

## Development and Implementation of Visual Exposure Indicator for Residential Development

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### **Abstract.**

*In recent years, residential tower blocks, residential rights such as a right to enjoy sunshine and good view have become socially sensitive matters. The research aimed to establish a methodology to find out the extent of visual damage and households caused by residential development. The research aims to make a quantitative calculation of visual grading and degree of concealment from residential development. Kumho residential apartment development was selected as a case study. Within the case study, 5 blocks were chosen to simulate which is located between Han River and Dalmaji hill. The degree of visual screening is analysed into three different visual exposures; Visual Exposure, Distance-weighted Visual Exposure and Area-weighted Visual Exposure. Then the Visual Exposures were compared with visual damage and landscape simulations. In particular, Area-weighted Visual Exposure has a great potential to be implemented into planning process including disputes, grant and assessment since it does reflect human visual perceptions.*

**Keyword:** *Visibility Analysis, 3D Simulation, VE3D, Arcview, Visual Exposure*

### **1. Introduction**

Within development management process, dealing with visual impact assessment is known to an effective way of evaluating environmental effect for the area of development. The process of visibility analysis also enables planners to identify potential landscape character and its changes. In particular, the visibility analysis based on computer generated media can be effective, intuitive and economic. Recently, within residential tower blocks, residential rights such as a right to enjoy sunshine and good view have become socially sensitive matters. Since visually valuable natural resources are within urban areas such as river and mountain, local planning authorities are concerned about the social rights and attempt to minimise or avoid any possible dispute. For local planning authority's point of view, the visibility issues – for this social reason - become significant in policy making [1,4]. Recently, Visual Density Indicator is used for various statutory legislations for height and density on residential projects. This research develops Visual Indicators which human visual senses were taken into account focusing on small size residential developments [2, 3]. The research also assesses the extent of visual damages caused by the development and therefore, the research finding aims to contribute in planning policy establishments. This therefore, aims to develop and implement visual exposure analysis for building proposals in particular residential developments [8, 9, 10].

The study also aims to develop visual exposure indicator for planning application in particular residential development. The process of production and accuracy of the analysis are taken into account in comparison with existing methodologies [5, 7]. The study employ a case study in Seoul as a methodology to develop a credible and accurate process of providing visual exposure indicator within urban environment and planning application [5].

This research is divided into five sections. Section 1 introduces the background, research questions, and overall organisation of the study. Section 2 attempts to conceptualise visual exposure indicator and analysis in formal form of planning. It also reviews historical backgrounds and definitions to reach the most appropriate concept of the research. Thereafter, it presents the main points of visual exposure indicator analysis process together with emerging issues of current use of the technology in planning through literature review. Section 3, methodology is divided into two sections with each addressing site selection/viewpoint and research methodology/process. Section 4 deals with findings and results. Finally, section 5 concludes the study with recommendations.

## 2. Development of Visual Indicator using 3D Visual Exposure

### 2.1 Developing 3D Visual Exposure

Visual Exposure quantifies visual opportunities and visual frequency from multiple viewpoints. However, raster dataset based Visual Exposure is not suitable for urban areas where built up structures are dominant. Moreover, simple black and white (visible and not visible) analysis does not reflect visible distance and characteristics of the site [6][8][9]. If Visual Exposure is carried out based on building elevations, the visibility opportunity, grading, and degree of concealment could be calculated. For this analysis, 3D modelling has to be performed based on vector datasets of terrain and buildings. Vector modelling technique is able to represent landscapes in better reality including mesh and surface. Recently, vector modelling programmes are highly advanced; however, vector modelling techniques for Visibility Exposure has not been developed yet.

The calculation of Visibility Exposure is measured from Lines Of Sight (LOS) and whether the LOSs hitting the objects. Consequently, the length of LOS becomes visibility distance and cumulative LOS makes Visibility Exposure map. In order to visualise this process within vector models, Visual Exposure 3D (VE3D) was developed.

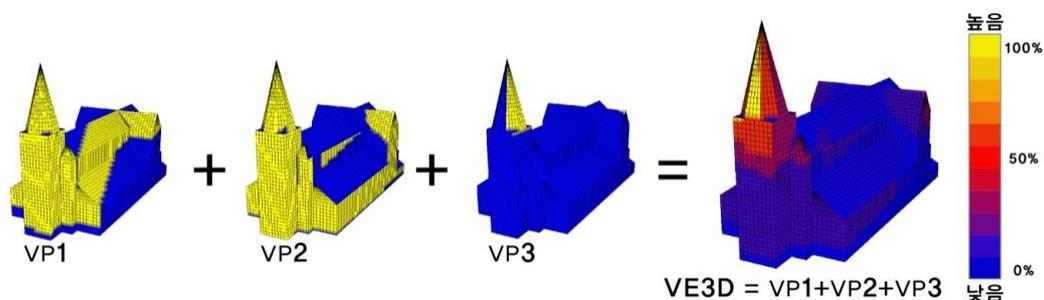


Figure 1. The Process of VE3D

### 2.2 Visual Exposure with Human Visual Perception

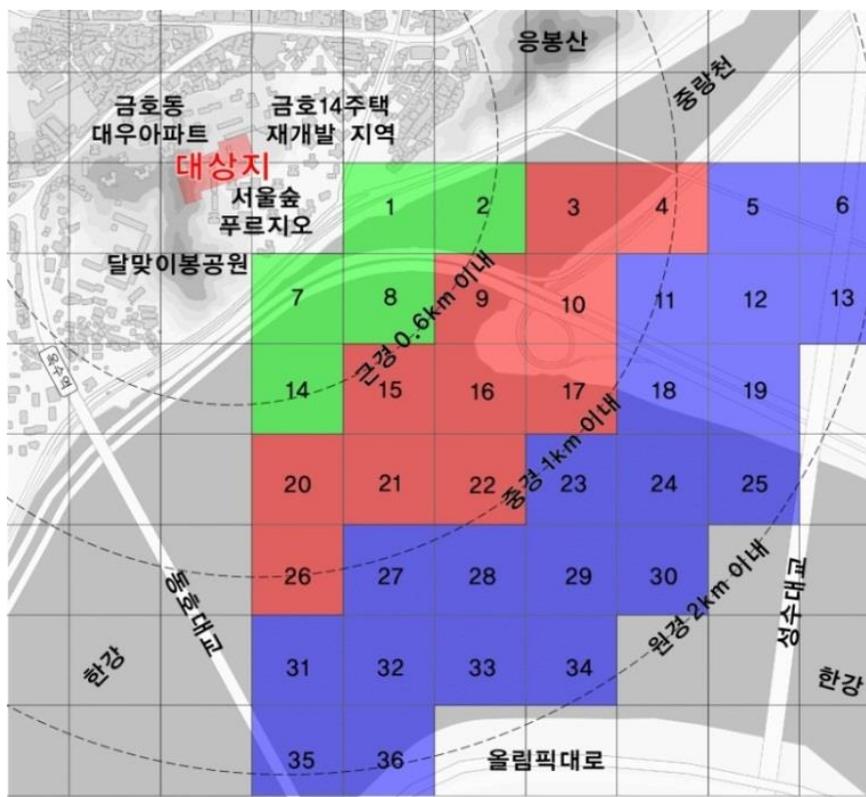
Traditionally, Visual Exposure and cumulative visibility map are produced without taking distances into account. However, human perceives visual objects based on distances and as a trade-off, visible objects are inverse proportion to squared distance. Therefore, visible distance and object size need to be considered in order to produce more accurate visible exposure results [Table 1].

**Table 1. Calculation of Visual Exposure**

Vf: Visual Exposure	Vd: Distance-weighted Visual Exposure	Va: Area-weighted Visual Exposure
$Vf = \sum_{i=1}^m \sum_{j=1}^n V_{ij}$	$Vd = \sum_{i=1}^m \sum_{j=1}^n \frac{V_{ij}}{D_{ij}}$	$Va = \sum_{i=1}^m \sum_{j=1}^n \frac{V_{ij}}{D_i^2}$
i: viewpoints on the building (m number), j: view objectives (n number), Vij: visibility (visible=0, invisible=1), Dij: distance between building (i) and view objects (j)		

### 3. Methodology

The research aims to make a quantitative calculation of visual grading and degree of concealment from residential development. Kumho residential apartment development was selected as a case study. Within the case study, 5 blocks were chosen to simulate which is located between Han River and Dalmaji hill. 10 thresholds of visual grading were classified based on Visual Exposure. Single residential block was also divided with 3m grids for use in individual households' Visual Exposure. Total 36 viewpoints were chosen to assess visible and not visible status and size/distance were considered as in 600m, 1000m, and 1800m. 36 grids (200m x 200m) were created which include near distance 5, mid distance 11, and long distance 20 from the centre point.



**Figure 2. Grid Methodology**

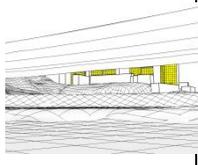
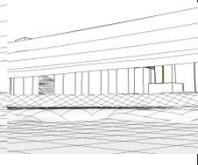
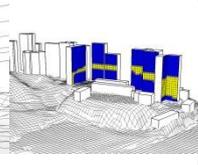
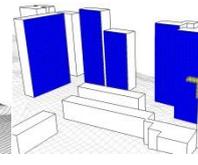
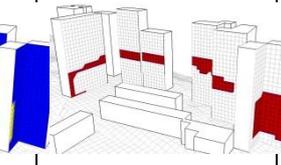
## 4. Research Results

### 4.1 Efficiency on Producing Visibility Analysis

The analysis models were created with Rhinoceros 5.0 in particular, NURBS were used for terrains and surface was implemented for buildings and other built up structures. For Visual Exposure analysis, VE3D were utilised. The system was Windows 7, Intel Core i7 950 3.07GHz CUP, 12GB DDR3 RAM, Nvidia GeForce GTx 460, 7200rpm Sata HDD. For instance, 134463 surfaces were calculated for façade of 7 residential blocks from a single viewpoint and it took 8 minutes 10 seconds. The more invisible surfaces increase, the quicker calculations were made. This result indicates that it could be common practice to carry out 3D Visual Exposure analysis using 3D models in urban landscape.

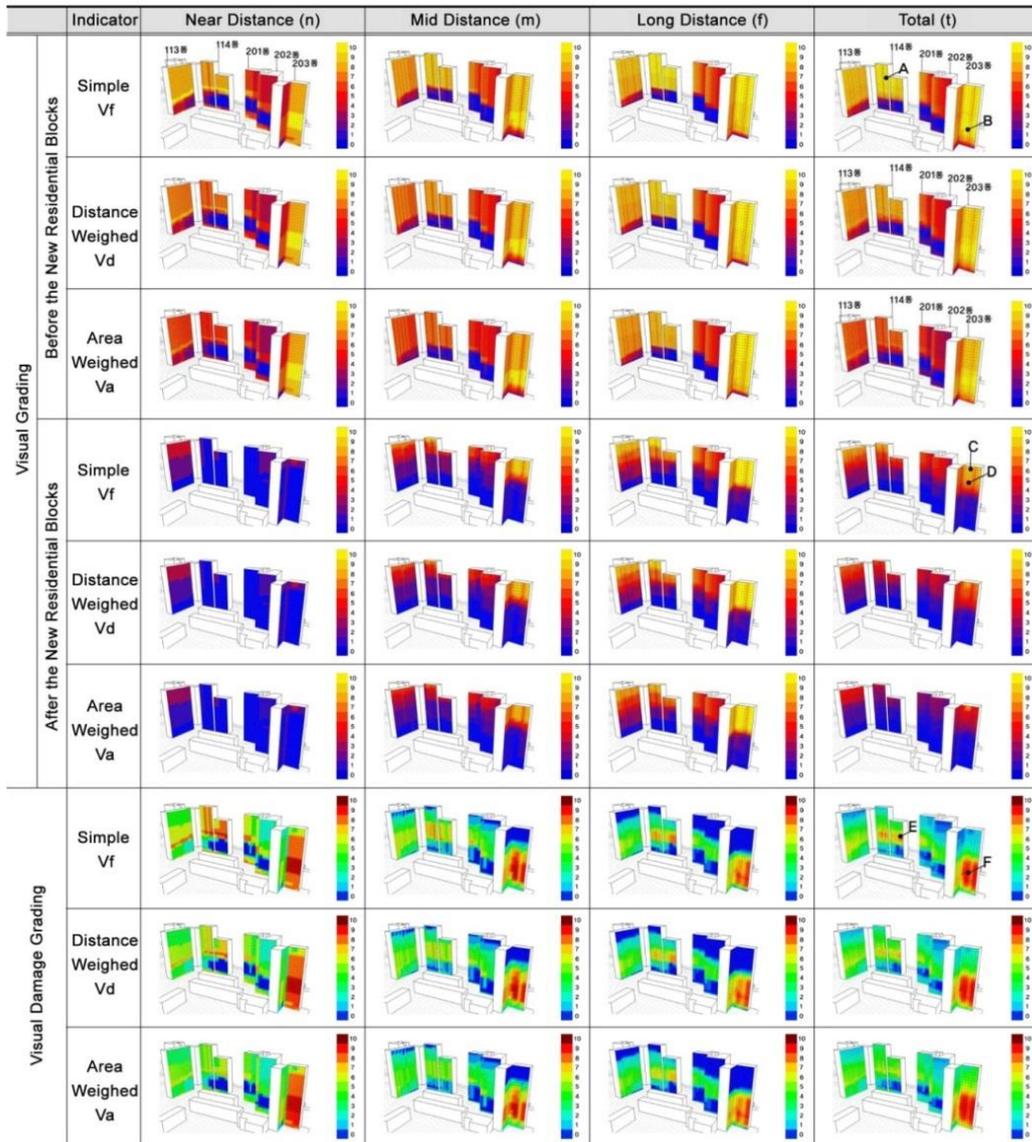
In order to check accuracy of the process viewpoint no 8 was exemplified for comparison of before, after, simulation, visual areas and VE3D. According to the perspectives, from the viewpoint no 8, lower levels of 113/ 114 blocks and mid levels of 201-203 blocks can be visible. This is the same results with VE3D analysis. After the new residential blocks, only from mid levels of 202 and 203 blocks viewpoint no 8 was visible. The research compared visibility before and after new residential blocks, then mid and lower levels of 7 blocks were visually affected. Meanwhile, VE3D results were matching with computerised landscape simulation; therefore, the results from visibility analysis by VE3D are credible. Moreover, VE3D would be effective for visibility comparisons of visual damage on highly valuable landmarks and assessing the extent of the damage [Table 2].

**Table 2. VE3D Visibility Comparison (Viewpoint No 8)**

Landscape Simulation		VE3D Analysis		Visual Damage
Before the New Residential Blocks	After the New Residential Blocks	Before the New Residential Blocks	After the New Residential Blocks	
				

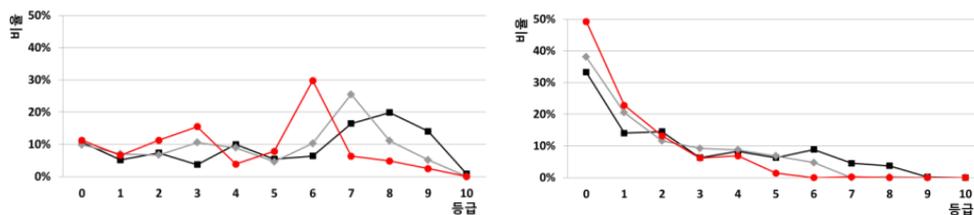
### 4.2 Visual Indicator Comparison

Visibility maps were produced from 36 viewpoints and then, using the formula [Figure 3], Visual Exposure (Vf), Distance-weighted Visual Exposure (Vd), and Area-weighted Visual Exposure (Va) were made. Each visual exposure was standardised as 10 grading system. Before the new residential blocks, grade 10 (maximum) was scored in most of block no 113 – no 203 in Vf, high/mid levels of no 203 in Vd and mid/low levels of no 203 in Va.



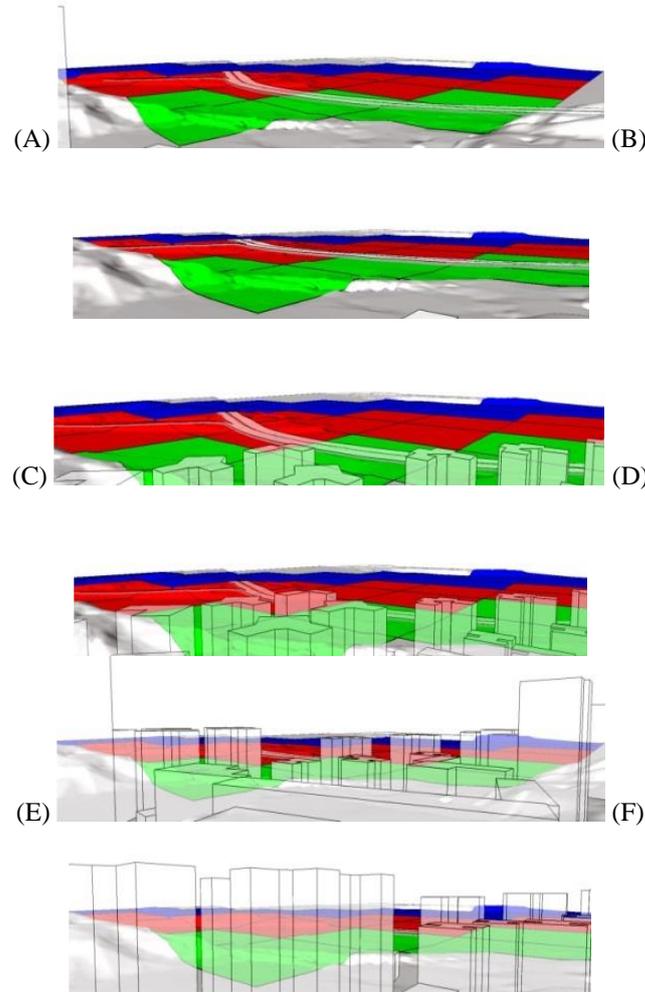
**Figure 3. Visual Exposure Results**

The produced visual indicators were cross checked with computerised simulations for accuracy and credibility.



**Figure 4. Visual Indicators before/after the New Residential Blocks**

Based on Figure 3 and 4, there are some discrepancies between Vf and Va due to the area differences. Accordingly, the results illustrated the areas of high value in Va have more visual damages [Figure 5].



**Figure 5. Locations A, B, C, D, E and F (Green-Near Distance, Red-Mid Distance, Blue-Long Distance)**

#### **4.3 Visual Indicator Analysis on Residential Tower Block**

The research introduced 3x3m grid which represents single household within residential tower blocks. Total of 7 tower blocks were applied and 1728 viewpoints were accordingly created. During the process, the majority grids in Vf fell into grade 7-9, in Vd most of grids were grade 7 and grade 6 as well as 2 and 3 were mostly appeared in Va. After new residential blocks were constructed, grade 9 and 10 would be disappeared in Vf; whereas, grade 1-8 remained same. Moreover, grade 0 was increased from 10.7% to 33.3%, which lead into increase of visual screening as 22.6%. However, grade 0 in Va increased from 11.3% to 49.2% which indicated nearly half of balcony of the households were screened. In addition, view towards Han River was sharply blocked since grade 6 – 10 were disappeared [Table 3].

**Table 3. Visual Indicator (per area, %)**

Landscape	Indicator – Grade	0	1	2	3	4	5	6	7	8	9	10
	Before New Residential Blocks	Vf	10.7	5.2	7.3	3.7	10.0	5.4	6.4	16.4	19.9	14.1
Vd		9.9	7.1	6.7	10.6	9.0	4.6	10.3	25.5	11.1	5.2	0.1
Va		11.3	6.6	11.3	15.5	3.9	7.9	29.8	6.4	4.9	2.5	0.1
After New Residential Blocks	Vf	33.3	14.1	14.5	6.3	8.3	6.3	8.9	4.5	3.7	0.2	-
	Vd	38.1	20.5	11.6	9.3	8.7	6.8	4.7	-	0.2	-	-
	Va	49.2	22.8	13.2	6.2	6.9	1.4	-	0.2	-	-	-

Residential tower blocks which contained 552 households were included for the case study. A large number of grades 7, 9 and 10 were appeared in Vf in before new residential blocks were constructed. Grade 8 is in majority in Vd; whereas, grade 4, 6, 7, 9 were dominant in Va. However, there were no grade 6 – 10 in Va in after new residential blocks were constructed. Grade 0 increase 600- 800 % in Vf, Vd and Va which means view to Han River would be screened dramatically. For visual damage, grade 0 increased from 3.3% to 23.2% in Vf, which indicated 19.9% of the households were blocked the view towards Han River. However, according to Va results grade 0 increased from 4.5% to 29% and households which were blocked views from Han River was 24.5% [Table 4].

**Table 4. Visual Damage (households)**

Landscape		Indicator – Grade	0	1	2	3	4	5	6	7	8	9	10
Visual Grading	Before New Residential Blocks	Vf	18	54	20	29	25	54	49	65	40	107	91
		Vd	17	41	38	38	41	70	32	72	121	52	30
		Va	25	38	46	63	88	25	74	104	1	75	13
	After New Residential Blocks	Vf	128	97	57	66	32	59	42	28	29	14	0
		Vd	149	105	83	59	68	33	28	23	4	0	0
		Va	160	164	96	66	34	28	0	4	0	0	0
Visual Damage	Vf	30	140	58	67	56	67	49	34	21	30	0	
	Vd	17	93	93	88	78	59	55	25	13	31	0	
	Va	22	77	97	88	91	70	43	17	10	37	0	

## 5. Conclusion

One of planning issues in recent years is visually valuable natural resources are within urban areas such as river and mountain, local planning authorities are concerned about the social rights and attempt to minimise or avoid any possible dispute. For that reason, within many planning application processes, Visual Density Indicator is used for various statutory legislations for height and density on residential projects. This research develops Visual Indicators which human visual senses were taken into account focusing on small size residential developments. The research also assesses the extent of visual damages caused by the development and therefore, the research finding aims to contribute in planning policy establishments. This therefore, aims to develop and implement visual exposure analysis for building proposals in particular residential developments.

The research also aimed to establish a methodology to find out the extent of visual damage and households caused by residential development. Visual exposure programme which developed in the research can be run in Windows based computers and have large potential to be implemented in common development practice. Moreover, the degree of visual screening is analysed into three different visual exposures; Visual Exposure, Distance-weighted Visual Exposure and Area-weighted Visual Exposure. Then the Visual Exposures were compared with visual damage and landscape simulations. In particular, Area-weighted Visual Exposure has a great potential to be implemented into planning process including disputes, grant and assessment since it does reflect human visual perceptions.

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