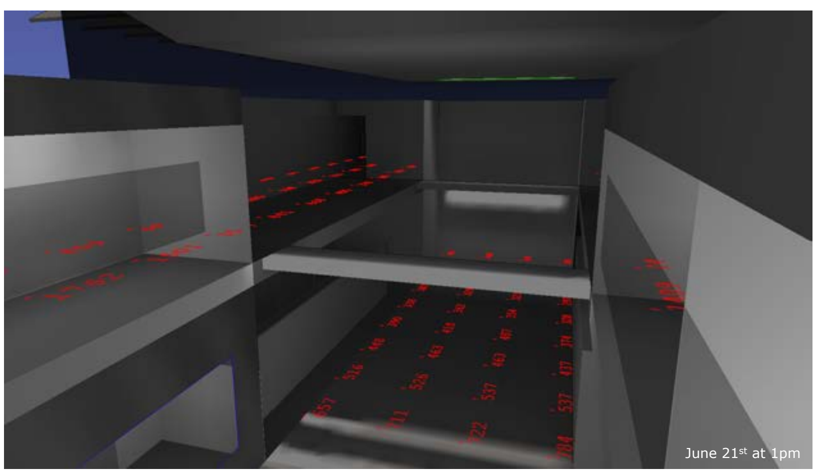
ALL FACETS OF LIGHT

Summer Midday:



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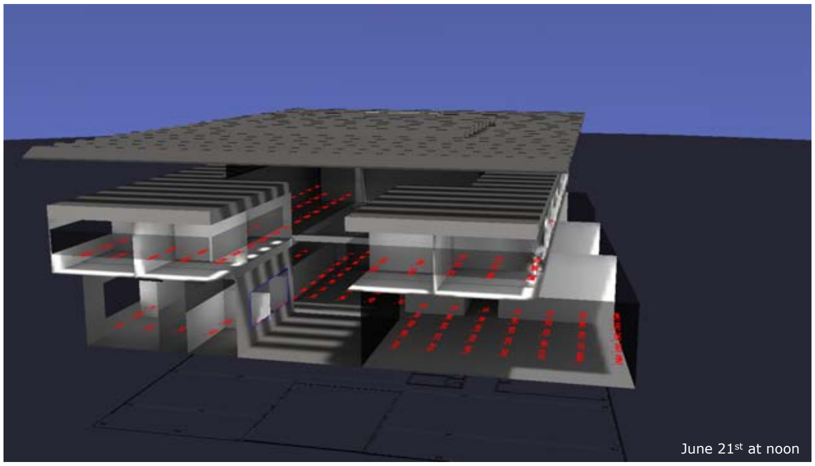
ALL FACETS OF LIGHT

Summer Midday:



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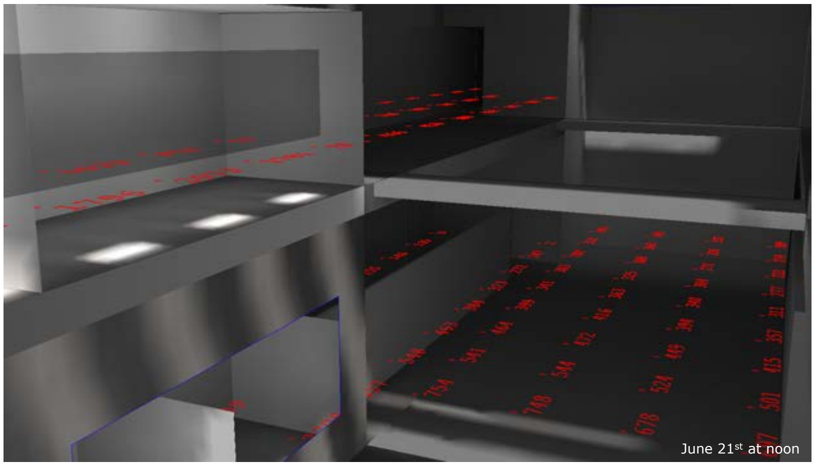
ALL FACETS OF LIGHT

Summer Midday:



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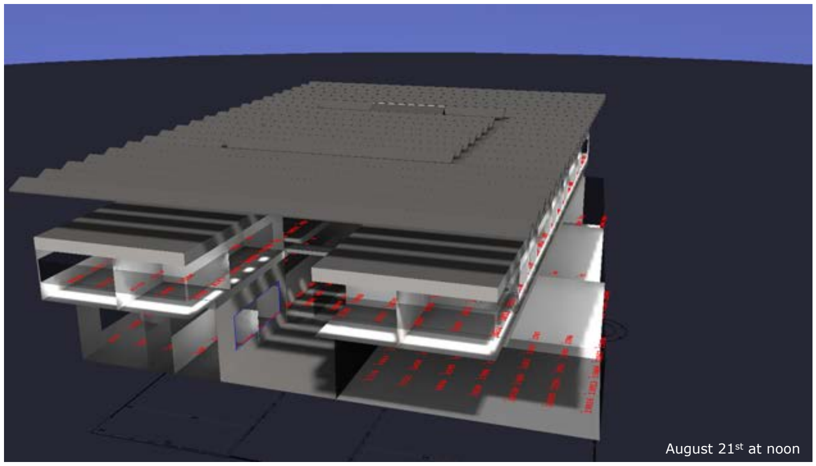
Summer Midday:



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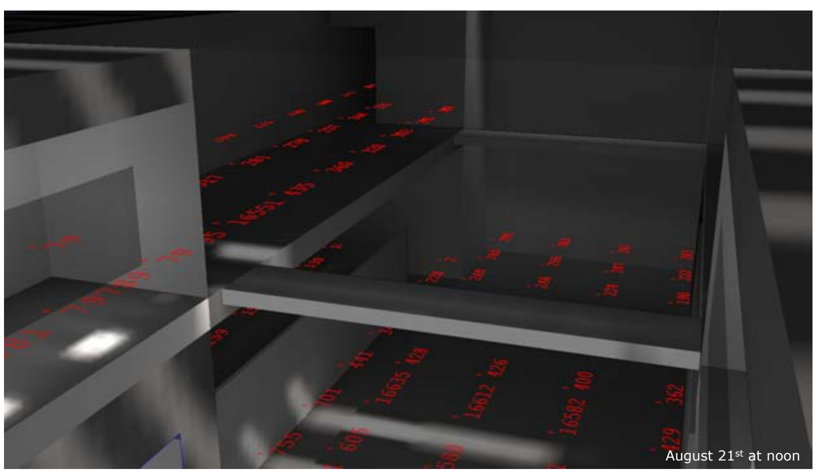
Summer Midday:



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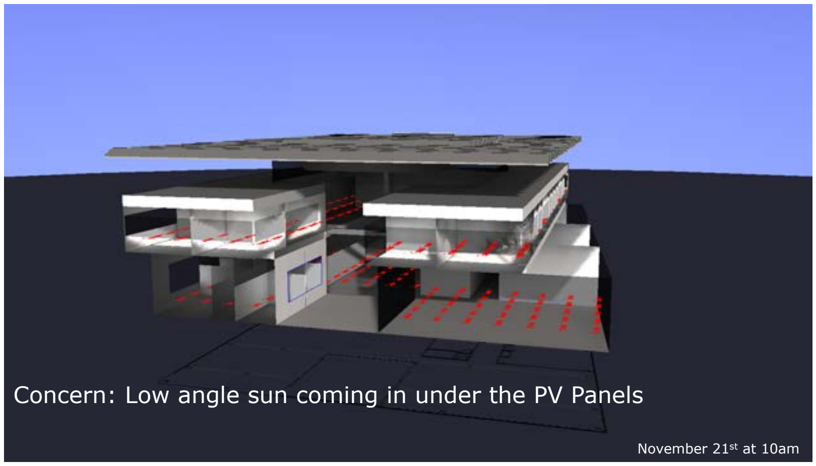
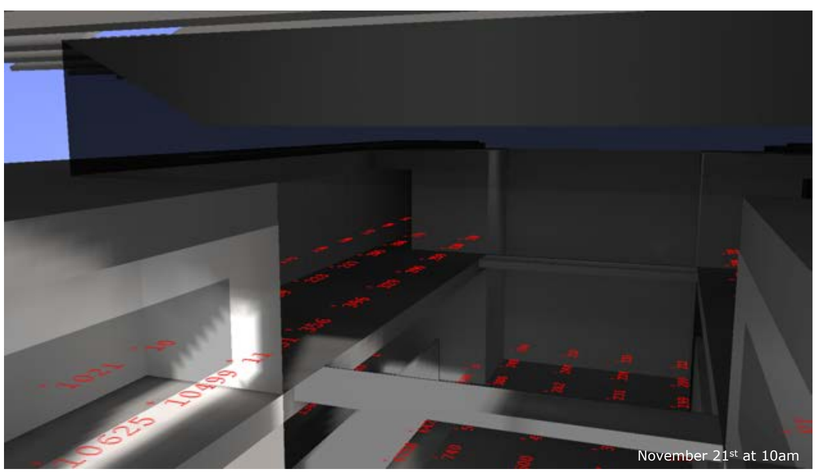
ALL FACETS OF LIGHT

Winter Mornings:



Winter Mornings:



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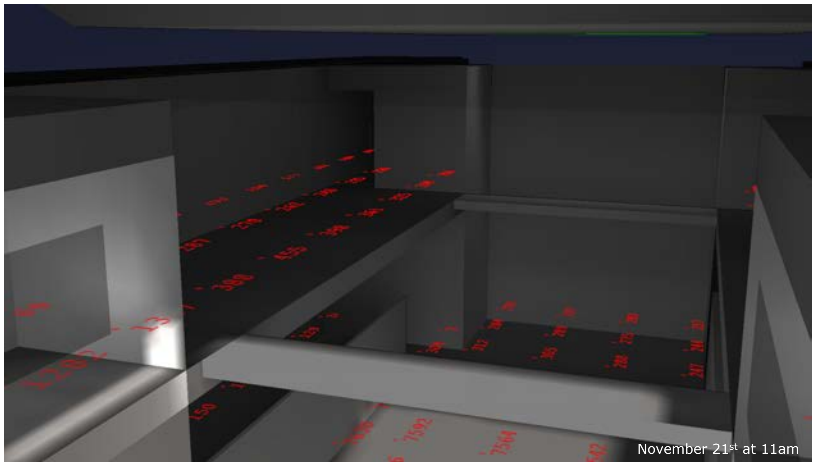

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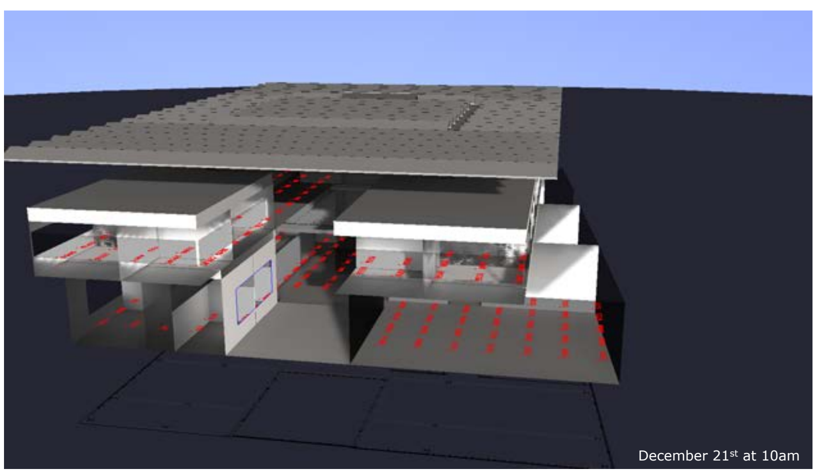

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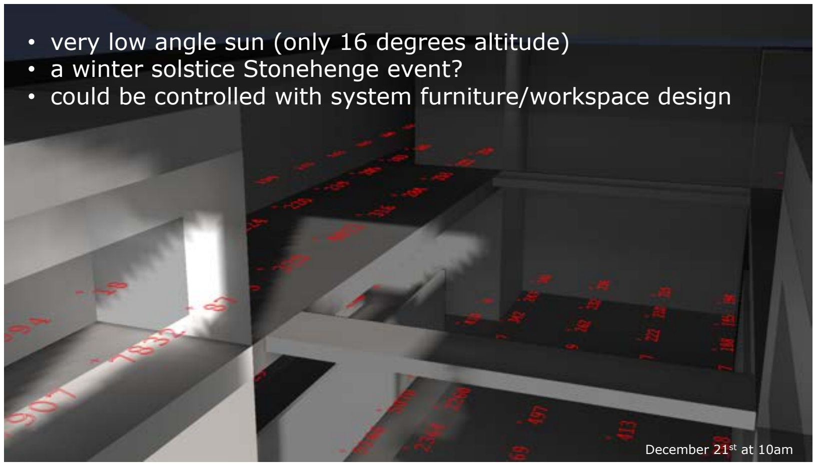

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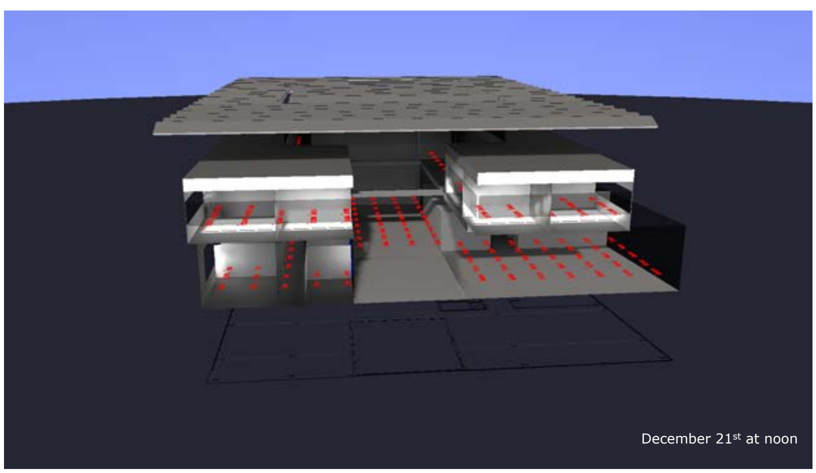

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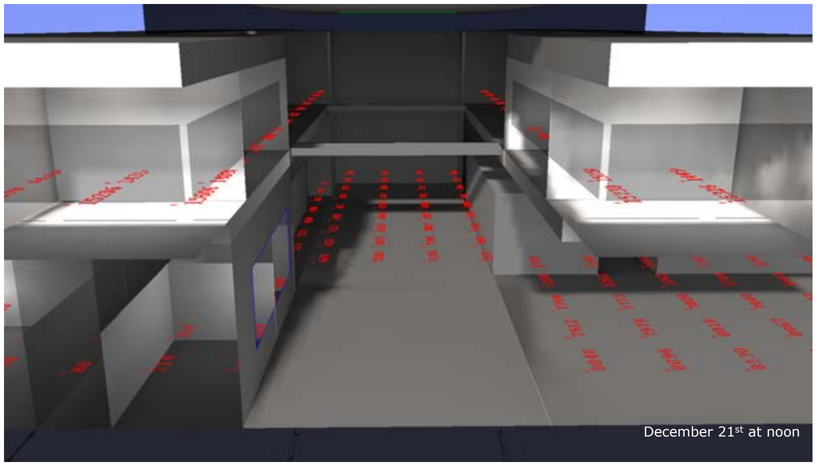
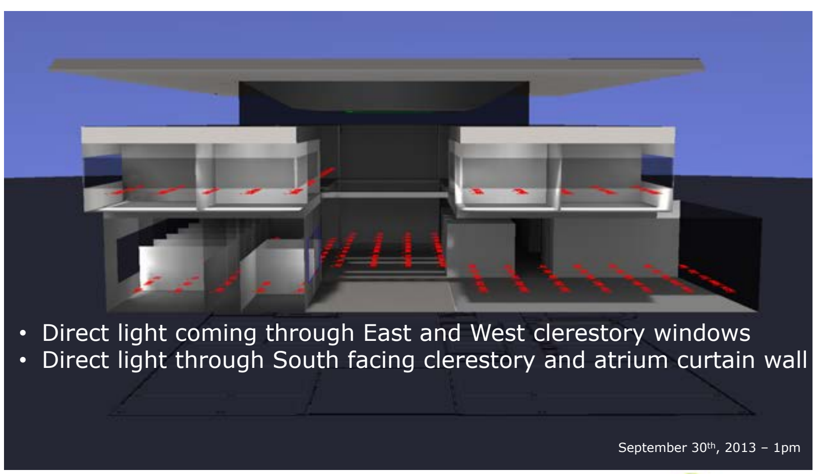


Glare Control



Recommendations

Glare Control required for direct light through clerestory windows

•Could be handled externally or internally

•External Option:

- Fixed metal louvres on underside of steel framework:
- Angled to block direct sun through clerestory windows,
- Will not interfere with solar panels
- Continues to allows indirect light through clerestories

•Internal Option:

- Architectural elements above or around third floor atrium work stations.

Recommendations

Consider effects of gaps between PV panels on direct light patterns in lower Atrium

- This will be a Spring and Summer, early morning and late afternoon condition
- Also midday for the southern portion
- Could be controlled with external option, as above