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# Parametric Approach as a Tool for Decision-making in Planning and Design Process. Case study: Office Tower in Kebayoran Lama.

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**Abstract**

This study offers discrete method in parametric design to solve problems during design process (programming, site planning, massing, structure planning, and facade planning). This study is applied in the design of office tower in Kebayoran Lama, Jakarta. The objective of the study is to explore the uses of parametric design method, yet, maintains its time feasibility. The result of the study is a method for planning and design that is more advantageous than the conventional ones in terms of simultaneous, coordinated and accountable. This method enables designer to do many iterations and monitor changes during the design process. However, the method needs a higher skill in logical thinking during the process, which demands time.

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*Keywords:* parametric design; discrete method; office tower; building modeling

## 1. Introduction

There are two parametric approaches. The first approach considers all designs are parametric because design is based on parameters, such as legal aspects, orientation, solar radiation, and wind (Gerber, 2007; Aish & Woodbury, 2005; Hudson, 2010). The second approach considers parametric design as using a certain tool (Grasshopper, Maya MEL, Rhino Scripting, Processing) to improve design by interconnecting and coordinating design components simultaneously (Woodbury, 2010).

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People recognize the method of parametric design as to make models of buildings with built & coordinated formula, in which the parameter is easily changed and edited. To a company, designing with coordinated formula is time-consuming and risky. Reusing and sharing a formula in a company is problematic because once the formula maker resigned, other designers will have difficulties to continue the formula. Other disadvantages of making complete coordinated formula are the requirements of computer with high specification and the aptitude of logical thinking in arranging formula. However, more experts are now exploring design by using parametric methods. Parametric is employed for structural oriented early design of tall building in that instant feedback on structural performance can be noticed (Almusharaf, 2010). And also implemented in fabrication and manufacturing building's components (Anderson, 2011) and various cases of urban planning (Bielik, 2012; Beirao, 2012).

The objective of this study is to explore the uses of parametric design method in mixed-use project at the design phase. Coordinated formula for solving problems comprehensively is risky and inefficient due to project's time schedule. The method being employed in this case study is discrete method where each specific design problem instead of all problems is to be solved. The interaction of human and computer will maintain the time feasibility of the project. However, the formula is only flexible within a certain cycle of problem-solving. After the designated cycle, the formula becomes inflexible (Fig.1).

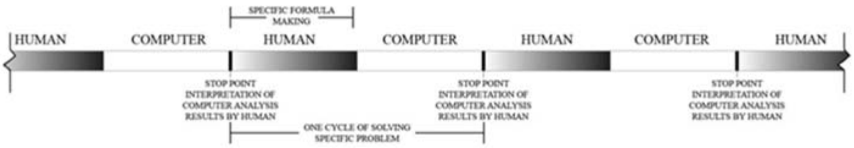



Fig. 1. Design Methodology

## 2. Implementation and Analysis in Design Process

Design phases that carried out parametric method are programming, site planning, massing, structure planning, and facade planning. The objectives of the method are project's time efficient, human related advantages (non-determinant decision-making, creativity, pattern recognizing,) and advantages by using computers (consistency, calculating, and repetition).

### *2.1. Programming*

Land is extremely precious in urban projects in that owner usually demands architects to maximize built area as high as legally permitted. Unfortunately, mixed-use projects always produce residual area because of the discrepancy between FAR regulation and FAR planning out of various multiplication factors of facilities. In this project, the built area was influenced by four factors: office area (x), retail area (y), office parking area (x*35/45), and retail parking area (y*35/100). In this exercise, parametric tool grasshopper is applied to determine the percentage of office and retail area in order that residual area is at the lowest. The calculation does not consider the general standard composition of office and commercial area.

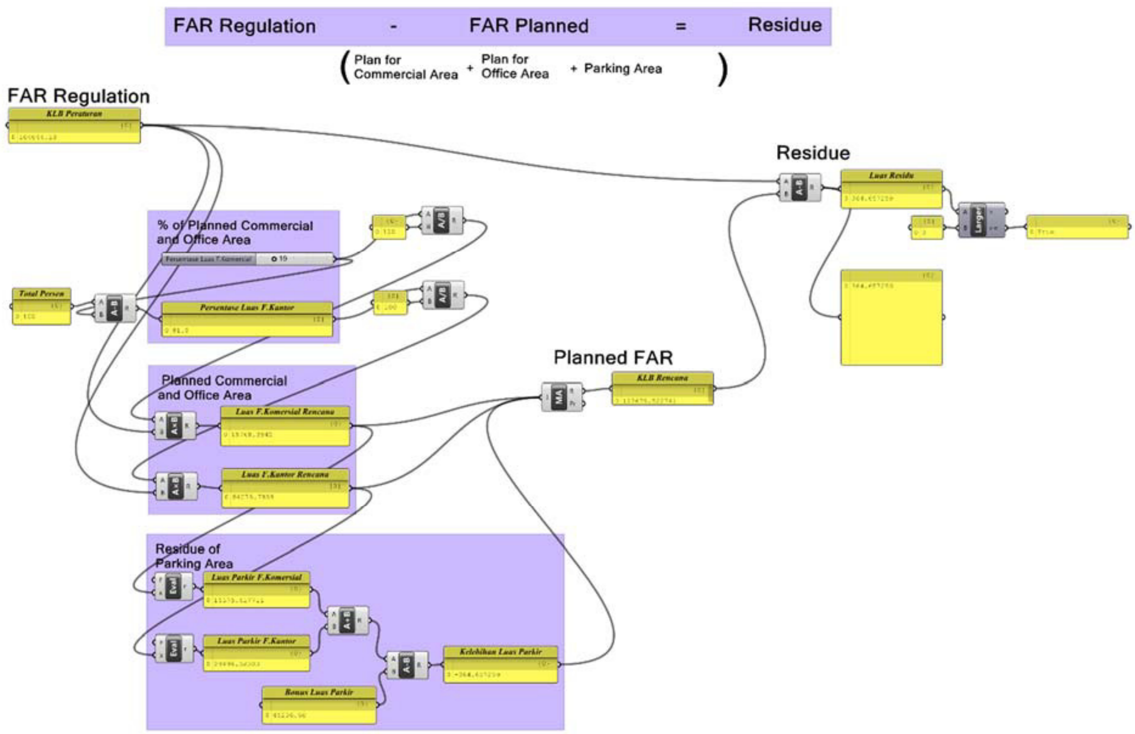



Fig. 2. Optimization algorithm for residual area

## *2.2. Site Planning*

The first issue in parametric design is the pattern of pedestrian pathways. The pedestrian pathway determines the security of the project's area whereas smaller building block increases visual control on streets (Porada, 2013). The method of sliced landscape divides the site by pattern of pedestrian circulation. Parametric design creates a formula in which the computer would search the suitable shortest pedestrian pathway automatically (Figure 3 & 4).

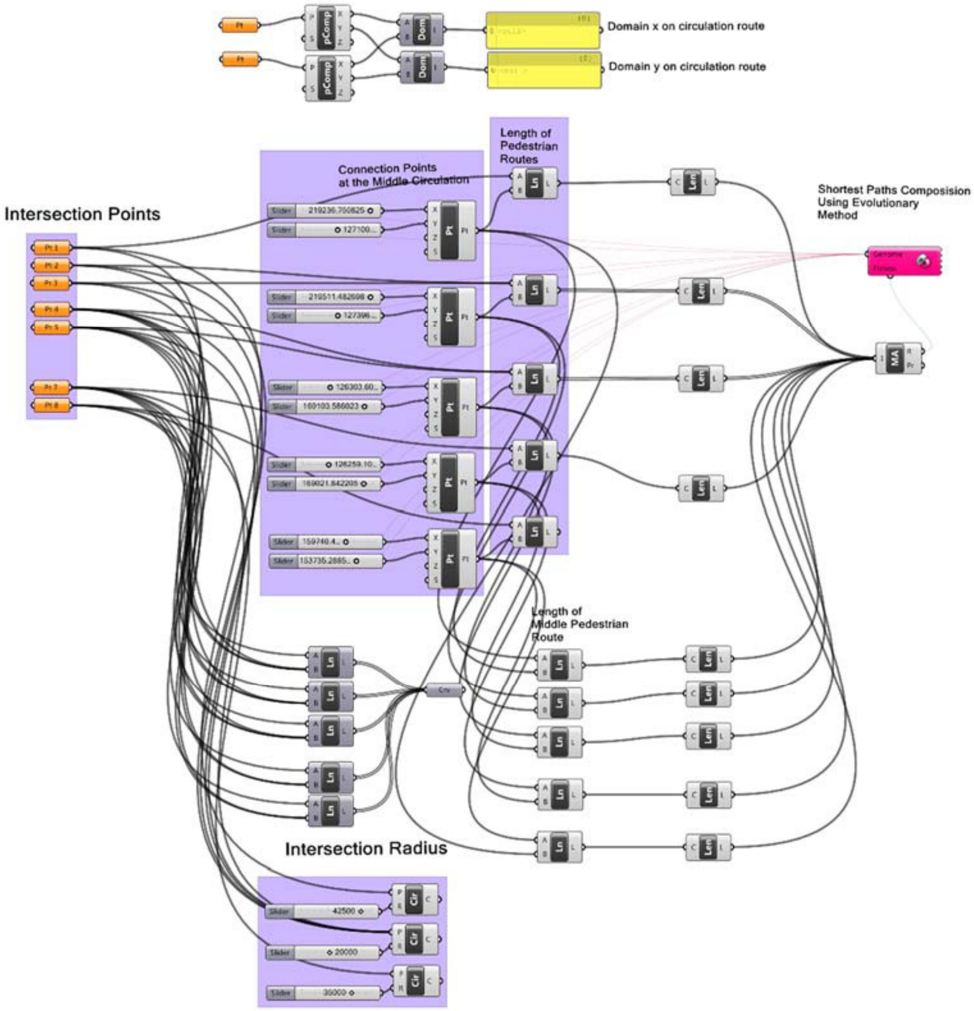



Fig. 3. Optimization algorithm for pedestrian pathways

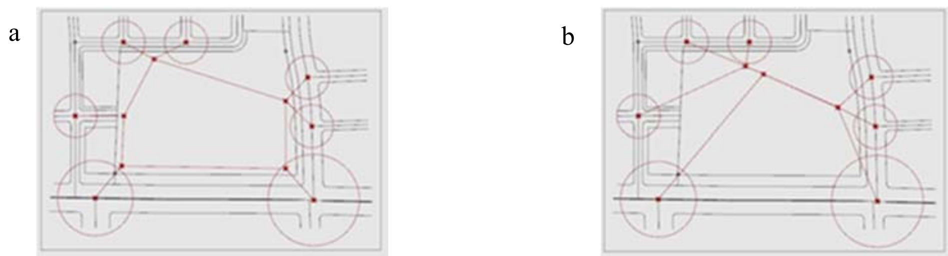
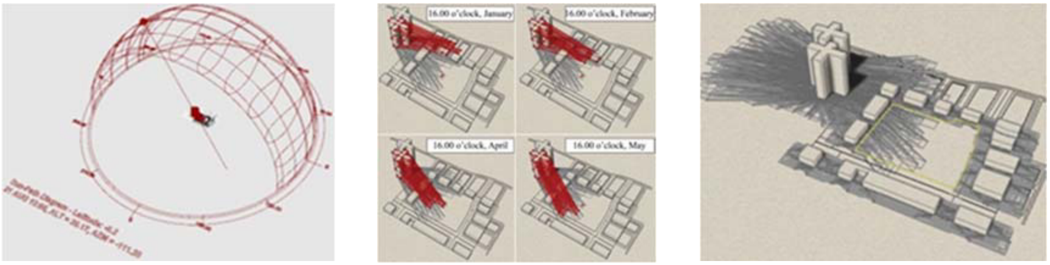



Fig. 4. Analysis of pedestrian pathways (a) Connectivity analysis; (b) Optimization analysis for shortest distance

### 2.3. Basic Environmental Analysis

The second issue is neighboring buildings that overshadow the site. Design in the tropic treats shadows on building as important. The purpose of the exercise is to seek the potential of neighboring buildings' shade in creating a comfortable environment in project's site. The sun-path diagram is utilized to create a trace of building's shadow between 08.00 am to 04.00 pm on the 21st day of the month in a year. The conclusion is that the western part of the site would be more comfortable in the afternoon because it is overshadowed by neighboring apartments after 03.00 pm in February to October (Figure 5).

*Fig. 5. Overshadow of neighbouring buildings in a year (08.00 am to 04.00 pm)*




### 2.4. Massing

The first step in building's massing is considering the skyline which is highly favored by urban people (Booth, 2012). Massing design should take into account legal aspects, such as BCR (Building Coverage Ratio), FAR (Floor Area Ratio), GSB (Building Setbacks), GSJ (Road Setbacks), and clearance between buildings. Specific formula is written to create models which allowed designer to monitor changes of skyline and requirements of regulation simultaneously (Figure 6a). Additional consideration in planning the initial massing is viewing angle from and to the site (Figure 6b).

a

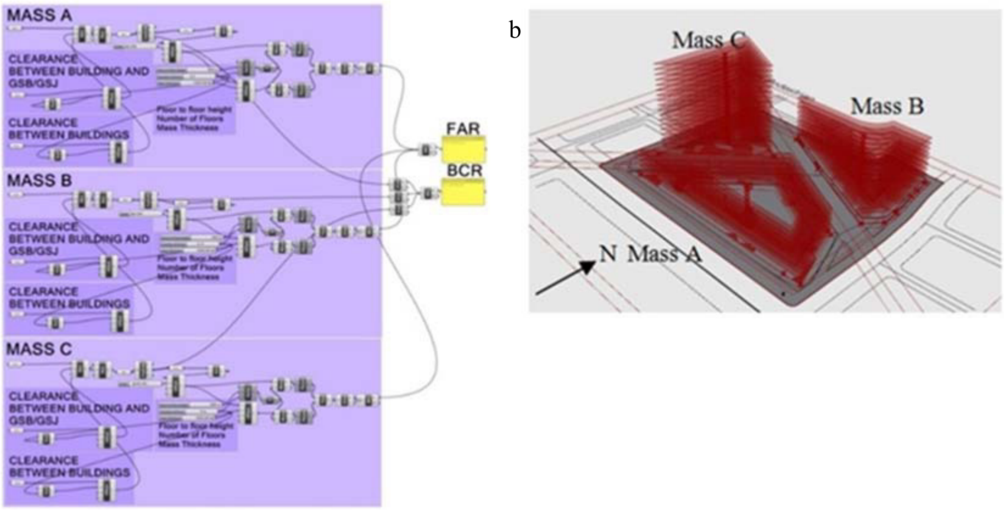



Fig. 6. (a) Massing formula to analyse maximum building's footprint in regard to BCR & FAR; (b) Initial determined massing

Three masses are formed by making depth of space, after consideration of skyline variation and connection to important road junctions which is equipped with traffic lights. Mass A and B are determined to be low in height to open a view to the active commercial place at the East-Southeast of the site. Mass A is determined to be the lowest, to enable the creation of a public place on the podium. People could observe the traffic on the main road from this podium, in that they may arrange their departure in case of traffic congestion takes place.

The second step in massing stage is to design a spinning tower. Mass C is considered to be the landmark of the area, yet, its exterior walls gained excessive solar radiation due to West and East orientation. The heat gain must be reduced by fixing the building orientation. In order to fix the building orientation, the lower part is fixed to the previous position and theory continuity of Gestalt is applied, in that spinning the concept was born. Parametric approach is utilized for solar radiation analysis by experimenting the spin/ rotation degree that has affected total heat gain of the building skin. The design challenge is to determine the degree of rotation that generates lowest total heat gain ($Wh/m^2$). The -90 degree of rotation is selected because it brings the lowest heat gain (1.321,26 $Wh/m^2$), aesthetic quality, structural expression, and tilted wall efficiency to the interior. (Figure 7 and Table 1).

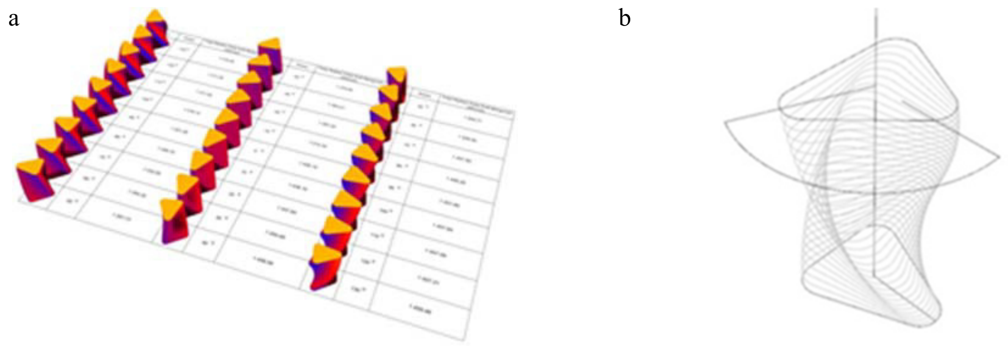



Fig. 7. Study of solar heat gain by exterior walls (a) Various rotation angles and solar heat gain; (b) Building profile and its rotation angle

*Table 1. Rotation angle and total solar heat gain*

| Figur | Rotasi | Total Radiasi Pada Kulit Bangunan (Wh/m2) | Figur | Rotasi | Total Radiasi Pada Kulit Bangunan (Wh/m2) | Figur | Rotasi | Total Radiasi Pada Kulit Bangunan (Wh/m2) |
|---|---|---|---|---|---|---|---|---|
| | -130° | 1.316,26 | | -40° | 1.370,65 | | 50° | 1.458,77 |
| | -120° | 1.317,26 | | -30° | 1.383,51 | | 60° | 1.458,82 |
| | -110° | 1.317,46 | | -20° | 1.397,42 | | 70° | 1.457,85 |
| | -100° | 1.318,14 | | -10° | 1.412,23 | | 80° | 1.458,26 |
| | -90° | 1.321,26 | | 0° | 1.426,15 | | 90° | 1.457,89 |
| | -80° | 1.326,75 | | 10° | 1.436,19 | | 100° | 1.457,64 |
| | -70° | 1.332,55 | | 20° | 1.447,84 | | 110° | 1.457,29 |
| | -60° | 1.344,32 | | 30° | 1.454,89 | | 120° | 1.457,21 |
| | -50° | 1.357,73 | | 40° | 1.458,59 | | 130° | 1.458,46 |

Third step is to study overshadowing the area between the masses. This analysis is carried out to find area that is more comfortable along the year. This overshadowed area will be allocated for public space, such as a seating area, al fresco, and other public activities. The snapshot of this study is presented below (Figure 8).

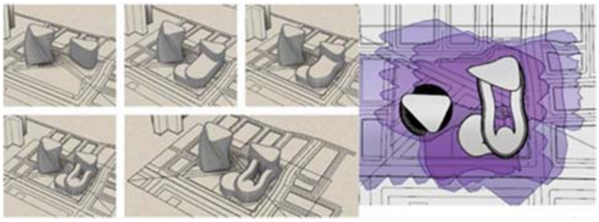


Fig. 8. Analysis of overshadowing area

### *2.5. Structure Design*

Spinning Tower or mass C is designed with the diagrid structure system. Diagrid system has many advantages: 1) 20% material reduction in structural steel, 2) combine gravity and lateral load bearing, 3) increase stability due to its triangular form, 4) provision of alternate load paths in structural failure, and 5) reduce the weight of superstructure that translates into load reduction on foundations (Boake, 2013). The parametric method is applied to verify deflections and material behavior. Analyzing through the algorithm, spiral columns are no longer needed, and beam profiles are smaller than the rule of thumb. This analysis and modeling have sharpened architect's intuition on structure system and enabled architect to be involved in the design process which was previously undertaken by structural engineering. The algorithm limits direct modelling of bearing wall structure, and it should be replaced by spring beam system.

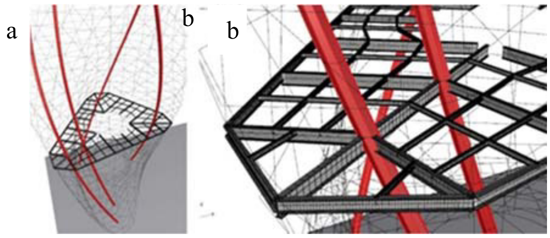



Fig. 9. Design of structure system (a) initial structure design; (b) member profile

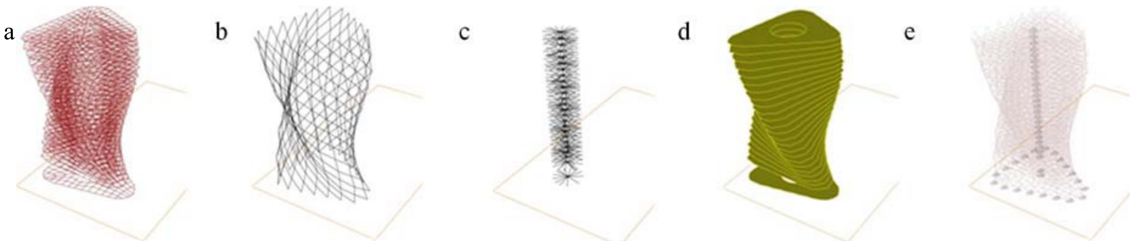



Fig.10. Structure System (a) beam structure; (b) diagrid enclosure; (c) core structure; (d) floor slab structure; (e) supporting structure

a b c

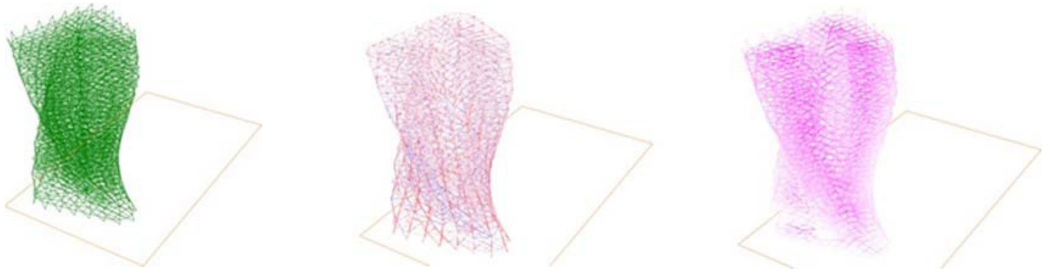


Fig. 11. Deformation analysis (a) deformation, (b) internal forces: compression and tension, (c) displacement

## *2.6. Facade Design*

The exterior walls are analysed again to identify areas that gain more heat or solar heat than the others. In respond to the condition, additional shading devices are added to protect the area from excessive sun radiation. The result of this analysis is used to select type of glass for building's skin, suitable shading device, and OTTV calculation. This simultaneous and coordinated analysis exceeds conventional design method in deciding the best orientation of building. Combination of Grasshopper, Ecotect and Geco as the bridge, has brought spectacular engineering design and increased architect's productivity through more iterations during the design process.

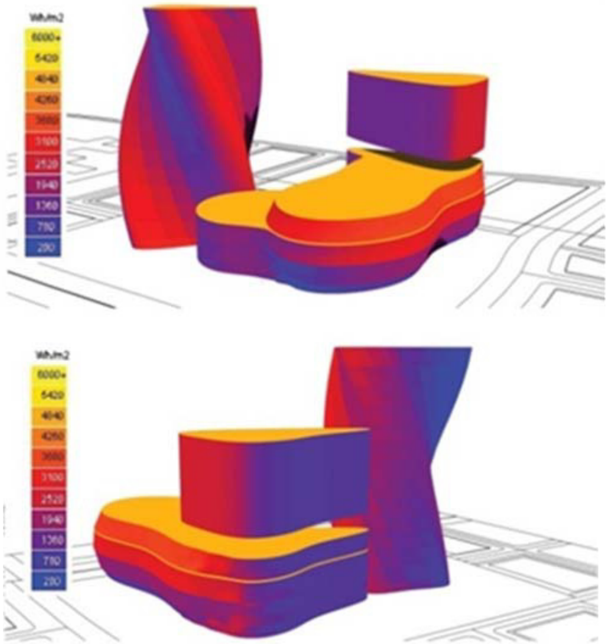



Fig. 12. Study of solar radiation

Table 2. Solar Radiation Summary

| Skin | Outer Wall Area/A (m2) | Solar Radiation/SF (Wh/m2) | A*SF (Wh) |
|---|---|---|---|
| X | 8.369,29 | 1.814,20 | 15.183.565,92 |
| Y | 4.443,70 | 1.597,00 | 7.096.588,90 |
| Z | 15.425,00 | 1.698,00 | 26.191.650,00 |
| Total | 28.237,99 | | 48.471.804,82 |

Total Radiation on all skins (Σ(A*SF)/ΣA) : 1716,54586 Wh/m2

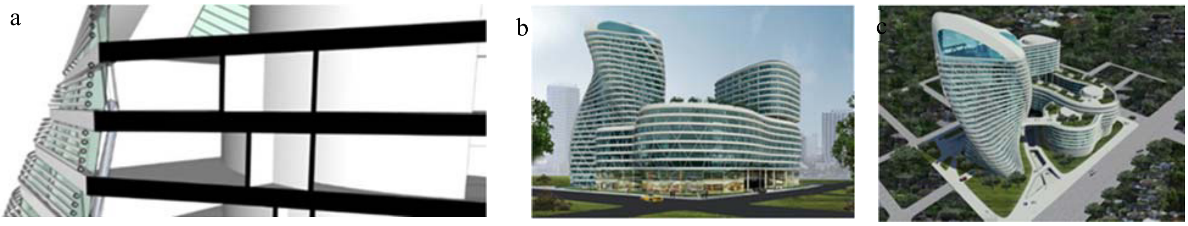


Figure 13. (a) Additional shading design; (b) Exterior view; (c) Bird eye view

## 3. Conclusion

The parametric method consumes longer time than conventional ones. Writing a formula is not easy, and process of trouble shooting often demands formula revision. The discrete method of problem-solving can reduce the inefficient and unpredictable time in writing formula. However, the method needs higher skill in logical thinking that demands more time. The parametric method brings remarkable result in iterative design process. The results are hardly obtained by conventional methods. The method accommodates combination of form parameters with various assessment tools or algorithms. The algorithms are useful for various analysis, e.g. climate, structure, and others. The quality of design is enhanced because it is based on scientific analysis. The simultaneous analysis introduced by this method enabled designer to monitor changes during the design process, which in turn, enhance the understanding and knowledge on design.

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