A COMPUTATIONAL MEDIUM FOR THE CONCEPTUAL DESIGN OF MIX-USE PROJECTS.

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Abstract. Mixed-use projects are becoming widely accepted as a sustainable approach for urban development. Nevertheless, a successful and responsive design solution for such building-type poses a substantial burden on the designers mental and intellectual capacities. This is due largely to the overflow of sophisticated design information and considerations. This paper reports on the development and implementation of an information modeling medium to support the architect in the conceptual spatial and formal exploration of this important sustainable building form.

Keywords: Conceptual design, Computation, Urban, Sustainability.

1. Introduction

It is projected that by 2030, 5 billion people will live in urban areas throughout the world (United Nations 2001). This amounts to 30 percent increase over current world wide urban inhabitants; A rapid influx that is expected to exert substantial strains on what is already a deteriorating urban condition. Recent studies on the built environment and urban development (Mir Ali 2008) warns that in the coming years, energy shortage, air pollution, disease, and global conflicts over land and resources are inevitable conditions of the twenty-first century unless we move quickly towards the notion and implementation of sustainability.

As the need to embraced and implement sustainable design strategies become ever more pertinent, mixed-use projects standout as a natural model of urban development. Susan Jones (Gissen and National Building Museum (U.S.) 2003) explains that any hope to address the deterioration of urban conditions must be conceived in the broadest possible way. In particular, Jones asserts that its only in the form of *large and mixed-use complexes*, that cities can continue to grow sustainably. The combination of residential units with retail, offices, cultural, recreational and other commercial spaces within a single building helps creates diverse, walkable and robust communities that limits urban sprawl, alleviate strains imposed on natural resources, and reduce transportation-related energy emissions.

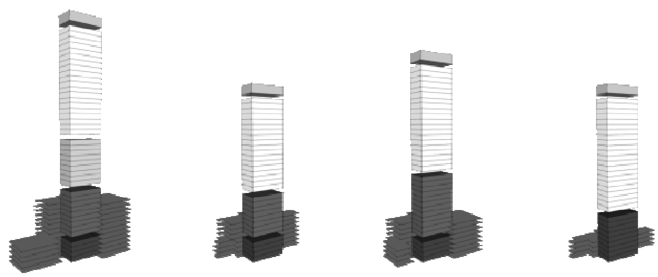

Figure 1: Mixed-use mid-rise towers.

It is perhaps evident that mixed-use development promises valuable sustainable benefits. However, most real estate experts will agree that developing mixed-use projects is challenging even in the simplest of circumstances (Heller 2010). The success, responsiveness, and fitness of this form of development is contingent on an increasingly complex design process. This is especially true during the conceptual design phase where designers are required to interpret, manipulate, and communicate an expansive, and often conflicting matrix of design information and requirements. Against this background, one might question: can emerging information modeling technologies mitigate complication associated with the conceptual design of this important building type? Engaging such question will indeed deepen our understanding of this important building form and its measures of success. Furthermore, it will contribute to the development of new design tools and strategies to support the development of sustainable urban environments.

The discussion below sheds light on the current stage of developing and implementing an alternative form of building information Modeling; One that is intended to support the architect in the conceptualization and early planning of mixed-use projects. The range of design issues and considerations associated with vertical structures are indeed vast and interrelated in nature. Eugene Khan and Paul Katz (Kohn and Katz 2002) From Kohn, Pedersen, & Fox present a useful abstraction. Their abstraction explicate that there exists ten key design considerations that are common, and in some cases unique to the design and planning of tall and mid-rise buildings. These key design considerations include core configuration, floor plate, floor-to-floor height, exterior wall systems, structure systems, mechanical equipment, loading and parking, code compliance, area schedules, and cost schedules. These key considerations are for single occupancy projects, the list becomes longer when considering mixed-use occupancies. For instance, architects have to design for occupancy operation separation, and coordinate structural system variations.

While these issues are indeed critical and inter-related, their holistic treatment falls beyond the scope of this study. Accordingly, the scope of this study shall be limited to the first, and what is perhaps held as the central consideration for both single and mixed-use vertical projects; core-configuration.

2. Core Configuration Design Considerations and its Complications

The architectural and financial viability of vertical structures depend on the success of its service core configuration. The process unfolds with a thorough survey of functional requirements. This information is typically passed on to the architect from the pre-design (programming) phase. This information is preliminary. It is usually ill structured, incomplete, and is likely to evolve throughout the design cycle. The architect's main objective in the configuration of the service-core is to enable the vertical stacking of the different functional requirements while giving heed to three important guiding principles: space efficiency, operability, and separation between the different occupancies. Space efficiency is percentage of rentable space in relation to service space. In the case of mixed-use buildings an efficiency ranging between 70% and 80% is considered ideal. Beside this overall measure of efficiency, there is a more localized measure referred to as *lease-span*, which measures the depth of the leasable space (usually from the core to the building's envelope). Each occupancy requires certain lease-spans that better suits the functions it accommodates. In general, Office and commercial occupancies require larger lease-spans than residential and hotel. Operability is concerned with travel distances and circulation. Lastly, separation is concerned with ensuring that each of the different occupancies is self-dependent in terms of operation.

The components that go into tall building's service-core include, but are not limited to elevators, egress stairs, lobbies, atriums, washrooms, and spaces for mechanical, electrical, plumbing, and structural elements and equipments. For a successful and responsive core-configuration, architects must work closely with other design professionals including engineers, maintenance, and management personnel; integrating their input into the final design proposal.

The challenges arising in core configuration manifest in terms of three primary areas. First, Information, there is an overflow of design information coming from different parties with separate aims. Second, configuration, the various service-core components are in competition with one another and their planning into a sound and fitting order becomes substantially problematic. Third, alternatives, in light of the difficulties arising from the first and second points, the examination of a wider range of design possibilities becomes an overly complex and time-intensive undertaking.

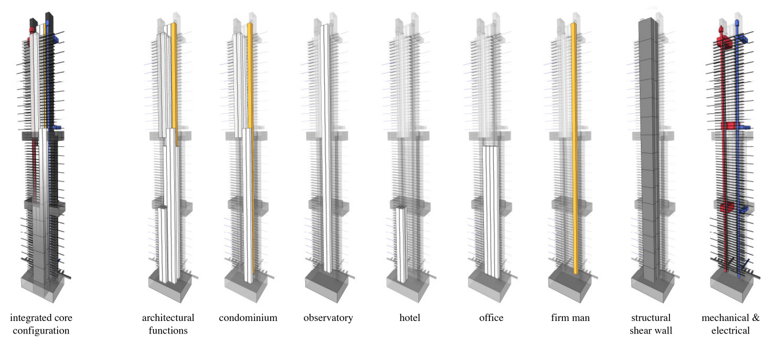

Figure 2: the complexity of core configuration lies in the criterion to accommodate its multiple architectural, structural, and mechanical needs in a very small foo print.

3. Investigating Alternative Design Media

In response to the challenges presented above, this project has set out to investigate and develop an alternative architectural design medium that can support and facilitate the conception of mixed-use mid-rise towers. In recent years, evidence of new trajectories for investigating new design media has emerged. These trajectories aim to support the architect through augmenting the cognitive and developmental traits of traditional study drawings, namely sketches and diagrams, with layers of information, computation, and interactive technologies (Herbert 1993; Cross 2007). This project follows the same direction, however, with special emphasis on appropriating (into architecture design workflows) information modeling strategies emerging from the study of complexity. This is pursued and manifested through the development of a conceptual building information model (CBIM) environment.

It must be noted, however, that such undertaking is not a revolt on existing BIM technology. To the contrary, it should be thought of as a complementary module; to support and facilitate conceptual design needs of large and complicated projects, which until very recently, used to fall beyond the scope and interest of existing BIM systems.

4. CBIM

CBIM, though similar in principle to existing BIM systems, presents a novel approach for interfacing with the underlying information-model. Unlike existing BIM systems where designers typically interact with discrete representations of building components such as walls, columns, slabs, etc. CBIM gives focus to spatial considerations represented through a simplified abstract notation, inspired by bubble and blocking diagrams. This proposed shift in building information modeling approach is implemented using graphs (networks). Graphs here refer to the prolific logical or mathematical system comprised of nodes and connecting edges. Presently, the research is focused on using graphs for modeling and representing spatial aspects of the design issue; including architectural program components, and information about adjacencies, spatial organization, and geometric form. This model is used to study and examine the project's spatial and formal structures and their sustainable parameters in relation to the surrounding urban setting.

5. Modeling Workflow

Modeling begins with the designer inputting the various architectural-program elements, represented as nodes, and the various spatial relationships between nodes represented as edges. This particular workflow is a close abstraction of bubble diagramming, working with limited set of syntactical elements, suppressing details and focusing on the broader context of the project. Once the information model is in place, the designer is able to analyze various spatial and formal aspects of the proposed design solution.

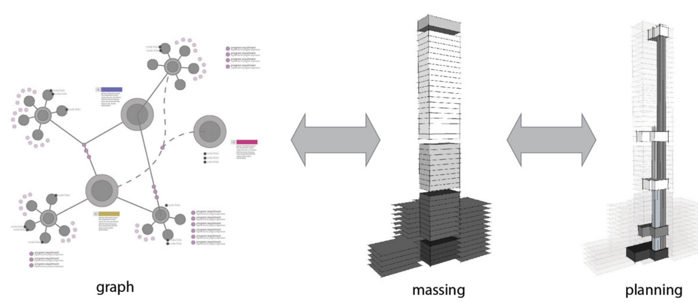

Figure 4: The graph underlies massing and planning activity during concept design.

At this stage of development, the possible occupancies include commercial, office, hotel, apartments, condominiums, observatory, parking, and an assortment of terraces and landscaped features. Beginning with an arbitrary site and building footprint, the modeling process unfolds with the designer identifying the primary functions with their high-level properties, for instance, office, hotel, apartments, terrace gardens, and parking, with each of these functions assigned a desired useable area, units (if applicable), and class of service. Then, the designer would add information about stacking and adjacencies that govern the spatial relationships between the various functions and their components. From this information, the modeling environment computes the service core requirements with a suggested initial core layout. From there, the designer can begin to query the information model using the analysis module.

6. Core Program Sustainability Appraisal (CPSA)

CBIM is developed to support the architect in the conception of mixed-use towers that deliver rich urban diversification and integration; two properties that are widely accepted as critical criterions of sustainable urban growth. Although narrow in terms of design considerations, CBIM's analysis environment delivers important feedback. This feedback helps architects deepen their understanding about the linkage between core configuration, architectural program, and possible sustainable benefits. This is facilitated through the development of The Core Program Sustainability Appraisal (CPSA). This appraisal is integrated within the conceptual building information modeling environment and is the core of the analysis module.

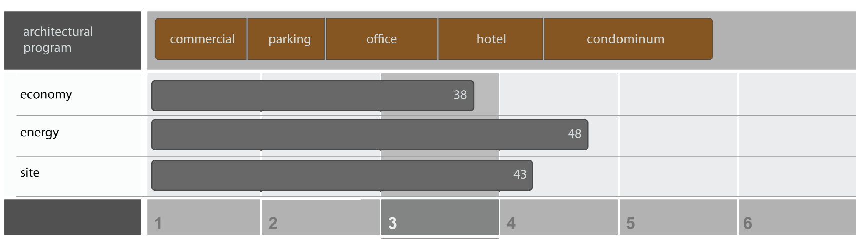

Figure 5: The CPSA graphical representation. The top row presents the program occupancies, rows 2 through 4 measure how the proposed core resolution to the architectural program scores in relation to sustainable urban issues: economy, energy, and site.

Understanding the linkage between core, program, and sustainability is proposed and pursued through examining the possible interrelations and interactions between the different components belonging to each of the three examined categories. In particular, how the different core components, and their underlying design considerations resolve, both effectively and efficiently, the spatial and formal requirements of the different program occupancies? and how this proposed resolution relate to sustainable urban development considerations, which currently focus on economy, energy, and site? That is to say how the proposed design resolution help in fostering economic opportunities, reducing transit-related energy consumption, and influence integration with the surrounding urban setting.

The information resulting from the appraisal is reported in a graphical format; a bar chart composed of four rows. The first row corresponds to the program's different occupancies. The functional diversity and spatial order of the project (established and articulated in the modeling environment) determines the value for each of the components listed in the sustainability category. As explained above, these considerations include economy, energy, and site. the overall sustainable contribution of the proposed design would be determined by the row with the lowest score. (see figure 5).

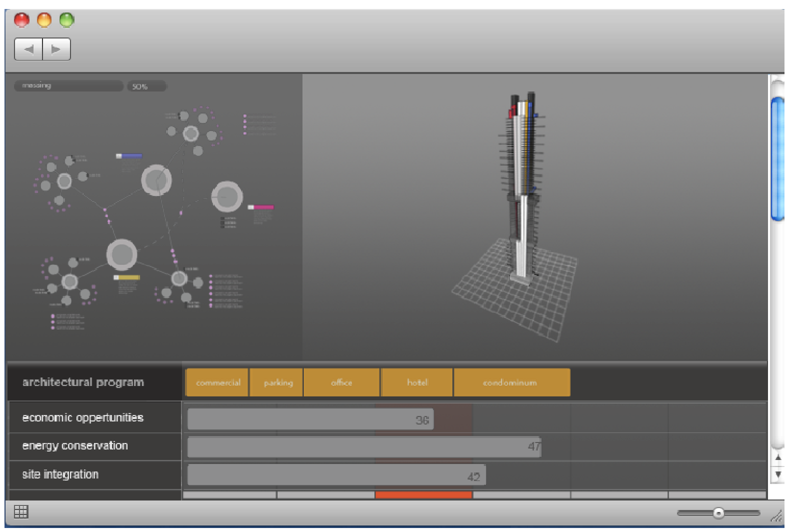

Figure 6: Interface for CBIM. This arrangement is composed of three panes. The program and its spatial order is depicted in the reft pane, the core-configuration is depicted with the right pane. The CPSA occupies the bottom pane.

7. Conclusion

As the need to embraced and implement sustainable design strategies become ever more pertinent, mixed-use towers standout as a natural model for sustainable urban growth and development. Nevertheless, the viability of this sustainable building form is contingent on delivering a design solution that resolves the complicated, and often conflicting, interests of various stakeholders. The discussion above has delineated a range of problematic design issues confronting the architect during the conception of this building form. Against this background, This paper presented CBIM; A *conceptual* building information modeling environment, especially developed to support architects in the conceptual design of sustainable mixed-use towers.

In particular, the development and implementation of CBIM is focused on supporting the architect in what is perhaps the central and key consideration in the conceptual design of mixed-use towers; core-configuration. The modeling environment offers the designer an interactive and integrated diagramming medium to manage and view manipulate spatial requirements and adjacencies. Beside the modeling environment, CBIM's analysis module is being developed to help architects deepen their understanding about the linkage between core configuration, architectural program, and sustainable practices. With such development, this study hopes to contribute knowledge and insight to ongoing efforts to deepen our understanding about the design of this important urban building form. Additionally, It hopes to help in paving the path for a new direction in the development of building information modeling; a direction that gives heed to the emerging requirements for design systems capable of supporting the conception of complicated mixed-occupancy projects.

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