Regulate for Light, Air and Healthy Living

Part III - The becoming of PNAP 278

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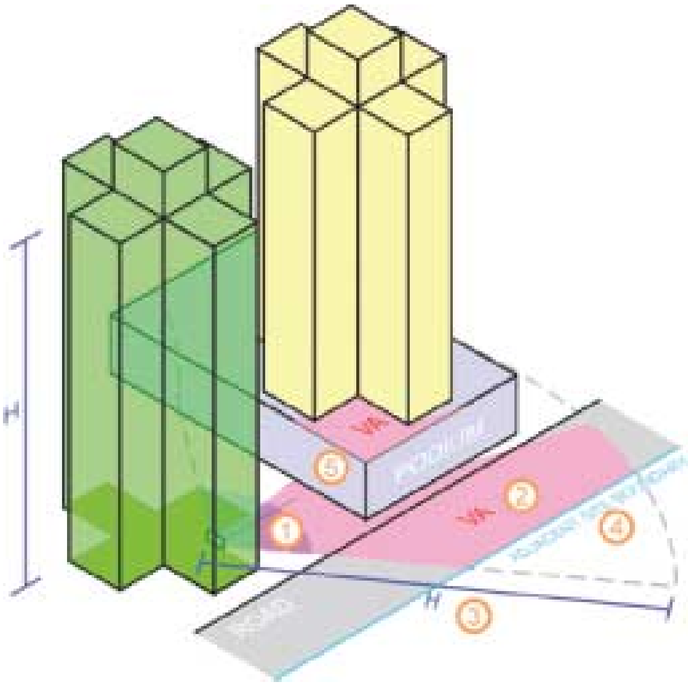

Figure 1: The UVA rules under PNAP 278

"If there is an open space, on plan, in front of a window as defined in the Unobstructed Vision Area (UVA) rules of X square metre, then there is a 75% probability that the amount of daylight receivable on the window pane will equal or exceed Y% Vertical Daylight Factor (VDF)."

Background

From the barren rock to the metropolis, Hong Kong has witnessed changes beyond imagination. The building regulations, began in 1903, were followed through until 1956. Then they stalled and have only recently been revisited. Part 1 of this series of papers traced the history of regulating natural light and ventilation to pre-history times in the UK. It provided a glimpse of what were to happen in Hong Kong later. Part 2 followed up with a history of the same in Hong Kong. Part 3 continues the story about a recent attempt by the Buildings Department to review their building regulations of lighting and ventilation in Hong Kong and the efforts accumulated to the introduction of PNAP-278 in early 2004.

PNAP 278, especially the lighting for domestic buildings portion of it, is the result of a technical consultancy agreement and some 4 years of work by researchers at the Chinese University of Hong Kong (CUHK). This paper summarises the path walked and some of the untold basis of its content. It serves to inform architects of Hong Kong its rationale and its fundamentals. The purpose of this paper is such that architects could have an informed basis when using the practice note.

Introduction

According to United Nations data, around 20 cities in the world nowadays have 10 million inhabitants or more. This number will continue to increase in years to come as human settlements continue to urbanise and industrialise. In cities like these, people are fighting for their share of space, and buildings are fighting each other for their exposure to natural light and ventilation. Develop designs to optimize the occupants' right of enjoying daylight and natural ventilation is an important task of the government, architects, engineers and industry stakeholders. Naturally lit and ventilated buildings are not only energy efficient, but also psychologically more peasant and potentially be more comfortable for their inhabitants, as well as being "green" and "sustainable".[1] [2]

Hong Kong is the most densely populated city in the world. Typically, residential buildings are built to a high plot ratio and high site coverage. This leads high rise towers built very closely together with very high site density. (Figure 2)

Light and ventilation for buildings in Hong Kong is governed by the Building Regulations [CAP. 123 Building (Planning) Regulations - Part IV Lighting and Ventilation (Clause 29-37)].[3] The current laws are more than 40 years old and, as demonstrated in Part 1 of this series of papers,[4] they were based on an aged UK model originally for a completely alien context than contemporary Hong Kong.[5] As previously illustrated, in Part 2 of this series of papers,[6] the assumptions and spirits underlining the UK model, which made the regulations appropriate when they were first applied, are no longer valid in contemporary Hong Kong.

Current regulations prescribe a minimum distance in the form of rectangular horizontal plan (RHP) between building blocks based on the concept of vertical angle requirements (currently 71.5° for living rooms and bedrooms), and a minimum glazing to floor ratio of 10%. (Figure 3, 4 and 5) However, the provisions have been proven to be ineffective. Worse still, they actually allow bad designs and discourage good designs. (Figure 6) The current regulations on daylight are dated; even China now has a better standard.[7] A new regulation is undoubtedly needed.

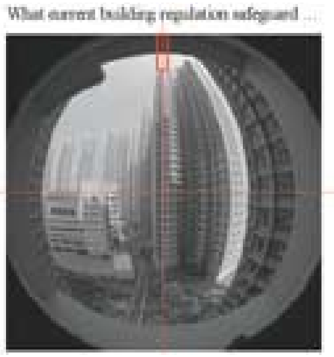

Figure 4: Current building regulations assures a tiny portion of the sky as indicated.


Figure 2: Old and new, the high-density cityscape of Hong Kong

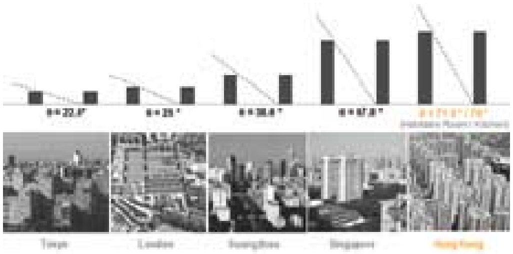
Figure 3: The vertical obstruction angle requirements of building regulations around the world

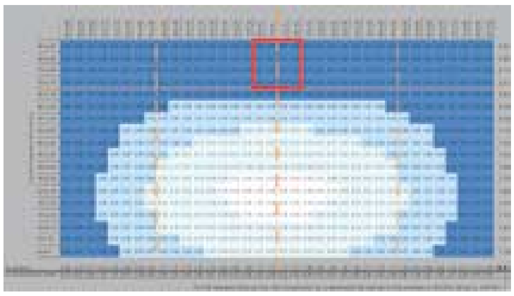
Figure 5: Based on the luminous distribution of the CIE overcast sky, the brightest portion of the sky (indicated white) in about 35° from the horizontal directly in front of the window. The portion of the sky the building regulations assures (marked red) accounts less than 2% of the daylight available to the window from an unobstructed sky.


Figure 6: (Right), the window facing into a narrow space and obstructed by an opposing building is allowed by the building regulations as long as the far wall perpendicularly in front of the window observes the 71.5° RHP requirement. (Left), the window facing directly a high block which is a bit too close, but with an open space on its left, is not permitted.

The Team

Noting some of the irregularities, the Buildings Department HKSAR (BD) in 1999 decided that a comprehensive review of the regulations was imminent. With the industry's support, they appointed Anthony Ng Architects Ltd (ANA) as the lead consultant to carry out the study. BD and ANA, supported by an army of specialists (table 1) spent the next 4 years of so on the task. The efforts were unprecedented for its seriousness of intent. There seemed to be an untold spirit behind almost everybody working on the review that, one way or another, the regulations must be updated and be made relevant for Hong Kong. This spirit held the team together and at times helped to overcome obstacles and confusions.

Areas of study	Specialists
Lead consultant	Anthony Ng Architects Ltd.
International code, non-domestic spaces	Ove Arup (HK) Ltd.
Air ventilation	Department of Building Services, HKPolyU & Ove Arup (HK) Ltd.
User survey	Department of Architecture, HKU
Lighting	Department of Architecture, CUHK
Health matters	Department of Family Medicine, CUHK
Planning matters	Townland Consulting & Ltd
Regulation matters	Professor Banabas Chung
International experts	Professor Baruch Givoni (ventilation), Professor Peter Tregenza (daylighting)
Survey (lighting) consultant	Professor Chan Ying Keung, Department of Social Science, CUHK

Table 1: key specialists on the job

Members of the large team each have their roles. And each will tell their portion of the story. This paper intends to tell a subset of a bigger story: the investigation of daylighting for domestic spaces by the research team at the Department of Architecture, CUHK under the directorship of Professor Edward Ng.

The Study Methodology

The research team at CUHK followed the following scientific methodology. (Table 2) With slight adjustments, the methodology could be used for other similar investigations.[8] [9] The work was the result of close consultations with Professor Peter Tregenza. Peter was the Chairman of the British Standard Committee responsible for the drafting of UK's BS8206 Part 2 - Daylighting.[10] He had been instrumental in guiding the process of this study,[11] and he must be credited with an insight to distinguish the difference between "minimum" and "reasonable" standards, and the need to develop a range of guides and requirements for designers. His insight was no doubt based on his vast standard making working experience in the UK.

- A review of the existing conditions of the built environment in Hong Kong, and to identify problem areas
- A historical review of the current building regulations. Note their historical basis, developments, assumptions, context of application, as well as limits.
- A territory wide user survey to note the performance requirements of local inhabitants and to establish performance criteria acceptable to them.
- Based on the performance criteria, develop easy-to-use and deem-to-satisfy design rules and guidelines that could easily be applied and evaluated in the day-to-day practice of architecture.

Table 2: Methodology of study of daylighting for domestic spaces

On-site measurements

It was important to know the problem one is solving; else one risks solving the wrong problem. On-site daylight measurements were conducted in a number of dense housing estates over a period of 6 months in 2000-2001.[12] The survey works required very expensive and sensitive equipment to be used.[13] The CIE overcast sky definition was used as a reference standard for the study. [14] The task turned out to be a lengthy process. While setting the equipment up was straightforward, selecting and obtaining suitable units for measurement, rotating the photocells and waiting for the sky to turn overcast were not predictable. 6 months lapsed before the task was finally completed.

It was noted that daylight performance at the lower floors of high-rise residential development, especially those facing into the estate (i.e., inter block overlooking), was very poor. Vertical Daylight Factors (VDF) of approximately 6% to 8% were recorded on the window pane when these windows were not obstructed by adjacent units of itself. Once the window panes are recessed from the facade (i.e., intra block shading), even less were recorded (about 2 to 4%). The room average daylight factors for habitable rooms were typically in the order of 0.2% - 0.3%. Since rooms are deep (up to 9m), daylight at the rear was very poor indeed. Kitchens located at the rear end of a deep re-entrant recorded close to 0.0% - 0.1% Internal Average Daylight Factor (DF), or hardly any daylight at all. (Figure 7) Some key problems were identified. Whilst satisfying the building regulations, these windows do not provide adequate daylight to their respective interior spaces. (Table 3)

Figure 7: Daylight performance of a residential unit in high density sites in Hong Kong. Daylight Factor at the rear of the space is about 0.2%. The sensor V1 on the front face of the living room measures 7% VDF in this case. The sensor VK of kitchen window measures 5.3% VDF.

A	Windows placed inside deep re-entrant (deep recesses from the main facade).
B	Windows facing into narrow streets where no height restriction is in enforced.
C	Windows placed in the 'large' light well formed by surrounding building blocks.
D	The misuse of the regulatory Rectangular Horizontal Plane (RHP). This results in tight spaces being formed between building blocks.
E	Windows not properly positioned to effectively illuminate the space.

Table 3: Existing problems identified after the on-site measurement

Historical studies

A thorough historical review was conducted to establish the rationale, basis and more importantly the boundaries and limits of the current building regulations. Much of the details of the study have been published in Parts 1 and 2 of this series of papers. It is assumed that readers have already acquainted with their logics. The process leading to the findings was interesting to note. When the study was first formulated, much effort was spent in Hong Kong to locate antiquated documents in the Public Record Office. Buildings Department informed that they don't have anything beyond the Japanese occupation. A few useful building plans and drawings dated back to 1956 were located. Architects of the time were already trying their best to "maximize" what the laws allowed! At the Legislative Council library, The Hansard, Gazette and all Year Books were referenced. They provided a backbone to the content of the report. Unfortunately, none of the detail minutes of the committees who had dealt with the legislations could be found. The study in Hong Kong led to the need to go further. As many local references were made to the UK, in the summer of 2001 and 2002[15], the author went to the UK and spent a total of 2 months researching in libraries and archives for clues. Results of the study have been published in Part 1 and 2. The most important finding was the discovery of the original Osbert Chadwick 1882 report in the Public Record Office of Kew Garden - quite accidentally amidst the files of the Commonwealth and Indian Office, and proceeded by some intense diplomatic exchanges of the Sugar trade in the region!

Two important findings of the historical study must be highlighted. Firstly, the current regulations assume a "mutually respected" spirit between one building and another. That is to say, by control oneself, one also expects others to do the same, hence resulting in a reasonable mutual relationship. Secondly, there is a "sharing" and "borrowing" spirit based on an assumption of a certain known building morphology and arrangements. For example, it was assumed that all windows were on the facade of the building without substantial recesses. Hence if a row of windows each could have their share of open space directly in front (in the form of RHP), the result would be a continuously larger, or longer, space in such a way that the benefits guaranteed by the adjacent windows could be shared to enhance one's enjoy of the natural elements. Sin against these unwritten spirits, the law has little meaning.

User survey

What is the acceptable daylight performance of its occupations for the type of high-density dwellings that Hong Kong is building? Daylight performance standards exist and are stated in various documents, for example British Standard 8206 Part 2. Some of these standards were established largely based on experimental data of human responses.[16] In urban Hong Kong, buildings have a lower overall daylight performance. It could be hypothesized that inhabitants could acclimatize to accept a lower daylight standard and this is dependent on various socio-cultural and climatic factors.

To establish this acceptable 'minimum' standard of daylight performance of high-rise residential buildings, user survey and computational simulation were used. 12 major high-density housing estates were selected. At the same time, daylight performances of around 6000 windows of the 12 housing estates were computed using simulations (Figure 8). Lightscape[17] was used as it has previously calibrated by the CUHK team.[18] From the computed results, daylight availability of the windows of each of the residential unit that were user surveyed was identified and coded into the survey forms. The performance data of each of the space and the associated user responses were then used to compute user satisfaction rates.

Results of the study indicated that the minimum acceptable daylight performance levels of inhabitants of Hong Kong are very low. Most of the people surveyed expressed an attitude of indifference to daylight. Only when daylight performance is obviously low that people begin to notice and complain about it. This switch of opinion happens very quickly at a certain threshold level. Thus, although the minimum acceptable standard is low, the fact is that it exists. Based on the data available, it was possible to calibrate a standard based on this switching behaviour.

For living rooms, it was noted that satisfaction rate stays at around 80% when VDF is 10% or above. Satisfaction rate goes up as the amount of available light increases; however, this improvement is not significant. In short, there is little to be gained by providing say 15% VDF or 30% VDF. However, once daylight performance falls below a certain level, around 8% in this case, satisfaction rate drops very rapidly.

For bedrooms, people generally prefer to a higher daylight standard. The satisfaction rate stays at around 80% when VDF is above something like 20%. Between VDF of 10% to 20%, around 70% finds it acceptable. Acceptance rate drops off below something like 7% to 8% VDF.

For kitchen, the acceptable minimum standard is very low. This may have to do with inhabitants getting used to the generally poor performance of existing building design. At 4% VDF, around 80% of the return still expresses that it is satisfactory. Below that, acceptance rate falls very rapidly indeed. This confirms that despite a low standard, a threshold exists.

Based on the survey results, it was recommended that an 80% satisfaction rate be used for establishing the performance standard threshold (Figure 9). And for simplicity of operation, living room and bedroom were considered together as habitable rooms. For the minimum acceptable threshold, Vertical Daylight Factor (VDF) for habitable room should be at least 8%. For kitchen, it should be at least 4%.[19] The findings so far is preliminary. Currently the CUHK team is employing more sophisticated Signal Detection Theory algorithms to further elaborate the data and statistical analyses.

When the 8% and 4% performance standards were proposed, there had been a tendency to lower it to 4% and 2%. Many points of view were tabled and debated. The higher standards were finally adopted for two key evidences presented. Firstly, photographs of windows with 8, 4 and 2% VDF were illustrated. (Figure 10) They generated a sort of gut feeling as to what the threshold should be. Secondly, a test was conducted to hypothetical buildings built 'true' to the spirit of the current regulations. It was found that typically they could achieve a VDF of some 6-8% for the habitable rooms; hence 8% VDF really represents a similar outcome with perhaps a small improvement.

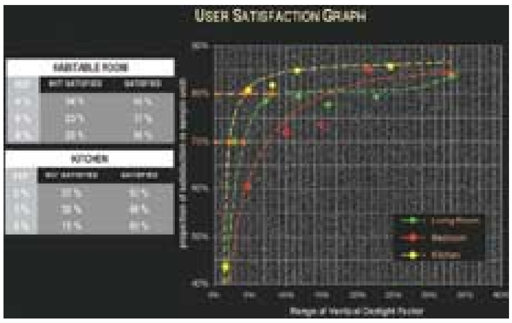

Figure 9: User satisfaction vs. simulated daylight (VDF) performance of Living room, Bedroom and Kitchen


Figure 8: The 12 surveyed estates simulated using Lightscape

Figure 10: Examples of fisheye lens photographs illustrating windows with different 8% and 4% VDF for habitable spaces.

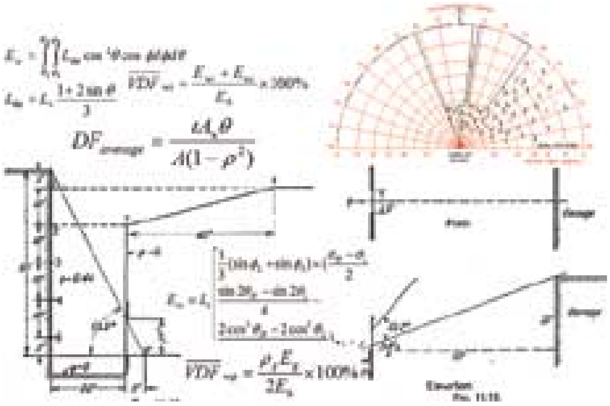

Figure 11: Mathematical formulae and methods and available to predict daylight performance of buildings. However, they are cumbersome to use.

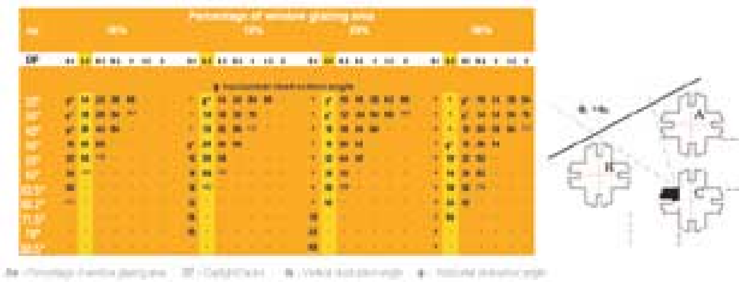

Figure 12: The initial table proposed to BD based on the split flux formulas

An interesting viewpoint was also exchanged. A question was asked if "without daylight, will people die?" The reply from the CUHK team was that, "No, people won't die immediately without daylight, but the consequences of not dying could be worse!" The debate brought out an important point of the definition of "health" and "comfort" or "psychological well-being". The CUHK team tends to adopt the definition of the World Health Organisation, which sees that the two terms are synonymous. If one wishes to split hair, the only difference could be a matter of "absolute minimum" and "reasonable minimum".

Design Tool

How to formulate a simple method for daylight design and building regulations was the next task. It was important to strike for "simplicity" and "reasonable accuracy" at the same time.[20] (Figure 11)

Scientifically, the amount of daylight one gets from the external environment only depends on two factors: the amount of sky one sees (Sky Component), and the amount of reflected light from objects outside the window (External Reflected Component). Using the CIE sky definition, the effect of orientation can be ignored, and the sky is around 3 times brighter above than on the horizon. A vertical window seeing an unobstructed sky would get a maximum of around 40% VDF. With high surrounding obstructions, this goes down. For a window heavily obstructed, like most windows on the lower floors in Hong Kong, reflected light becomes the main source of daylight. The amount of reflected light depends on two factors: how well these surfaces are illuminated, and what are the surface reflectances. Hence, one could get more reflected light if the opposing obstructed surfaces are well lit and of white colour. The mathematics of daylighting is largely known. The problem was to resolve them to something that could be practical, simple and enforceable in the contemporary context of Hong Kong.

In the beginning, a more accurate Sky Component method using the split flux formulas was used to create a table.[21] [22] The table was presented to the Buildings Department and was discussed in various meetings. (Figure 12) The problem was that it could be very restrictive in dealing with the varying and complicated skylines of Hong Kong.

Later, a method based on a two-dimensional "visible area / volume in front of the window" was speculated - initially on a napkin during a dinner session! (Figure 13) It was actually very similar in spirit to the existing regulatory Rectangular Horizontal Plan (RHP) requirements, but it deals better with the unique built morphology of contemporary Hong Kong. The method was based on modifications of a more accurate three-dimensional sky component overlay method

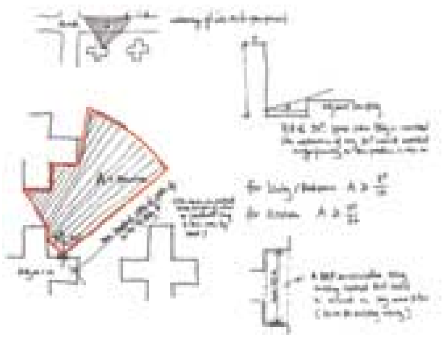

Figure 13: The napkin of the initial ideas of the UVA method

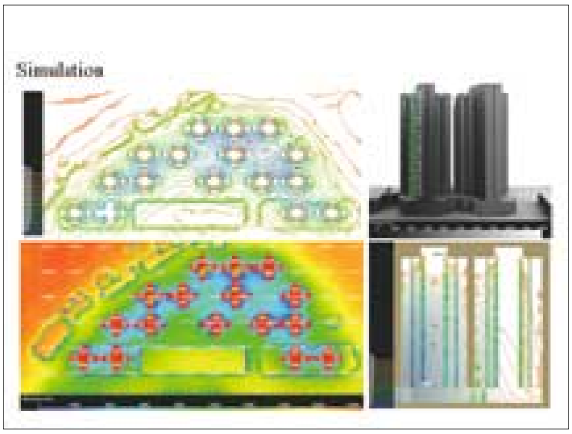

Figure 14: image captures of two of the best computational lighting software in the market: Lightscape and Radiance.

developed by Tregenza.[23] The new method, dubbed the Unobstructed Vision Area (UVA) Method is a simple method suitable for high-rise, high-density development.[24] The method is not fundamentally new. R G Hopkinson proposed a similar offering in the UK in the late 60s.[25] [26]

Basically, the UVA method speculated that for high-density environment where surrounding buildings are high, the sky component above the buildings could be assumed to be very small. Light from gaps of buildings could then be approximated using the plans. Reflected light depends largely on how the surrounding surfaces are illuminated and thus the openness of these surfaces to the sky.[27] It seemed that it might be possible to devise a design method only based on two-dimensional plan information.[28] To obtain adequate amount of light on the vertical surface of the window plane, the window must face into an outdoor open area. The larger the open area, more light it is likely to receive. The UVA method considers an area in the shape of a cone that is 100° wide - beyond 100° the efficacy of light entering the window is significantly reduced (and is not linearly proportioned to the space in front). The length of the cone is equal to the height of the building from the window. When such a cone overlays onto the site plan, the surrounding buildings will obstruct part of the area. The resultant area is the Unobstructed Vision Area that the window 'sees'. Scientifically, it is possible to devise a mathematical formula for UVA provided that the shapes of the spaces in front of the window are known geometrically and are of finite shapes. However, since the shapes and geometries of the areas are site specific, it is meaningless to devise a simple formula for it. But it could be proved mathematically that:

$$A=kH^2 \qquad (k \text{ being a coefficient}) \qquad (1)$$

A is the UVA in front of the window
H is the height of the building containing the window to be tested
K is a coefficient and needs to be devised using parametric tests

The equation, when first formulated, resembled Einstein's $E=mc^2$. It seems that nature has its way and its simplicity could only be revealed if one looks hard enough. To devise K, statistical and parametric methods may be used. Computational simulations provided a quick and convenient means to conduct the parametric tests. (Figure 14) The hypothesis is that *k* could be statistically devised using block plans that are likely to be encountered by designers in Hong Kong.

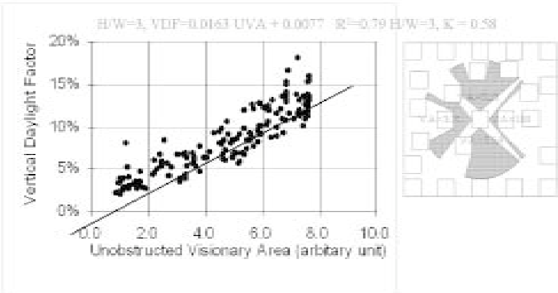

Figure 15: An example of tests of VDF vs. UVA of the scenarios. A regression line representing the lower quantile values of the data is drawn.

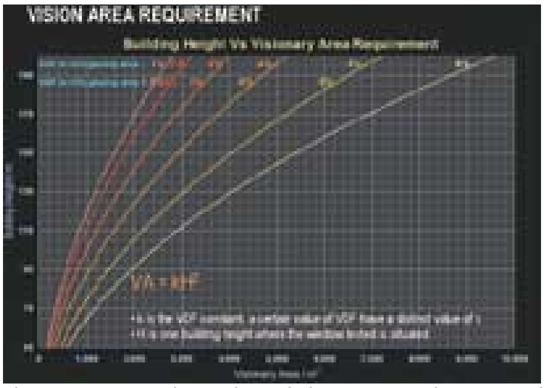

Figure 16: An early version of the UVA requirements of various VDF performance

A number of parametric tests were designed. For example, one such test involved putting square blocks 3 units high on a grid 1 unit wide to simulate a 1:3 building height to street relationship.[29] (Figure 15) Design scenarios were constructed carefully to yield data points of the full range of UVA.

The coefficient k is a constant and its value depends on the daylight performance (VDF) required. k is worked out statistically. The lower the VDF required, the lower the value of k. Therefore, it can be stated scientifically and statistically that "if a window located on the surface of a building 100m high could achieve a UVA of 2400m^2, there is a 75% chance that the window could achieve a VDF of 8%." (Figure 16 and Table 4)

Table 4: Unobstructed Vision Area Requirement for Habitable Room (8% VDF) as in PNAP 278

Height of façade (m)	Minimum UVA (s. m.)		
	Glazing Area: 10% of UFA	Glazing Area: 15% of	Glazing Area: 20% of UFA
10	50	30	20
20	100	100	60
30	250	200	150
40	400	300	200
50	600	500	400
60	900	700	500
70	1,200	900	700
80	1,600	1,200	900
90	2,000	1,500	1,100
100	2,400	1,800	1,300
110	2,900	2,200	1,600
120	3,500	2,600	1,900
130	4,100	3,100	2,200
140	4,800	3,600	2,800
150	5,400	4,100	3,000
160	6,200	4,600	3,400
170	7,000	5,200	3,800
180	7,800	5,900	4,300
190	8,700	6,500	4,700
200	9,600	7,200	5,200

As an example, suppose a window is designed within a housing estate of cruciform blocks, and it needs to be tested. The building is 120m high. From Table 4, the UVA requirement is 3500m^2. If the available UVA in front of the window is only 2700m^2, the window does not satisfy the requirement. The designer could attempt a number of changes to improve the situation. Firstly, the blocks could be moved to increase the UVA area. Secondly, he could lower the height of the building to say 100m; the UVA requirement will then be 2400m^2. Thirdly, he could increase the window size from 10% to 15%. The UVA requirement is now 2600 m^2. The UVA formulation is scientific and is flexible.

The becoming of PNAP 278

Once the UVA design tool is developed, the final task was to translate it into the Practice Note. A number of tests were conducted to investigate the UVA's impact to design. (Figures 17 and 18) with some adjustments to the design, the tests indicated that it is possible to provide the required UVA given Hong Kong's tight site constraints - save some very tight circumstances. However, re-design and a new mind set is necessary.

During the final stages of the study, street and boundary conditions, multi-windows and their definitions, and some specific site conditions were discussed. Additional rules had to be incorporated. This invariably made the UVA method more complicated. But it was inevitable. When say "how to deal with bay windows?" was asked, it was necessary to go back to the first principle to work it out. Sometimes, it could be difficult to resolve all enquiries to a cohesive outcome. And it was difficult to translate complicated scientific resolutions into simple practical guidelines, for one is never quite sure what could be missing or overlooked.

The most important contribution of the studies that lead to PNAP 278 has been the use of performance criteria. The 8% and 4% VDF are performance criteria. The UVA method is a prescriptive resolution of the performance. Like the RHP rules and all prescriptive standards before it, the UVA method was formulated based on a number of reasonable assumptions of the circumstances. No prescriptive rules could be completely comprehensive and be applied to all known and unknown circumstances. For example, the UVA rule could be unnecessarily tight for buildings located in low rise, low density areas. And for example, in areas where there are very large differences in building heights. To resolve complicated sciences into simple prescriptive rules, it is always necessary to build into the method reasonable assumptions. For example, the RHP originally assumed buildings are low rise and windows are on the facade, and so on.

However, once the performance requirements are known, many methods could be used to prove it. An appendix B of PNAP 278 has been formulated to allow designers to use computational methods to demonstrate compliance. (Figure 19) More appendices could be added later if required. And this is the beauty of the "performance based" arrangement.

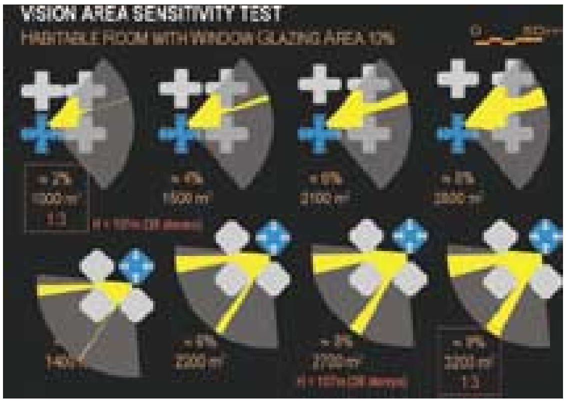

Figure 17: UVA sensitivity tests

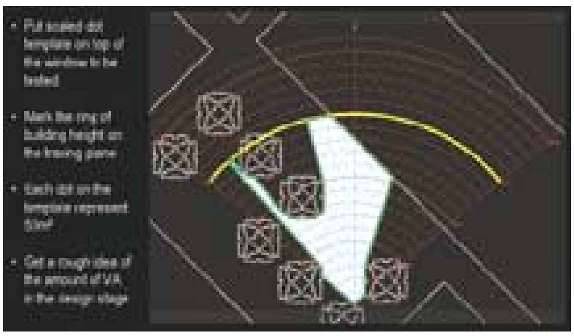
Figure 18: UVA sensitivity tests using a standard template the CUHK team developed. The template allows the quick calculation of the UVA based on dots on plan.

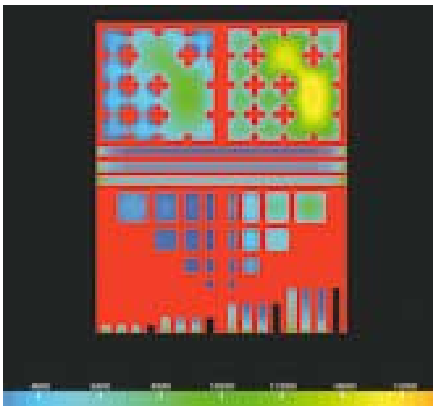
Figure 19: The standard 3D model proposed to test the accuracy of computer software (under PNAP appendix B).

The bulk of the scientific works and development works were completed by late 2002. A lot of debates, exchanges and consultation were conducted. Progress was grind to almost a halt, and it was not known then if anything could result from the study. The unfortunate coming of SAR in 2003 completely changed the balance of risk assessment and public opinion of our built environment. It was then generally felt that "something needs to be done", and there was then a spirit of "give it a try". In late 2003, the UVA method was adapted by the Buildings Department HKSAR as an alternative basis for regulatory control of daylight performance of buildings in Hong Kong under their recently issued PNAP278. A test period of two years was agreed.

Acknowledgement

A reason for this paper is to document a process. Hopefully, unlike the lost history of all previous attempts to change the building regulations, some hints of the process could be recorded. It is hoped that this would be useful for others in the future when revisiting the laws again.

The study was conducted under a consultancy project of Buildings Department, HKSAR commissioned to Anthony Ng Architects Ltd. (CAO G05). Professor Chan Ying-Keung of Department of Sociology, CUHK and Professor Peter Tregenza of School of Architectural Studies, Sheffield University, UK collaborated and contributed to the daylight and survey portion of the studies. Some background materials were researched in the UK under a fellowship award from the Association of Commonwealth Universities. Thanks are due to K S Wong for his comments. Thanks are also due to Gigi Lam, Barnabas Chung, Max Lee, Dr Wu Wei, Vicky Cheng, Chan Tak-Yan and many student helpers in the department of architecture, CUHK.

I am indebted to my sons, who always remind me that they desire a better place to live when they grow up. I dedicate this essay to them.

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13 1 set of Krochmann multi-head (20 heads) photometers with multiplex and data-logger for the living space and 5 sets of 3-head Li-Cor 1400 photometers for the minor spaces were used. Fish eye photographs were taken from the photometer positions of windows measuring the vertical sky component (SC) for cross-reference. A synchronized single cell Li-Cor 1400 photometer was set up on the rooftop of the spaces to be measured. This allows for the calculation of Daylight Factor4 (DF) later. Data was logged every 5 seconds, averaged and recorded every 1 minute. Each of the unit was monitored for a period of 1 to 3 weeks. Weather reports were obtained, together with the readings on the rooftop, periods of 'near' CIE overcast sky were predicted and noted. Useful data was recorded for further analysis.

14 The CIE Overcast Sky definition has been used throughout the study as it approximates Hong Kong sky conditions, as well as providing a convenient standard to work on. See Peter Tregenza, Standard skies for maritime climates, LRT 31(4), 1999. Also see K P Lam et al, Evaluation of Sky luminance prediction models using measured data from Singapore, LRT 31(1), 1999.

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16 BS 8206 specified 2% average daylight factor for kitchen, 1.5% for living spaces and 1% for bedrooms. The recommendations were largely based on a user survey conducted under Post-War Building Studies no.12, 'The lighting of buildings', HMSO London 1944.

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24 A limit of the UVA method is that it will under estimate for conditions of low rise buildings, for the UVA does not account for light available from the top of the obstructions. This is not a problem for scenes of high density as light from above high rise obstructions are small. The UVA method will also under estimate if the obstructions in front are better illuminated than normal.

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