THE 'NORDSTROM TOWER': A LANDMARK DAYLIGHT INJURY STUDY

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Abstract

This paper describes a landmark daylight injury study whereby measures predicted using climate-based daylight modelling formed part of the legal agreement for the development of a skyscraper building in New York. Now known as the Nordstrom Tower, when completed in 2018 it will become the world's tallest residential building. The evaluation was carried out in two stages: original design proposal in 2005, and the final design in 2013. The background/context for the study, and the daylight injury evaluations carried out at both stages are described. The potential implications of this unique study for planning guidelines are discussed.

Keywords: Daylight Injury, Urban Planning, Climate-Based Daylight Modelling.

1 Background

Any new building will have a detrimental effect on the daylight provision to the surrounding buildings to a greater or lesser degree depending on the particulars of the proposed design and the existing context. The detrimental effect, or 'injury', can be determined by a variety of means depending on the mode of assessment. Attempts to systematise the assessment of daylight injury date back to at least the 1800s (Kerr, 1865). Daylight injury can be measured in terms of the reduced view of the sky or the diminished illumination from it. Or, it could be judged in terms of the potential reduction in direct sun insolation, either for particular times of the day/year or the number of annual probable sunlight hours (Littlefair, 2011). The method used may depend on local custom/practice or a legal requirement. In the UK, the possible infringement of "daylight adequacy" to an existing space by a proposed building is sometimes determined using the "rights to light" schema (Harris, 2007). For this, a sky factor of 0.2% delineates the so-called "grumble point". Areas of the space where the sky factor is greater than 0.2% are deemed to be "adequately" daylit. The sky factor is a measure of the illumination on a horizontal surface resulting from any direct view of a uniform luminance sky, expressed as a percentage of the horizontal illumination from an unobstructed view of the sky. Neither reflected light nor attenuation from any glazing are accounted for in the "rights to light" schema.

All of the existing measures for daylight injury are simplifications and/or idealisations of actually occurring conditions. The daylight illumination experienced by people in real spaces is the combined effect of skylight and (when present) sunlight, including the contribution of reflections from both outside and inside of the space. Because of the natural variability of daylight, any measure of injury should be based on a long-term evaluation rather than at just one or perhaps a few instants. Given the seasonal variability of daylight, the shortest truly representative period for evaluation should be a full year. This paper describes a landmark, and possibly still unique, evaluation of daylight injury which is founded on climate-based daylight modelling (CBDM). The evaluation was set in New York (USA), and the proposed building – now known as the Nordstrom Tower – it set to be the tallest residential tower in the world when completed in 2018.

1.1 Context: Building bulk, height and Zoning Lot Mergers

Building bulk in New York City is governed by the New York City Zoning Resolution which primarily uses the concept of Floor Area Ratios to regulate the amount of floor area allowed in a building. In Midtown Manhattan building height is not directly regulated, but the amount of floor area allowed is limited to a ratio of zoning floor area[1] to lot area. In the highest density district in New York City, the maximum floor area ratio (FAR) for a new residential building is 12 FAR (or 12 square feet of building area for every one foot of lot area). Commercial buildings can even be larger in the highest density districts, in some areas going up to 21.6 FAR with bonuses.

Yet, very large buildings have recently been built that to the casual observer appear to have FARs much larger than the maximums allowed under the Zoning Resolution. In most of these cases these very large buildings can be built because the Zoning Resolution also allows something known as a Zoning Lot Merger (ZLM). A ZLM is a legal agreement between land owners which merges adjacent tax lots so that they are considered as a single lot for the purposes of zoning. The mechanism is described in Section 12-10 of the New York City Zoning Resolution.[2] This mechanism allows owners of buildings that are smaller than what the underlying zoning allows to sell their unused floor area to adjacent developers while still controlling their existing building. ZLMs allow developers to build very large buildings that would not be allowed under zoning if the maximum FAR was calculated only on the property owned by the developer. A ZLM is commonly referred to as selling air-rights, but is actually more than just a transaction involving floor area, as all other zoning rules apply to this larger lot including: lot coverage, building spacing and legal windows. So, for example, a building on a merged zoning lot may be able to have windows allowing legally habitable rooms on the tax lot line because that line does not exist in the zoning lot. Floor area may also be transferred absent of a ZLM by buildings that have been designed as landmarks by the New York City Landmarks Preservation Commission.

1.2 The Art Students League of New York

The Art Students League of New York (ASL) is housed in a 4– and 5–story brick and limestone building on West 57th Street in Midtown Manhattan. The building is both historically and architecturally notable and has been designated a New York City Landmark. The ASL has educated many notable artists and remains a magnet for talent from around the world. This talent was educated, in part, in artist studios that occupy the top floors of the building. These artist studios have no artificial lights and are lit by north facing skylights. In the early 2000s, the lot directly to the west of the ASL was acquired by the Extell Development Corporation, which is the developer of some of Manhattans largest new buildings. Shortly after acquiring the lot, Extell started the process of merging its tax lot with neighbouring tax lots to make a very large zoning lot, which could house an extremely tall building.

A very tall building on the site would have views of Central Park, the southern boundary of which is just two blocks to the north. Views of Central Park are a desirable amenity for luxury residential units and the taller the building, the more units would have views of the Park, which provided incentive for Extell to merge lots with the ASL. Additionally, if Extell merged its lot with the ASL, lots neighbouring the new zoning lot could be extended to other lots adjacent to the ASL, so that the building could be made even taller.

The site is located in the Midtown Special District, which does not regulate building height. Rather, buildings must demonstrate that their form will not reduce the amount of daylight reaching the street below a certain standard. Implemented in 1982, the Daylight Evaluation (81-27) method of measuring the daylighting performance is based upon the Waldram Diagram. Generally, to meet the standard required by Daylight Evaluation, developers can build short squat buildings, buildings that step back in a wedding-cake fashion, or tall thin buildings. To maximise views and value, but to still meet the daylighting requirements, Extell has planned for an exceptionally tall and thin tower

In 2004 the ASL sold its development rights to Extell after studying the impact of the building on its skylights in detail. This first study was discussed in detail in Mardaljevic et al. (2012). That study showed the studios would experience significant impact to the amount of daylight they received, but the diminution of light could be mitigated by a change in design and/or the use of reflective materials. By 2013, the zoning lot was extended to include nearly the entire block, which resulted in significantly more development rights to use in the new building. Consequently, Extell proposed changes to the agreement with the ASL that included a significant change of design

[1] Zoning floor area is similar to building floor area, but does not include cellars, pipe chases, mechanical spaces, most accessory parking, and some other usually small areas of buildings.

[2] http://www.nyc.gov/html/dcp/html/zone/zonetext.shtml

of the proposed tower, including increasing its height from 689 feet to 1,435 feet, in addition to a design change that required a portion of the proposed tower to cantilever 28 feet over the ASL building, including its skylights. This new design would result in the tallest residential building in the western hemisphere, which is now proposed to cantilever over the north facing skylights that provide daylight to the artist studios, Figure 1.

The ASL needed to understand how much the increased height, new design, and the cantilever would impact the amount and quality of the light reaching the artist studios. Further, because the building was now cantilevering over a New York City Landmark, the project would need to get a Certificate of Appropriateness from New York Citys Landmarks Preservation Commission, which means that unlike the 2004 proposal, Extells new building – now called the Nordstrom Tower – would have to go through a public review. Similar to the 2004 study, the ASL needed to understand the impact of the changes to the proposed building on its skylights and again engaged the Environmental Simulation Center and Prof. Mardaljevic to study the new building and its impact on the quantity and quality of the light reaching the skylights.

Figure 1 – Art Students League building alongside superposed visualisation of the Nordstrom tower, plus two further visualisations of the tower

2 Daylight Injury: 2005 evaluation

The solution offered to the client was an assessment of the daylight injury in terms of realistic measures of illumination determined using New York climate data. Total annual illumination is a measure of all the visible daylight energy incident on a surface over a period of a full year. In everyday terms, this is equivalent to the cumulative measure of illumination recorded by a light meter left at a fixed position on a building for a full year. The potential daylight injury to the studios would be determined by predicting the total annual illuminance incident on the skylights for the existing situation and with the proposed building in place. For the client, the significance of these measures was readily understood since a decrease in incident illumination at these skylights translates directly into reduced daylight provision for the studios. The cumulative illumination was predicted using climate-based daylight modelling (Mardaljevic, 2006).

2.1 Climate data

Standard climate datasets contain hourly values for various irradiation and illumination quantities. From these it is possible to derive hourly-varying sky and sun conditions for use in lighting simulations. Equally, it is possible to synthesise cumulative luminance “maps” for arbitrary periods (e.g. annual, monthly, etc.) that contain the aggregated luminance effect of all the unique hourly sky and the sun configurations. Separate luminance maps for the annual cumulative sun and the annual cumulative sky were synthesised from the standard climate TMY2 dataset for New York City (WBAN# 94728). The hourly irradiance data were first interpolated to a 15 minute timestep and then converted to illuminance, Figure 2. The sky luminance pattern at each timestep was based on a blend of CIE clear and CIE overcast sky models depending on the Perez clearness index (Mardaljevic, 2008). The aggregated luminance map for the annual sky was the cumulative effect of all the individual timestep luminance patterns derived from the blend model (Figure 2).

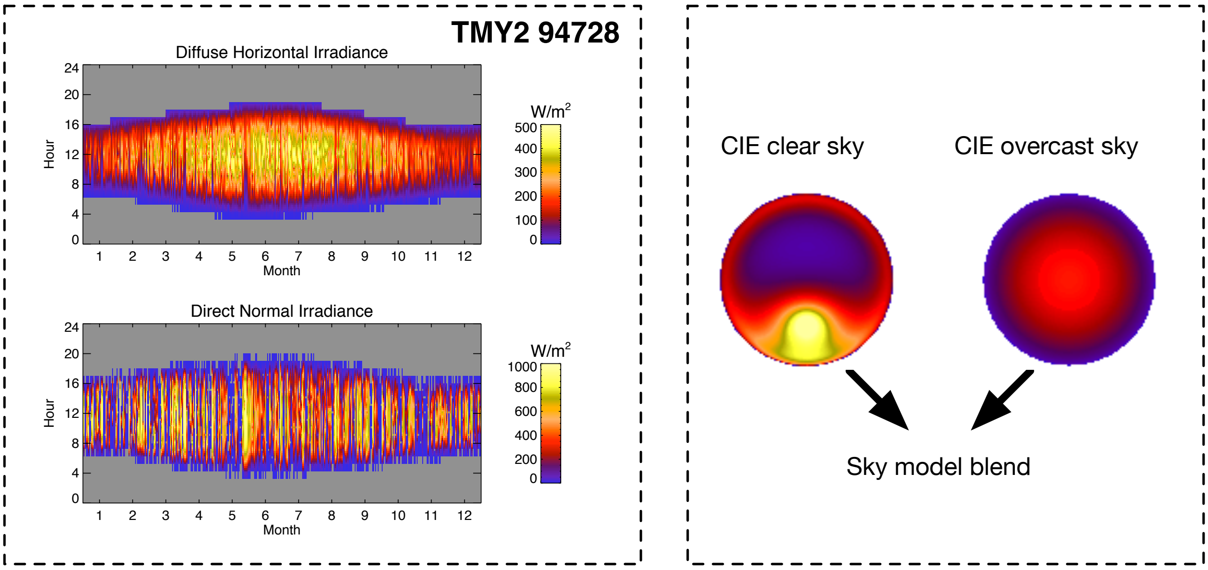

Figure 2 – Interpolated (15 minute timestep) irradiance data for New York and sky model blend

2.2 The 2005 building model

A highly detailed 3D model of the ASL and surrounding buildings was employed in the simulations. Renderings of the 3D model showing both the existing situation and with the proposed development are given in Figure 3. The two skylights – the only sources of daylight for the studios – are enclosed by the dashed-line ovals. Note that the skylights are not the same size. The cumulative luminance maps were used to determine the sky and sun components of total annual illumination (TAIL) incident on the skylights of the ASL. The simulations were carried out for the existing arrangement of buildings and with the proposed tower in place (Figure 3). Simulations with the proposed tower in place were carried out with the tower reflectivity set first to zero and then 50%. The zero reflectance case determines the diminution of TAIL with the tower acting purely as an obstruction. For the 50% reflectance case, the tower acts both as an obstruction and a reflector of light from the sun and the sky, including multiple reflections from other buildings. A reflectance of 50% is the highest that can be reasonably expected for an exposed vertical facade that is subject to weathering. The effect of intermediate reflectivity values for the proposed tower can then be determined from a simple interpolation of the results for the zero and 50% reflectivity cases.

2.3 The 2005 results

The area-weighted mean TAILs were 36,946 klux hours for the existing scenario, 23,455 klux hours with a tower of zero reflectance and 29,972 klux hours for a tower with 50% reflectance – a percentage reduction in TAIL against the existing case of 35.5% and 18.9%, respectively. The simulations showed that the building as planned had a potential to significantly impact the quantity of natural light that reached the skylights of the artist studios. The simulations also showed that the impacts on the skylights could be mitigated through both building design and materials.

In the terms that were agreed upon following the study, the final design for building had to be evaluated against the initial design proposal. This is believed to be the first – and perhaps still only – example in any city where the legal agreement covering the development of a site incorporates measures of daylight availability founded on CBDM. In 2008 the development project was put on hold following the global downturn in new construction projects.

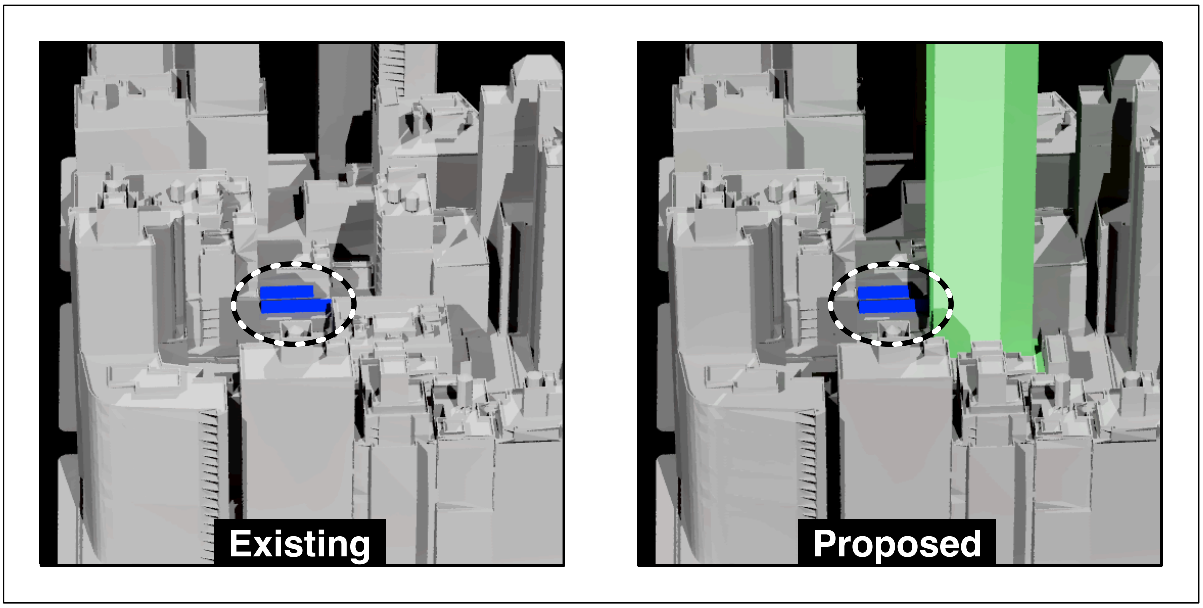

Figure 3 – 2005 evaluation of existing and proposed arrangement of buildings - skylights marked in blue and ringed

Figure 4 – Total annual illumination incident at the skylights for the existing and proposed cases (2005 evaluation)

3 Daylight injury: 2013 evaluation

The development of the 225 West 57th Street plot eventually restarted and, in 2013, a revised design was proposed. The new design – named the 'Nordstrom Tower – would be a very tall skyscraper, with a cantilever design that 'stepped over' the ASL building. As per the original legal agreement, the 2013 design had to be evaluated using exactly the same methodology to demonstrate that the level of daylight injury agreed between the parties in 2005 is not exceeded significantly by the new design.

A particular concern for the Art Students League, and indeed many others in New York concerned with planning and the city's skyline, was the Nordstrom Tower's cantilever which projected over the ASL building at a height of approximately 60 m above the rooflights. This is evident in the section drawing given in Figure 5.

3.1 The 2013 building model

Views of the 3D model used for the lighting simulation are given in Figure 6. The ASL roof detail had changed since 2005 and there were now five individual rooflight areas. As before, the rooflight areas function as 'sensor grids' for the calculation of total annual illuminance incident on the rooflights. The grid for each rooflight area comprised several thousand calculation points; the total number of calculation points for all five rooflights was over eighty thousand.

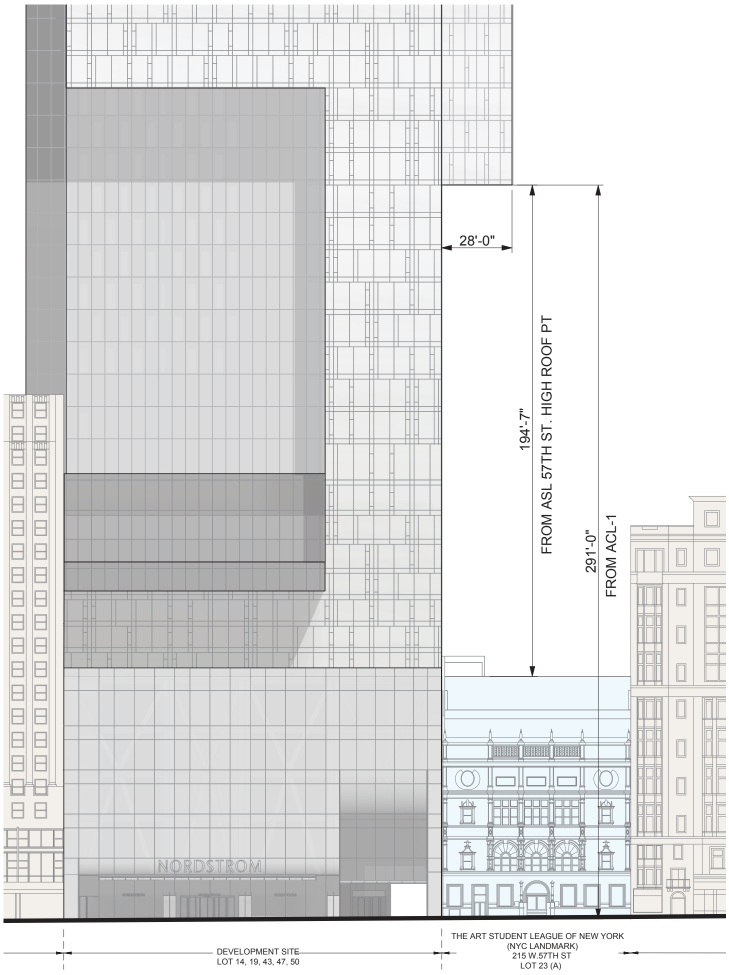

Figure 5 – Section drawing of the Nordstrom tower showing cantilever projecting over the Art Students League

3.2 The 2013 results

The same climate data and methodology for preparing the cumulative annual sun and sky models used for the 2005 evaluation were employed again for the 2013 predictions of daylight injury. The existing condition was repeated for the new arrangement of five rooflights, and now the daylight reduction was evaluated on a per-rooflight basis rather than calculating a single area-weighted value as used in the 2005 evaluation.

The results are shown in Figure 7. The total annual illuminance received at the rooflights for the 'Existing' case is, as expected, very similar to that predicted in 2005. The small differences between the 2005 and 2013 results are due to the different configuration of the rooflights – two of the rooflights are divided according to the separate studio spaces that they illuminate. The results for rooflight to Studio 5 are summarised in Table 1.

Despite the monumental visual impression of the development conveyed by the concept renderings of the Nordstrom Tower (Figure 1), the daylight injury to the ASL skylights was found to be only marginally greater than that agreed upon for the original design in 2005. The Nordstrom Tower design was finally approved in late 2013 following much heated debate amongst key stakeholders.[3]

[3] Link to article: **Judge dismisses Art Students League suit over Extell tower**

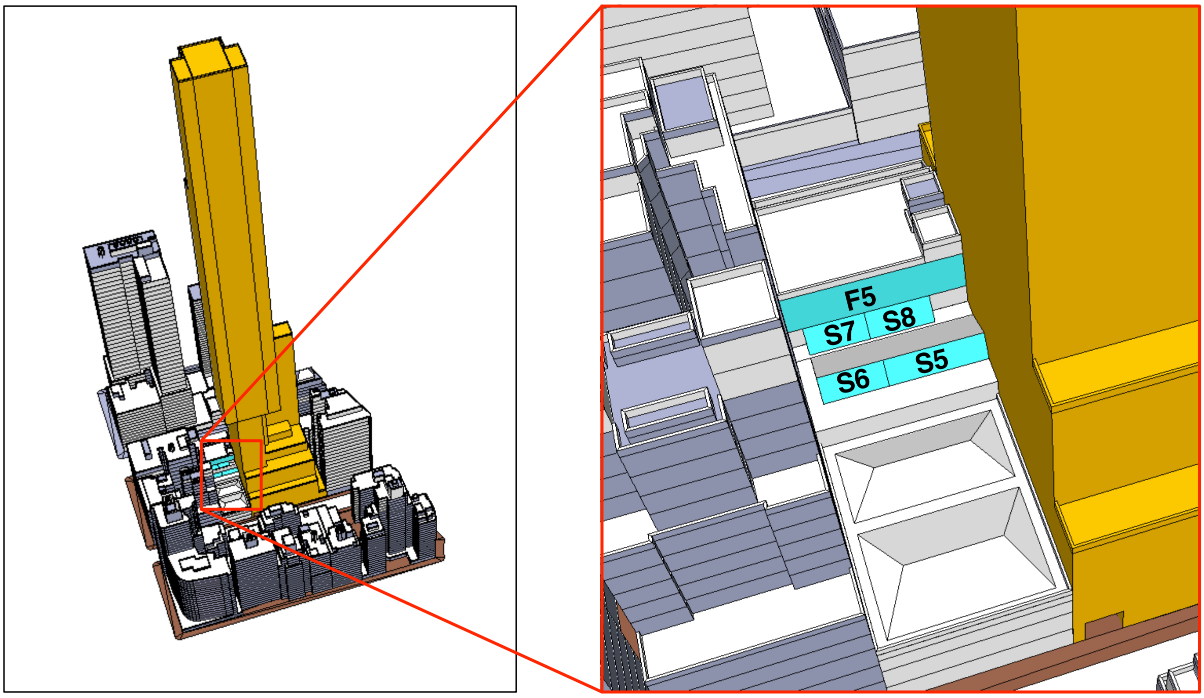

Figure 6 – CAD model of the Nordstrom tower and new arrangement of rooflights (shaded blue) on the Art Students League building

Table 1 – Predicted change in total annual illuminance (TAIL) caused by the proposed tower and 'alternative' (without cantilever) for the rooflight to Studio 5

Case	Predicted TAIL [klx hrs]	Change in TAIL [%]
Existing	39,136	
Proposed 0% refl.	22,426	-42.7%
Proposed 50% refl.	29,499	-24.6%
Alternative 0% refl.	22,857	-41.6%
Alternative 50% refl.	30,181	-22.9%

4 Discussion

The information from the simulations was used in at least two ways. First, and most importantly, they showed the ASL management that there was real risk to the amount and quality of the light reaching their artist studios. In other words, unlike most Zoning Lot Mergers where the seller has little risk of impairing their property, the ASL faced a very real risk of a diminution of an important asset. Knowing these risks, the ASL was more informed during negotiations with Extell regarding the Zoning Lot Merger. Second, the simulations helped to guide the legal agreement for the Zoning Lot Merger that came out of the negotiations. Extell has agreed to attempt to minimise the impact their building will have on the skylights to the greatest degree possible, provided the developer is still able to use all the floor area he has acquired. Extell has further agreed to provide the ASL plans for the proposed building early in the design process so that the ASL can evaluate the buildings impact and suggest ways an alternate building design could mitigate impacts. The developer has reserved the right to build a building that may seriously impair the light received by the skylights, but this would require a one-time payment of $10,000,000 to the ASL for damages.

The nature of this study was certainly unusual for New York City. Codified in the City's environmental reviews are requirements for shadow studies, but except in very limited circumstances, proposed projects are not required to study impacts on daylight, on either public or private property. This is ironic considering that one of the major reasons for the adoption of the nation's first

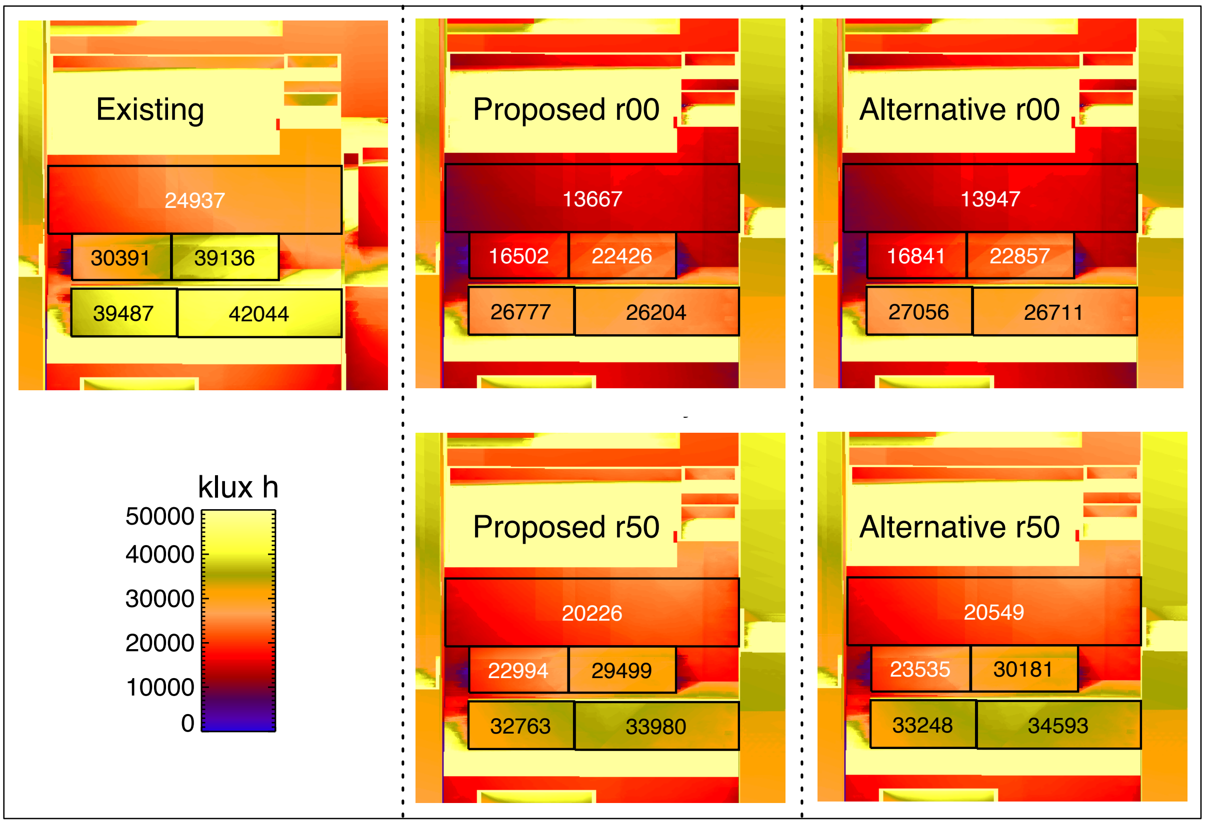

Figure 7 – Results from the 2013 evaluation – proposed building with and without ('Alternative') the cantilever

zoning ordinance, the 1916 New York City Zoning Resolution, was because very large buildings (such as the famous 31-story Equitable Building) were built with no setback from the sidewalk and created very dark streets. The darkness these buildings created was only partly related to the shadows they cast, of course, and have much more to do with the amount of sky that is visible from the street. The New York City Zoning Resolution recognises that the sky is important to creating light and attractive streets, and requires in many zoning districts sky exposure planes to ensure that light reaches the street below. Indeed, the Mid-town Special District adopted in 1982 includes a performance-based sky exposure system based on the Waldram diagram that helps to shape the building form to maximise sky-exposure from street level (Hopkinson et al., 1966). Nevertheless, despite these relatively innovative regulations to increase the exposure to sky that are already part of New York City's law, developers are never required to measure their proposed project's impact on daylight.

The ASL study helps to show both how simple and how important it can be to study the impact of a proposed building on neighbouring buildings and at the street/sidewalk level, and that simulation can be used to inform design and minimise impacts. Considering the state of the current practice, the time may be coming when instead of simply following a predetermined sky exposure plane that may or may not impact light reaching the street, a designer can demonstrate how a proposed building will actually diminish light levels at the street. Such concepts shouldn't be revolutionary, yet when they regard regulations that are slow to change, they often are.

The ASL study also has implications for the UK where the almost century-old "rights to light" schema devised by Waldram for the determination of daylight injury has recently been critiqued in a number of papers (Chynoweth, 2004) (Chynoweth, 2005) (Chynoweth, 2009) (Defoe et al., 2007). The measure of daylight used in the Waldram method is direct sky illumination under a uniform sky (without sun). It is now believed that this measure has little correspondence to commonly perceived notions of daylight sufficiency. In 2013 the UK Law Commission began a public consultation on "Rights to Light".[4] The 2005 ASL evaluation was submitted to the Commission as part of the consultation exercise and it was noted in their final report.[5]

The existing daylight injury measures are largely irrelevant for the purpose of, say, determining the injury (i.e. degraded performance) of some solar-dependent building technology, e.g. BIPV. Indeed, for photovoltaics a decrease in total annual illuminance (or alternatively, irradiance) has direct correspondence to the degradation in performance caused by the introduced over-shadowing. Thus, the analysis described for the ASL building could help to quantify the reduced output of a BIPV array, and so provide a basis for financial compensation to indemnify the owner for the reduced performance of the system. BIPV installations are costed on a performance life-time of 20 years or more, during which time it is quite probable that an unforeseen building development could be proposed that over-shadows the BIPV array to some degree. As yet there is no technical-legal framework to assess the degree of injury. Climate-based daylight modelling however, using standardised climate files, is well suited to provide the technical basis for any legal procedure(s). For any such application it would be vital to ensure that validated, 'best practice' modelling procedures were used, and that this could be verified from the documentary evidence in the technical report.

It may be some time before it is possible to gauge the full impact of the study reported in this paper. In 2013 the UK Education Funding Agency (EFA) made climate-based daylight modelling a mandatory requirement for the evaluation of designs submitted for the Priority Schools Building Programme (PSBP) (Education Funding Agency, 2014). This is believed to be the first major upgrade to mandatory daylight requirements since the introduction of the daylight factor more than half a century ago (Mardaljevic, 2015). In the US, a climate-based daylight metric approved by the IESNA has appeared in the latest version of LEED (Illuminating Engineering Society, 2012). In light of these developments, it seems likely that sooner or later climate-based daylight modelling will become a routine part of the evaluation of daylight injury at the planning stage. Until that time, the ASL / Nordstrom Tower daylight injury study will serve as a manifest demonstration of the application of a new approach to solving a long-standing planning issue.

Acknowledgements
Prof. Mardaljevic acknowledges the support of Loughborough University. The images in Figure 1 and Figure 5 are from the "Application for a Certificate of Appropriateness made to the New York City Landmarks Preservation Commission for the Broadway Trio, LLC project at 217 West 57th Street New York, NY; 4 March 2015" – a public document with no known restrictions on fair use.

References

CHYNOWETH, P., 2004. Progressing the rights to light debate – part 1: a review of current practice. *Structural Survey*, 22(3), 131–137.

CHYNOWETH, P., 2005. Progressing the rights to light debate: Part 2: the grumble point revisited. *Structural Survey*, 23(4), 251–264.

CHYNOWETH, P., 2009. Progressing the rights to light debate: Part 3: judicial attitudes to current practice. *Structural Survey*, 27(1), 7–19.

DEFOE, P. and FRAME, I., 2007. Was Waldram wrong? *Structural Survey*, 25(2), 98–116.

EDUCATION FUNDING AGENCY, 2014. EFA daylight design guide - version 2. *Deaprtment For Education, UK*.

HARRIS, L., 2007. *Anstey's Rights of Light and How to Deal with Them*. 4th edition, RICS Books, London.

HOPKINSON, R. G., PETHERBRIDGE, P. and LONGMORE, J., 1966. *Daylighting*. London: Heinemann.

ILLUMINATING ENGINEERING SOCIETY, 2012. Approved Method: IES Spatial Daylight Autonomy (sDA) and Annual Sunlight Exposure (ASE). *IES LM-83-12*.

[4] http://lawcommission.justice.gov.uk/consultations/rights-to-light.htm
[5] http://lawcommission.justice.gov.uk/areas/rights-to-light.htm

KERR, R., 1865. *On Ancient Lights: And the Evidence of Surveyors Thereon : with Tables for the Measurement of Obstructions*. J. Murray, London.

LITTLEFAIR, P., 2011. Site Layout Planning For Daylight And Sunlight: A Guide To Good Practice 2nd Edition. *Building Research Establishment*.

MARDALJEVIC, J., 2006. Examples of climate-based daylight modelling. *CIBSE National Conference 2006: Engineering the Future, 21-22 March, Oval Cricket Ground, London, UK*.

MARDALJEVIC, J., 2008. Sky model blends for predicting internal illuminance: a comparison founded on the BRE-IDMP dataset. *Journal of Building Performance Simulation*, 1(3), 163–173.

MARDALJEVIC, J., 2015. Climate-Based Daylight Modelling And Its Discontents. *CIBSE Technical Symposium, London, UK*, 16-17 April.

MARDALJEVIC, J. and JANES, G. M., 2012. *Solar Energy at Urban Scale*, chap. Multi-Scale Daylight Modeling For Urban Environments. John Wiley and Sons, Inc.