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Preference for void-to-solid ratio in residential facades

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ABSTRACT

This paper proposes that there is a need to quantify the value of void-to-solid ratio in residential facades. When quantified, void-to-solid ratio is expected to influence preference for these facades. To test this hypothesis, computer-simulated facades were created using a number of mesh editing and photo-editing software packages. The independent variable, void-to-solid ratio, was varied at three levels of windows' orientations and four levels of buildings' heights, resulting in 60 stimuli. A total of 174 participants were randomly sampled from Mutah University, Jordan, who input a total of 10,440 preference responses to the stimuli. The simulated facades were able to convey the values of void-to-solid ratios to participants. Responses revealed that there is an inverted U-shape relationship between preference for residential facades and their void-to-solid ratio, and that the most preferred range of void-to-solid ratios was (0.4–0.5).

1. Introduction

Void-to-solid ratio in a building façade is defined as the area of the façade covered by openings (windows, doors, arches, etc.) divided by the area of the solid wall (Carmona, Heath, Oc, & Tiesdell, 2003). It is a measure of the balance between negative openings (figures) against the positive walls (grounds). It is the proportion of the area of fenestrations to that of the wall (Lundgaard, 1995). Some scholars referred to void-to-solid ratio in terms of transparency and opacity, lightness and heaviness, or openness and enclosure (Ewing & Handy, 2009; Şen, Özdemir, Kahya, Sarı, & Sağsöz, 2011; Sinkevitch & Petersen, 2004; Stamps, 1999; Strauss, Polshek, Sawyer, & Polshek Partnership, 2005; Taylor, 1999).

Architecture and urban design literature used void-to-solid ratio as a design factor that involves a number of psychophysical, functional, and environmental implications. These implications include architectural style (Michael, Moffet, & Wodehouse, 2004), façade level of complexity (Akalin, Yildirim, Wilson, & Kilicoglu, 2009; Imamoglu, 2000), urban preservation and infill (Larson, 1995), and architectural control and regulatory guidelines (Richards, 1994).

The ratio of void to solid varies with the function of the building. For example, façades of office buildings typically have high void-to-solid ratios, whilst façades of places of worship have low ones. Previous studies reported that people judged buildings that have large glass façades as office buildings, museums or shopping centers, and those with smaller glass areas as religious or residential ones (Şen et al., 2011). Buildings with different façades' void-to-solid ratios can evoke a sense of heaviness conveyed at the ratio's lowest level and a sense of lightness conveyed at its highest level (Bacow, 1995).

Residential buildings, due to their function, are expected to dwell somewhere in the middle of the range of void-to-solid ratios. The current research aimed at designing a method to measure this ratio and determining the preferred void-to-solid ratio or range of ratios in residential façades. A quantification method for void-to-solid ratio was developed and, by using a number of computer programs, 60 façades with variations in void-to-solid ratio and windows orientations were produced. The simulated façades were incorporated into an on-screen survey that measured the preference of 174 participants from the students of the University of Mutah in Jordan.

1.1. Research significance

There are three reasons for investigating void-to-solid ratio in façades. The first reason is to quantify the verbal descriptors like transparent, opaque, heavy, and light that are frequently attached to façades in the literature. The second reason is to uncover any possible relationships between preference and void-to-solid ratio in façades. The third reason is to uncover which value, or range of values, of void-to-solid ratios are most preferred. Although a review of related studies revealed that void-to-solid ratio is considered one of the most important design factors (Burden, 2000; Neumeyer, 1999; O'Connor, 2006; Richards & Gilbert, 2006; Thomson, 1984;

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Urban, 2009), its descriptors were verbal, vague, and untranslatable into scientific knowledge or practical applications. Examples of literature expressions that are used to describe void-to-solid ratio are "strong relationship of solid to void" (Heyer, 1993, p. 66), "Symmetrical façade with perfectly proportioned windows to walls" (Ambrose, Harris, & Stone, 2008, p. 191), "… to produce a complex juxtaposition of solid and void" (MacDonald, 2001, p. 5), "The façades are rich compositions with opaque and transparent, solid and void elements coming to a balance" (Sinkevitch & Petersen, 2004, p. 285), and "an attractive ratio of solid to void" (Casey, 2005, p. 182). Such verbal descriptors cannot be communicated precisely, and will not be translated easily into practical regulations; these descriptors need to be quantified. With this dilemma in mind, five subsequent problems that might arise on a practical level are stated next.

1.2. Research problems

First, there is a need to quantify the descriptors for historic preservation and urban infill projects. Façade's void-to-solid ratio is a determining factor for fitting new buildings into existing sensitive urban contexts, particularly in historic sites (Gehl, Kaefer, & Reigstad, 2005; Nasar & Stamps, 2009; Watson & Bentley, 2007). Postmodern paradigm emphasizes fitting buildings into their surroundings. One way to do that is by designing new façades with proportions, articulation, and void-to-solid ratios that honor the existing urban context (Larson, 1995; Punter, 1999). For example, in a context where the overall urban street image conveys a sense of opaqueness, urban regulations recommended the making of visually compatible new façades by lowering their void-to-solid ratio. Some scholars suggested that even if the windows' shape, proportion, and orientation in new buildings are different from their historic context, maintaining the same void-to-solid ratio will help fit the building in its context (Nasar & Stamps, 2009).

Second, there is a need to quantify the descriptors for urban design regulation purposes. A façade's void-to-solid ratio is considered an urban design guideline factor (Friedman, Lin, & Krawitz, 2002; Parolek, Parolek, & Crawford, 2008). Urban planning and design guidelines in many countries regulate for façade composition, especially in well-established urban settings (Constant, 1993). For example, the city of Adelaide, in Australia, regulates for void-to-solid ratio in its streets (Legoe, Bechervaise, Olsson, & Challen, 1988). In the UK, among other criteria, the item 'windows proportions' is listed as an urban design code; the master plan of Crown Street specified ratios of glazing and fenestration to preserve the character of Glasgow (Tiesdell & Macfarlane, 2007). Other cities specified range of ratios like the City of Saint Louis, Missouri, which recommended a void-to-solid ratio in the range of (0.25–0.50) to accept any addition to historic buildings (Saint Louis City, 2007). The City of Asheville, NC, recommended a void-to-solid ratio of (0.45) (City of Asheville, 2009). The City of Corsicana, TX, recommended a range of (0.4–0.6) of void-to-solid ratio (City of Corsicana, 2007). City of Nashville, TN, regulated a range of void-to-solid ratio of (0.25–0.80) (City of Nashville, 2005). It is not established in literature neither in practice on what basis such ratios were advised.

Third, there is a need to quantify the verbal descriptors mentioned above in order to use them as a design tool. Previous studies suggested that façades' void-to-solid ratio is a design tool that can be used by architects to convey senses of massiveness or monumentality, uniqueness, dignity, attraction, repulsion, and social and commercial status, (Borden, Kerr, Rendell, & Pivaro, 2002; Krusche, Aijian, Anders, Dokonal, & Kapadia, 2010; Maciuika, 2005). Architects' normative and intuitive capabilities produced buildings that expressed these values in different places and times, but others do not know how, and on what scientific basis they were produced.

Fourth, there is a need to quantify the descriptors for architectural and urban design education purposes. Architectural students struggle through their first two to three years trying to understand, by trial and error, numerous architectural concepts that pertain to proportions, hierarchy, rhythm, balance, contrast, etc. To communicate such ideas, architects and architecture educators need to quantify values of solid-to-void ratio, among other values, and tell what ratios pertain to what sensorial values. The communication of architectural ideas needs to be grounded into what (Stamps, 1999) called 'low-level concepts' of design geometry. One way to produce low-level concepts is by measuring the geometric relations of volumes and surfaces in the built environment.

Fifth, there is a need to quantify the descriptors for theory and history of architecture purposes. Façades' void-to-solid ratio is a factor that scholars used to differentiate between architectural styles. Change in void-to-solid ratio indicates shifts in architectural styles; (John, 2010, p. 48) reported that architect Robert Adam abandoned the "traditional relationship of solid-to-void found in masonry buildings…", and shifted his style to something different. In their book *American Architecture*, Whiffen and Koeper reported that architect Henry Hobson Richardson's concentration on relationships of void and solid, of window and wall, produced harmony and abstraction, with little reference to the past (Whiffen & Koeper, 1980). Describing the later work of Alexander Thomson, (McFadzean, 1979, p. 240) noted that "The rhythm which the contrast of solid and void had given to so many of his earlier buildings has been replaced by a static façade in which the masonry wall clearly dominates and arrest the window pattern."

The frequent appearances of the façades' void-to-solid ratio or its equivalents, the importance it was given in the literature and its psychological inference motivated this current research. The implicated usefulness of understanding void-to-solid ratio in façades to urban planners, urban designers, and architects, stirred this work to isolate this value and measure it. The need to find a theoretical piece of information to fill a small gap in the body of literature guided this work to find its influence. When change of geometric value of void-to-solid ratio is capable of indicating a shift from one architectural style to another, then it is quite logical to empirically quantify that value and investigate its influence on users.

1.3. Questions

Question 1: Can manipulation of the values of void-to-solid ratio in façades predict preference?
Question 2: What void-to-solid ratio or range of ratios in façades is the most preferable?
Question 3: What windows orientation is most preferable?

1.4. Hypotheses

1- Quantification of the void-to-solid ratio in façades makes it easier to understand, design for, and communicate the sensorial values that are attached to it.
2- Frequent citations of the value of void-to-solid ratio in literature and the importance assigned to it suggests that a relationship does exist between the void-to-solid ratio of façades and preference.
3- Based on preference for complexity in the reviewed experimental research, it is expected to find the preferred ratio of void to solid somewhere in the middle of the spectrum.