Title:
Building Massing Optimization in the Conceptual Design Phase

Authors:
Y.-S. Huang, D10013006@mail.ntust.edu.tw, National Taiwan University of Science and Technology
W.-S. Chang, M10213014@mail.ntust.edu.tw, National Taiwan University of Science and Technology
S.-G. Shih, sgshih@mail.ntust.edu.tw, National Taiwan University of Science and Technology

Keywords:
Building massing, optimization, dimensionless, genetic algorithm

DOI: 10.14733/cadconfP.2014.78-80

Introduction:

Taipei is the most densely populated city in Taiwan. Land is very expensive and living environment is crowded. Evaluation of shadow of building allocation and building massing estimate are two most important tasks of an architect in the conceptual design phase. Architect proposing the best-optimal object measurement solution in the conceptual design phase is the key to a successful development.

The best-optimal solution in this investigation is to be able to derive a massing algorithm for maximum floor area and gross floor area. According to the interview results in this investigation, architects are used Excel to calculate the legal area. AutoCAD is used to draw 2D diagrams for rule checking. 3D MAX is used to simulate relationship between mass location and the environment, these methods and tools are used currently in the conceptual design phase in Taiwan. This investigation concludes that conceptual design phase requires a rule evaluation method that can be linked to BIM Software Tool.

This investigation focuses on a site being evaluated for development. The site is located in proximity to Xikou Primary School in Ching-Fu Street of Wenshan District, Taipei City. This type of site is suitable for constructing a complete legal system framework.

Main Idea:

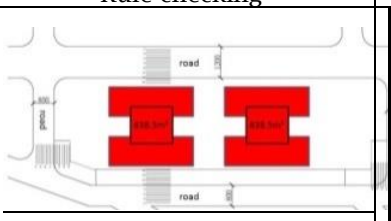
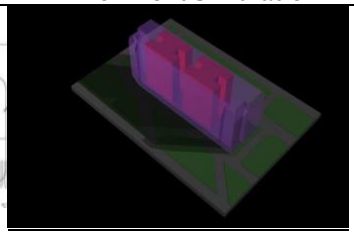
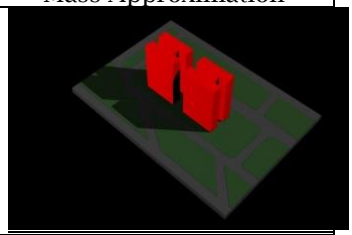
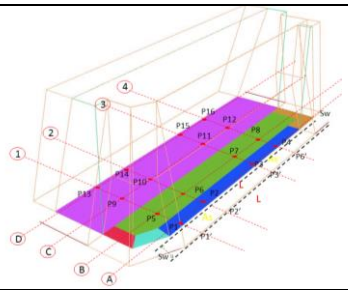
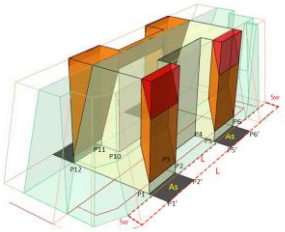
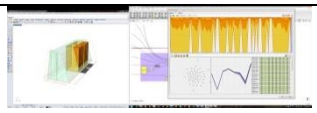
Genetic Algorithm is applied to building design optimization to estimate a frequently seen method. Past researches applied Genetic Algorithm to LEED energy efficiency analysis such as Barnes (2009) [1], green buildings such as Wang (2006) and building optimization analysis [4]. Optimization flows in these researches are generally the same. Ouarghi (2006) [2] uses Neural Network to investigate building shape optimization together with Genetic Algorithm. Renner (2003) [3] adopts DOE-2 and MATLAB to perform building massing parameter generation and structure similar to this investigation but this investigation focuses more on optimized simulation of legal and mass allocation plan

This research designs a building mass structure formed by structural components. Five frequently seen building mass types are optimized and simulated and the types are rectangular, L-shaped, square-shaped, H-shaped, and U-shaped. A set of parameters can be defined for each shape. A grid structure system develops a set of parameters. Unit of every type is applied to the dimensionless grid system to form a type calculation unit.

This paper uses Genetic Algorithm to design a set of simulation programs to be able to optimize and precisely estimate the building massing parameters. Genetic Algorithm uses a nature evolution concept to select good units for optimization and converges into a best solution

The simulation in this investigation is performed using Rhino and grasshopper software to derive building massing parameters and formula of legal limitations. Galapagos is then used to perform the best-optimal simulation of Genetic Algorithm.

Conclusions:
This investigation aims to build an optimized simulation method to achieve a breakthrough in the conceptual design phase and overcome the drawback of an architect not being able to derive an optimized massing. This system combines legal information with massing process, which has never been investigated before. Results showed a significant increase of the massing preciseness. The solution of this research combines a rule checking tool with an optimized tool to propose cross application of different software tools to achieve the most effective algorithm. However, format conversion between software tools and simplification of massing variables are issues to overcome in the future to enhance more complicated legal checking functions.

Items	Rule checking	Environment Simulation	Mass Approximation
General Design Flow			
	2D Auto CAD	3D Max	Excel and 3D Max
Genetic Algorithm Simulation System	3D Rule checking Framework	Building massing Shadow Simulation Analysis	Floor Area Calculation
			
	rhino	rhino	galapagos

Tab. 1: Conceptual design software application and analysis.

Items	Optimized Solution	Rule checking	Quantitative Analysis	Structure System	Solution estimate	Required Time
General Design Method	3D Max cannot perform precise data analysis.	2DAutoCAD labels 3.6:1, relationship between shadow and mass retreatment.	Excel is used to calculate maximum floor area and gross floor area.	Cannot estimate the system structure.	Cannot precisely estimate; must reserve 3-5% for adjustment (approximately 480 square meters for 3%).	Basic information database construction requires two days; 1-2 hours per solution.
Genetic Algorithm	Galapagos directly calculates the best-optimal solution.	Real time simulation of 3D legally evaluated framework.	Grasshopper generates parameters for direct judgment of requirement conditions.	Directly generates structure system.	Error margin is not required (error range is 1 square meter only)	Real time parameter adjustment.

Tab. 2: Table of conceptual design analysis.

References:

[1] Barnes, S.; Castro-Lacouture, D.: BIM-enabled integrated optimization tool for LEED decisions, 2009 ASCE International Workshop on Computing in Civil Engineering, June 24-27, 2009, Austin, TX. 2009.

[2] Ouarghi, R.; Moncef, K.: Building Shape Optimization Using Neural Network and Genetic Algorithm Approach, ASHRAE Transactions, 112(1), 2006.

[3] Renner, G. Ekárt, A.: Genetic algorithms in computer aided design, Computer-Aided Design, 35(8), 2003, 709-726. http://dx.doi.org/10.1016/S0010-4485(03)00003-4

[4] Wang, W.; Hugues, R.; Radu, Z.: Floor shape optimization for green building design, Advanced Engineering Informatics, 20(4), 2006, 363-378. http://dx.doi.org/10.1016/j.aei.2006.07.001