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Original Research Article

Analysis of the Physical Criteria of Infill Buildings to be Used in Design and Evaluation*

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Abstract

Problem statement: So far, various approaches have been raised regarding the design of infill buildings that usually, categorization of these approaches has been focused on physical topics. Therefore, it can be said that the issue of physical criteria is very important in the design of infill buildings. In this regard, according to the lack of a unified discourse about effective physical criteria to select approaches from theorists point of view, as well as the existence of obvious differences in the introduced criteria and the lack of some criteria in these definitions, it seems necessary to consider all the effective physical criteria and achieve a coherent set from them.

Research objective: Therefore, this study's primary goal is to analyze and investigate various theories to scrutinize and achieve a comprehensive complex of effective physical criteria in selecting and defining the approaches and the other purpose of the research is to classify those criteria in the form of main criteria and sub-criteria to use them in designing and evaluating infill buildings.

Research method: Regarding the methodology, it can be said that this descriptive-analytical research has used the logical reasoning strategy and the content analysis technique using library recourses to organize the indicated criteria by theorists and related organizations in a more comprehensive system.

Conclusion: Therefore, all those criteria are classified as the main criteria in four general areas: 1. Position 2. Form & shape 3. Scale and proportions 4.Material appearance characteristics, due to having the highest frequency and importance in the studied literature of research. Then, their sub-criteria are presented in the form of a diagram to help determine different approaches to the design &evaluation of infill buildings.

Keywords: *Physical criteria, Infill buildings, Historical environment, Designation, Evaluation.*

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Introduction

In particular, about selecting approaches to design infill buildings and determining the approaches to evaluate those buildings, various criteria have been proposed by theorists and related institutions since the 1980s. In this regard, the physical form of infill buildings is one of the important factors that is addressed using the afore-mentioned criteria. Thus, since theorists and institutions have provided their own definition of these criteria, some criteria are still missing in the body of these definitions. Furthermore, the wide variety of definitions proposed in this regard have given rise to a need for collecting all those criteria proposed by institutions and theorists. In addition, since some of the criteria proposed by theorists and institutions can serve as subsets of other criteria and contribute to the definition and delineation of those criteria, the present study attempts to provide a comprehensive classification of criteria and determine the main criteria and their sub-criteria and thereby contribute to the selection of approaches in designing and in the process of infill building physical evaluations.

In order to achieve a comprehensive list of criteria in this field, the theories put forward by theorists and relevant institutions to address the physical structure of infill buildings will be investigated. In the first step, all the criteria mentioned in the theoretical foundations will be collected. After that, the repetitive items will be deleted, and new items will be added to the body; and finally, the criteria that can be presented as the main or sub-criteria will be presented in the form of a chart. Each main criteria and their sub-criteria will be subjected to in-depth reviews and investigations to determine their applicability in designing and evaluating infill buildings.

Research questions

- What are the comprehensive and effective physical criteria that can contribute to selecting adequate approaches for the design and evaluation of infill buildings?

- How can these criteria be classified into main and sub-criteria according to their applicability in the design and evaluation of infill buildings?

Methodology

The present study falls within the category of descriptive-analytical studies (pursuing a qualitative goal) in terms of nature and methodology. In the present study,, first,, qualitative content analysis is used to investigate the evolution trend of relevant literature and extract physical criteria that can effectively contribute to the delineation of approaches used in the design of infill buildings. In the next step, the quantitative content analysis technique is used to determine the frequency of criteria extracted from the relevant literature. Afterward, the frequency of the criteria and the logical reasoning strategy are used to classify the criteria into a more comprehensive system covering both the main and sub-criteria Each of the main criteria to complete and scrutinize this system and extract and add their unmentioned sub-criteria is then descriptively examined. In the following, the final classification of criteria and sub-criteria related to the physical form of infill buildings, using the results of the previous steps, is done so that it can clarify the definition of infill buildings approaches to adopt them in the design and identify them in the process of evaluating infill building.

Theoretical foundations

• Effective physical criteria used to determine the strategies of infill buildings

Although the construction of new and infill buildings beside historic buildings has always existed throughout history, historic sites and buildings' preservation and continuity emerged as a new challenge after rapid environmental changes affected by world wars and the industry's rapid growth. This could be primarily attributed to the increasing awareness of the stark difference between new and historical architectural works. The

term "infill" was first introduced in the 1980s at the ICCROM, ICOMOS and UNESCO joint summit on the design of modern buildings in historic sites.. Since designing in historic sites requires a deep understanding of the surrounding environment's criteria (Nasr, 2015; Lambe & Dongre, 2017), Examining the existing architecture criteria can significantly affect the designers' decision-making when applying an infill design approach (Lambe & Dongre, 2017). Therefore, considering the lack of some criteria and their high diversity in the definitions provided, the present examines the infill buildings' documents to explain and analyze their physical criteria that can contribute to the design and evaluation of infill buildings.

Therefore, it can be argued that before the 1983 ICCROM, ICOMOS, and UNESCO joint summit on the construction of modern buildings in the historic site, charters such as the 1933 Charter of Athens mainly focused on buildings that do not dominate the volume, color, and shape of historic buildings. Moreover, in 1972 ICOMOS resolution on the introduction of contemporary architecture into ancient groups of buildings put forward criteria such as the use of traditional techniques and materials and consideration of mass, scale, rhythm, and appearance. Aside from the above-mentioned criteria, some other criteria such as mass, building height, building location, occupancy area, and materials were taken into account in the 1975 Amsterdam Congress resolution.

Moreover, Standards for Rehabilitation and Illustrated Guidelines for Rehabilitating Historic Buildings, first issued in 1977, hold that "in order to maintain the coherence of the environment, additions need to be at the same time "differentiated" from the historic fabric and "compatible with the historic materials, features, size, scale and proportion, and massing (Penn, 2007). Similarly, Brolin discussed the role of form, scale, ornament, materials, and details in fitting architectural works to their contexts (Brolin, 1980). the physical criteria presented at the 1983 ICCROM, ICOMOS and UNESCO joint summit; where the term infill was first introduced, also encompassed rhythm, shape, mass, facade features, and materials. The 1987 Washington Charter added the relationship between building and open space, style, and ornamentation to the above-mentioned criteria. According to Weeks & Grimmer, modern buildings should be "differentiated" from the historic fabric but "compatible" with materials, features, size, scale, proportion, and massing to protect the integrity and its environment (Weeks & Grimmer, 1995, 62). Moreover, according to Cañas Guerrero et al., design variables associated with height (size), color, and materials are among the most common physical features that are taken into account in the configuration of new buildings with urban landscapes (Cañas Guerrero, AyugaTellez & OrtizSanz, 1995).

In 2005, the New South Wales Heritage Office and the Royal Australian Institute of heritage suggested that criteria such as scale, form, buildings locating, materials, and color need to be taken into account in the assessment of the impact of new development on valuable historic sites (Riza & Doratli, 2015, 5). Management Guidelines for World Cultural Heritage Sites- Iccrom also noted that the new buildings should respect the character and scale of their historical fabric, as well as factors such as rhythm, mass, street boundary line, silhouette, compatible materials, as well as thewindow to the wall ratio (Rodwell, 2007, 136). Similarly, *Ching* (Ching, 2007) has considered seven visual features for the architectural form. These features include shape, size, color, texture, position, orientation, and visual forces (Hu, Heat, Tang & Zhang, 2017). The Royal Fine Arts Commission (RFAC) has also identified six evaluation criteria for achieving visual coherence and contemporary architectural design. These criteria include volume, position, scale, proportions, rhythm, and materials (Carmona, Tiesdell, Heat & Oc, 2010, 187). Sotoudeh & Wan Abdullah showed that for designing buildings that can integrate into historical sites, a variety

of construction features such as materials, color, surfaces, proportions, doors and windows, buildings locating, shape, scale, enclosure, and style are more important than other characters. In architectural design, three factors such as proportion, shape, and scale are among the most important factors that need to be taken into account to ensure design fitting into historical contexts (Sotoudeh & Wan Abdullah, 2012). The results of a study conducted by Ballester et al. during the same year showed that three criteria, namely color, shape, and texture, are among the design features that can guarantee to fit into the existing context (Cloquell-Ballester, Torres-Sibille & SantamarinaSiurana, 2012).

According to the 2013 Australia ICOMOS Charter, sitting, scale, mass, form, color, texture and material need to be taken into account in the design of new buildings in sites of historical significance (ICOMOS, 2013). In a study entitled "Infill architecture: Design approaches for in-between buildings and 'bond' as an integrative element," Djordje and Sanja Alfirevic also mentioned five factors of shape, color, structure, texture, and orientation (Alfirevic & Alfirevic, 2015). According to Mehdizadeh Saradj, architectural criteria for designing new buildings in the historical sites can be prioritized as height and skyline, visual quality, form and shape, style, and architectural ornaments (Mehdizadeh Saradj, 2016). Similarly, Hu et al. mentioned some criteria such as character, style, complexity, overall form, roof profile, proportions, projections from the facade, doors and windows, location of the entrance, materials, and color (Hu et al., 2017). Karimimoshaver & Winkemann also stated that the height of buildings is an important physical feature that affects human perceptions of the environment (Karimimoshaver & Winkemann, 2018). Serra et al. also emphasized on criteria of shape, size, color, texture, and materials (Serra, Llinares, Iñarra, Torres & Llopis, 2020). Therefore, the physical criteria mentioned in the literature can be summarized as Table 1.

Investigation and analysis

Since most of the criteria introduced by theorists and relevant institutions (as presented in Table 1) are common, a thorough list of criteria is presented in Table 2 (the repetitive criteria have been removed).

A review of the criteria proposed by theorists and relevant institutions showed that theorists and institutions have mostly focused on criteria such as volume and form, scale, proportions, position and buildings locating, Materials, and colors. These criteria have been more frequently used compared to other criteria presented in the literature (Table 3). Therefore, the following four criteria are actually the most important and frequently used criteria that can be recognized as the four main physical criteria in infill buildings: 1. Position, 2. Form and shape, 3. Scales and Proportions and 4. Appearance of materials.

Considering the four above-mentioned criteria: 1. Position, 2. Form and Shape, 3. Scales and Proportions and 4. Appearance of materials) as the main criteria, one can review and analyze other criteria and fit them into the category of main criteria concerning their level of consistency with the main criteria (Table 4). In the following section, the four above-mentioned criteria are addressed in detail in order to develop a complete set of effective physical criteria and sub-criteria.

- **Position**

Sitting, orientation, boundaries of the historical setting, entrance position, and the dimensions of the historic building and site are among the factors that must be taken into account when determining the position of infill buildings in a historical setting. When it comes to the harmony of infill buildings with historical sites, sticking to the orientation of historic buildings in the new building can be helpful. Respecting the territory of historic buildings and trying to preserve and enhance their intrinsic features at the same time can also effectively contribute to the harmony of infill buildings with historical sites. Building position is also related to the surface area of the building and its relation to

Table 1. Physical criteria of infill buildings in the relevant literature. Source: Authors.

Row	Experts and related institutions	Physical Criteria
1	The Athen charter, ICOMOS (1931)	Volume - Color - Form - Preservation of landscapes - Materials
2	The Venice Charter, ICOMOS (1964)	Size - Color - Landscapes
3	Resolutions of the Symposium on the Introduction of Contemporary Architecture into Ancient Groups of Buildings, ICOMOS (1972)	Volume - Scale - Rhythm - Materials
4	European Charter of the Architectural Heritage, Council of Europe (1975)	Form-size-proportion-scale-texture
5	Amsterdam Congress on the European Architectural Heritage, Declaration of Amsterdam (1975)	Volume - building height - position - materials
6	Standards for Rehabilitation and Illustrated Guidelines for Rehabilitating Historic Buildings-1977 (as noted by Penn, 2007)	Volume - Size - Scale - Proportions - Materials
7	Brolin (1980)	Form - Scale - ornament - Materials
8	Heritage Convention (ICCROM, ICOMOS and IUCN) and the UNESCO World Heritage Centre guidance (Feilden & Jokilehto, 1983)	Rhythm - shape - mass - materials - facade features
9	Washington Charter: Conservation of Historic Town, ICOMOS (1987)	Relationship between open space and building - scale - size - style - materials - color - ornaments
10	Cañas Guerrero et al. (1995)	Height (size), color and materials
11	Weeks & Grimmer (1995, 62)	Historical characteristics of materials - size - scale - proportions and volume
12	The Burra Charter, ICOMOS (1996)	Form-scale-color-texture-materials
13	The New South Wales Heritage Office and the Royal Australian Institute of heritage (2005)	Scale - Volume - buildings locating- Color
14	*Xi'an Declaration on the* Conservation of the Setting of Heritage Structures, Sites and Areas, ICOMOS (2005)	Rhythm - volume - street boundary line - silhouette - compatible materials - window to wall ratio
15	Management Guidelines for World Cultural Heritage Sites-ICCROM (Rodwell, 2007, 136)	Form-size-color-texture-position-orientation-visual forces
16	Ching (2007)	Shape-size-color-texture-position-orientation-visual forces
17	The Royal Fine Arts Commission (RFAC) (2007)	Volume - buildings locating - Scale - Proportions - Rhythm - Materials
18	The New Zealand charter, ICOMOS (2010)	Materials - Form - Scale - Mass - Color - Texture - Landscape
19	*Madrid* International *Conference,* ICOMOS (2011a)	Scale-position-proportions-structure-materials-texture-color-form-character
20	Valletta principles, ICOMOS (2011b)	Skyline - Landscape - Relationship between mass and space - Form - Scale
21	ICOMOS Charter, ICOMOS (2011c)	Height - consideration of boundary lines - Materials
22	Sotoudeh & Wan Abdullah (2012)	Materials - Color - Surfaces - Proportions - Openings - Arrangement - Shape - Scale - Enclosure - Style
23	Cloquell-Ballester et al. (2012)	Shape-color-texture
24	The Australia ICOMOS Charter for Places of Cultural Significance, ICOMOS (2013)	Buildings locating - Scale - Mass - Form - Color - Texture - Materials
25	Alfirevic & Alfirevic (2015)	Shape-color-structure-texture-orientation
26	Mehdizadeh Saradj (2016)	Height, skyline, visual quality, form and shape, style, architectural ornaments
27	Hu et al. (2017)	Character, style, complexity, overall form, roof profile, proportions, projections from the facade, doors and windows, location of the entrance, materials and color.
28	Karimimoshaver & Winkemann (2018)	Height
29	Serra et al. (2020)	Size-color-texture-shape-materials

Table 2. Effective physical criteria in determining infill building strategies. Source: Authors.

Set of Physical Criteria of Infill Buildings							
Row	**Criteria**	**Row**	**Criteria**	**Row**	**Criteria**	**Row**	**Criteria**
1	Opening	9	Texture	17	Landscape	25	Doors and Windows
2	Massing	10	Size	18	Scale	26	Direction
3	Ornament	11	Window to wall ratio	19	Skyline	27	Color
4	Style	12	Arrangement	20	Position	28	Material
5	Entrance location	13	Surfaces	21	Height	29	Buildings locating
6	Façade projections	14	Traditional techniques	22	Street boundary line	30	Rhythm
7	Relation between mass and space	15	Orientation	23	Roof profile	31	Form
8	Proportions	16	Shape	24	Structure	32	-

the streets and other spaces and buildings around it. In general, building position is important to maintain harmony and consistency while respecting the patterns and dimensions of the surrounding land plots (Carmona, Tiesdell, Heat & Oc, 2003).

Regarding the position of new buildings in the existing historical context, Schermann (Schermann, 2005) and Niković (Nikovic, Marić & Manić, 2010) have identified four general categories, which are described in Table 5. Moreover, Djordje and Sanja Alfirevic (Alfirevic & Alfirevic, 2015) addressed the afore-mentioned categories where some or all facade walls are minimally detached from the existing objects. New buildings' edges or borderlines relative to historic buildings are also one of the principles usually taken into account to maintain existing buildings' visual continuity. Solutions to this problem are presented in Table 6.

The important point about the position of infill buildings is their harmony and adaptability with the surrounding historical environment. This harmony is the outcome of respect for aspects such as setbacks from the historic buildings, proper orientation, privacy and distance from the existing buildings, sitting and natural landscape, as well as important views of the site.

When it comes to building a new addition to a historic building, it should be noted that additions that connect to the visible and important view of the historic building should be avoided as much as possible. In such cases, additions should sit on the secondary side or behind the monument so that they can have the least significant physical and visual effect on the historic buildings (Grimmer & Weeks, 1986, 3). Of course, it should be noted that the addition of a new building to the visible view of the historic building is admissible as long as the addition is not incompatible with the historic buildings or in cases where the addition can't sit in the secondary sides or behind the historic sites. It should also be noted that the addition sitting must be differentiated from the façade of the old building through a recessed connector, as this can represent more respect for the monument.

- **Form and shape**

In general, form in infill buildings refers to general volumes and surfaces (either filled or empty), their relations,as well as the way they meet the sky and earth, and the ornaments. In designing infill buildings, compatibility with the dominant form of the background buildings is of vital importance. This requires a deep perception of the formal characteristics of the historic sites.

According to Semes (2009), the abstraction of formal features of a historic building and the creation of new forms in physical contact with old buildings is recognized as a universally recommended method for designing new buildings in historical sites. The abstraction approach seeks the nature and intrinsic features of historic buildings that can be used in new buildings, as well as features that can be translated in a new but consistent way (Guzmán & Zasha, 2009, 12).

Table 3. Investigating the frequency of infill buildings physical criteria. Source: Authors.

Theorists by row number	Physical Criteria																												
	Massing	Form	Color	Material	Landscapes	Scale	Rhythm	Size	Proportion	Texture	Height	buildings locatings- Position	Shape	Surfaces	Roof Profile-Sky Light	Mass & Space	Style	Orientation	Observe distances & boundaries	Ornament	Façade features &- Openings	Façade projection form-	Window to wall ratio	Structure	Entrance Location
1	*	*	*	*	*																					
2	*		*		*																					
3	*			*		*	*																			
4		*				*		*	*	*																
5	*			*							*	*														
6	*			*		*		*	*																	
7		*		*		*															*					
8	*			*			*						*									*				
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11	*			*		*		*	*																	
12		*	*	*		*				*																
13	*		*			*						*														
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25			*							*			*					*							*	
26		*									*		*		*		*			*						
27		*	*	*					*						*		*					*				*
28											*															
29			*	*				*		*			*													
Total	12	10	15	19	4	14	4	7	7	9	4	6	7	1	3	2	5	2	3	3		3	1	2	1	
Average	41.3%	34.4%	51.7%	65.5%	13.7%	48.2%	13.7%	24.1%	24.1%	31%	13.7%	20.6%	24.1%	3.4%	10.3%	6.8%	17.2%	6.8%	10.3%	10.3%		10.3%	3.4%	6.8%	3.4%	

The skyline may also play an important role in determining the formal features of neighboring buildings.Thus, infill buildings should respond to existing skylines and try to enhance them. In other words, instead of merely imitating and copying them, they should take steps towards constructive consistency with them (New South Wales Heritage Office and the Royal Australian Institute of Architects, 2005). Djordje & Sanja Alfirevic, provide an example of how to adjust the skyline height of new buildings

Table 4. Categorizing all criteria into a subset of the four main criteria. Source: Authors.

Main criteria	Position	Form-Shape		Scale& Proportion	Materials
Sub-criteria of each of the main criteria	Buildings locating	Massing	Façade Projection	Size	Color
	Orientation	Relation between Mass & Space	Roof Profile & Sky Light	Height	Texture
	Street boundary line	Style	Ornament	Window to wall ratio	——
	Entrance Location	Surfaces	Opening	Rhythm	——
	Landscapes	——	——	——	——

with that of historic buildings. This procedure is discussed and presented in Fig. 1.

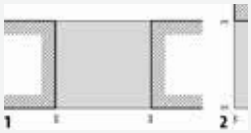
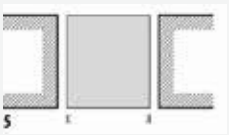
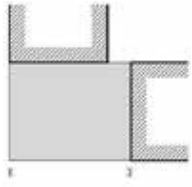
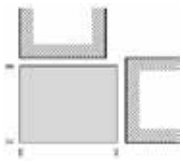
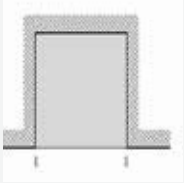
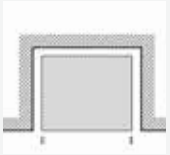
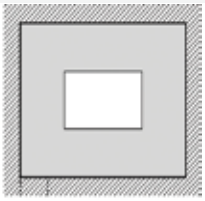
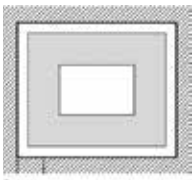
Building ornaments also play a major role in determining building forms. The contemporary architectural works may make you generally believe that ornaments are the least important element that should be taken into account when interconnecting new and historic buildings. According to another hypothesis, general similarities between new and ancient buildings (similarities in height, materials and masses) can guarantee interconnection of new and historic buildings. But ornaments, visual fabrics, and their associations often seem to be able to guarantee the consistent visual connection between buildings (Brolin, 1980). For example, according to Brunelleschi's Old Sacristy development plan (1421-1440, AD), which Michelangelo started in 1534 AD, unconditional consideration of the old building properties is obviously visible, and the whole work seems very creative at the same time. This connection between the contemporary and historic buildings is so robust that it allows us to readily embrace the completely different architectural forms he has designed. Brunelleschi's traditional forms for corners and entrances have been modified with new innovations that owe their existence to special changes that mainly focus on simplicity. These modifications brought about such masterful innovations that have caused the Sacristy to be recognized as a rich architectural work (Fig. 2) (Brolin, 2007, 21).

Therefore, an in-depth perception of the historic buildings' characteristics is required to create consistent forms that do not disrupt historic buildings' authenticity, Contribute to the continuation and promotion of valuable features of the historic buildings, and finally prevent the creation of a uniform environment."As for consistency of contemporary building with historic sites, both harmony and differentiation are among the important factors that must be taken into account to ensure that everyone can perceive the Historical developments of the Historical site. This factor is of vital importance because the design and development of similar and identical buildings will make it difficult to identify the historic site" (Shahteimori & Mazaherian, 2013) and may even disrupt the authenticity of the historic sites. As for observation of "differentiation" in the design of a contemporary building, it can be argued that contemporary buildings, according to theorists, should be designed to strike a proper balance between differences and similarities with the historic sites, thereby ensuring their harmony and consistency with such sites. As for observation of "differentiation" in the design of a contemporary building, it can be argued that contemporary buildings, according to theorists, should be designed to strike a proper balance between differences and similarities with the historic sites, thereby ensuring their consistency with such sites.

- **Proportions**

Proportions are dimensional relationships among building elements. The proportional relationship

Table 5. different scenarios of the new position of the buildings in the existing historical site. Source: Alfirevic & Alfirevic, 2015; Schermann, 2005, 70; Marić, Niković, Manić, 2010, 47.

Row	Scenarios	Examples	Description	Scenarios
1		 A contemporary home in a conservation area in London's Chelsea	New building constructed between two linearly built neighboring houses. This scenario seeks to preserve the visual coherence, compositional coherence and systematic structure of the new building and two adjacent historic buildings	
2		 MACRO Contemporary Art Museum, Rome.	This scenario indicates the position of a new building at the corner of a historic site interconnecting the facades of two streets crossing each other. This scenario acts as a cohesive element encompassing spatial, formal, and functional factors.	
3		 Glass addition at the back of a historic factory, London.	In this scenario, the new building is surrounded on three sides and is somewhat similar to the first scenario (linear). This scenario encompasses compositional and visual connections to neighboring buildings. Clerestory or atriums can be used to supply the light of indoor spaces.	
4		 German Parliament	In this scenario, the new building is surrounded on four sides. A fifth facade or roof is necessary in some cases. This scenario requires Clerestory or atriums (just like the third scenario), but the interior spaces of the atrium character can be differentiated from neighboring buildings.	

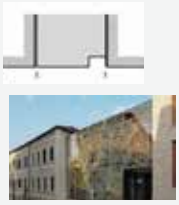
Some or all facade walls are minimally detached from the existing objects.

here some or all facade walls are minimally detached from the existing objects.

between elements lead to the formation of architectural compositions and can visually adjust the difference between elements in a composition by assigning all the parts to the same proportion (Vitruvius, 1914, 72) proportion-based systems create a sense of cohesion and harmony between the elements of a building and between different buildings. Proportions can actually be defined as relationships between sizes of building elements. These relationships can be represented in different areas,, including the relationship between the width and height of the building elements, the relationship between the dimensions of a given element relative to other elements or to the entire building, and even by dimensional relationship of a building with the surrounding buildings (Punter, 1999, 132).

The proportions of existing buildings tend to reflect the architectural principles of their historical period.

Table 6. Examples of the edge and borderlines of new buildings relative to the existing buildings. Source: Alfirevic & Alfirevic, 2015.

Row	Scenarios	Descriptions	Row	Scenarios	Descriptions
1	 Nord west flügel des Rathauses, Germany.	The situation in which the infill building is in line with the facade of the neighboring buildings and forms a continuous linear row.	5	 The extension of a historic School, Iphofen, Germany.	The situation in which only one side of the facade is recessed for specific reasons disrupts the facade surface's continuity: In this case, the recessed part of the building is often made up of different materials.
2	 M - house in La Nou De Gaia, Spain.	The situation in which the facade of the infill building does not share the orientation of the neighboring buildings and the new building uses a variety of elements such as materials, structure, color, etc., to preserve its harmony with the neighboring buildings.	6	 Duke University, West Campus Student Union Addition, U.S.	The situation in which the the symmetrical or asymmetrical projections emphasize some part of the infill building's façade.
3	 Gallery of Kew House, United Kingdom.	The situation in which the infill building only partially follows the orientation of the neighboring buildings. The new building,, which sits at the center, exhibits a change in artistic composition.	7	 The Bank of Montreal Building (BMO) extension, Montreal	The situation in which the previously mentioned principles are combined such that the facade surfaces can make the modern building look more dynamic.
4	 Transformation of a Tiny London lot. A four-story Home in London.	The situation in which the facades of buildings in the neighborhood are not linearly consistent for some specific reasons. In this scenario, the facade surface is designed using the same principles but without wall projections.	8	 The Mirror Hotel, Barcelona	Most commonly seen in the contrast or expressionism approaches because the continuation of the cut surfaces of the neighboring building gives rise to a specific sort of dynamism in the central part of the new building.

Proportions are among the vital factors that need to be taken into account to establish harmony with the surrounding context in historical sites. When the relationship between size and contextual proportions are not adequately taken into account, buildings that are in a poor and out-of-balance condition in terms of proportions may seem to be inconsistent with their surroundings. As Fig. 3 shows, a small change in proportions can significantly affect the harmony and consistency of a building with the surrounding buildings (ibid.).

The adverse effects of a building with improper proportions cannot often be compensated by form, decoration, etc. But the proportions of infill buildings,

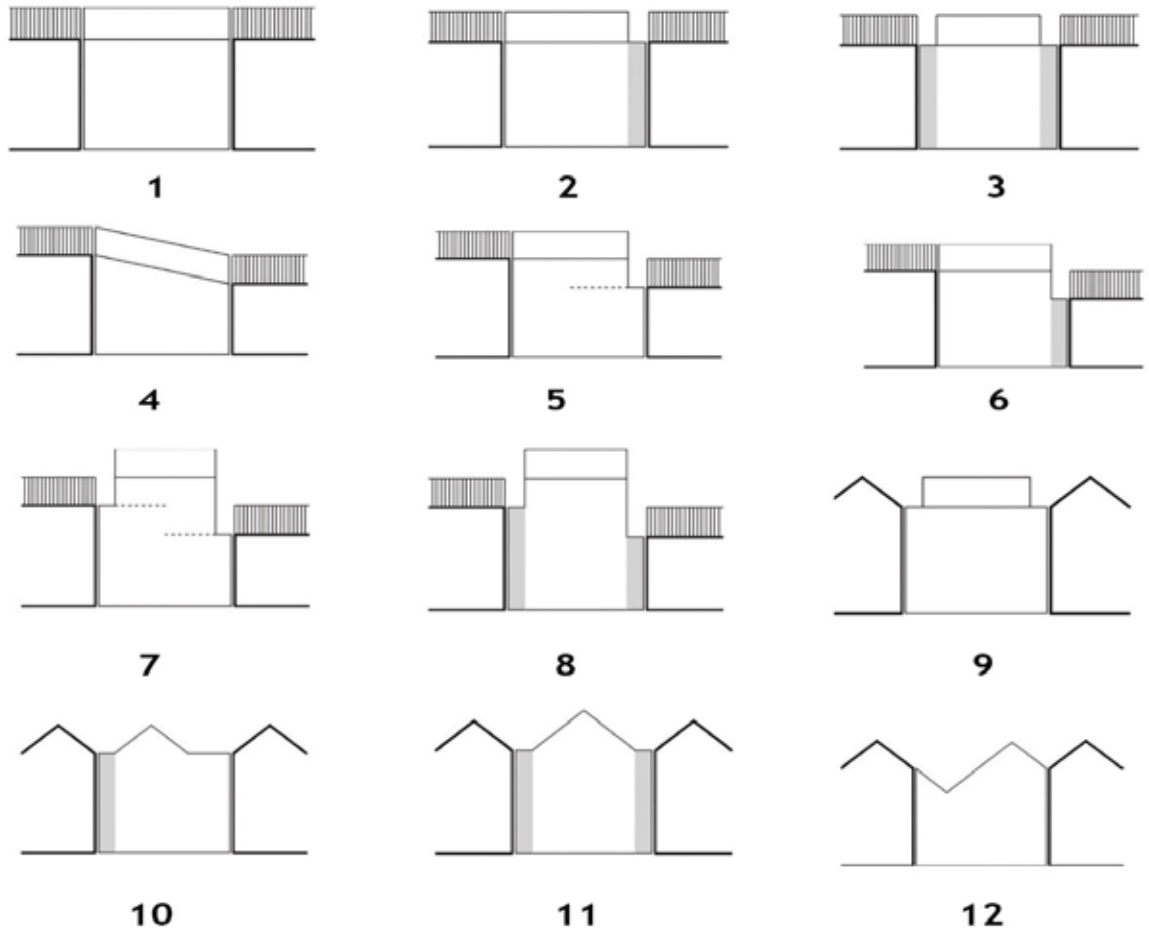


Fig. 1. Examples of how to adjust the skyline height of new buildings with that of historic buildings. Figures (1), (2), and (3) show scenarios in which the roof edges of neighboring buildings share the same height; Figures (4), (5), (6), (7), and (8) show the scenario in which the height of Neighboring buildings is different; Figures (9), (10), (11), and (12) show how the skyline rhythm of the new building is adjusted to that of historic buildings. Source: Alfirevic & Alfirevic, 2015.

Fig. 2. left: the old building by Brunelleschi; Right: the new building by Michelangelo. The new building depicts simple ornaments. Source: Brolin, 2007, 20.

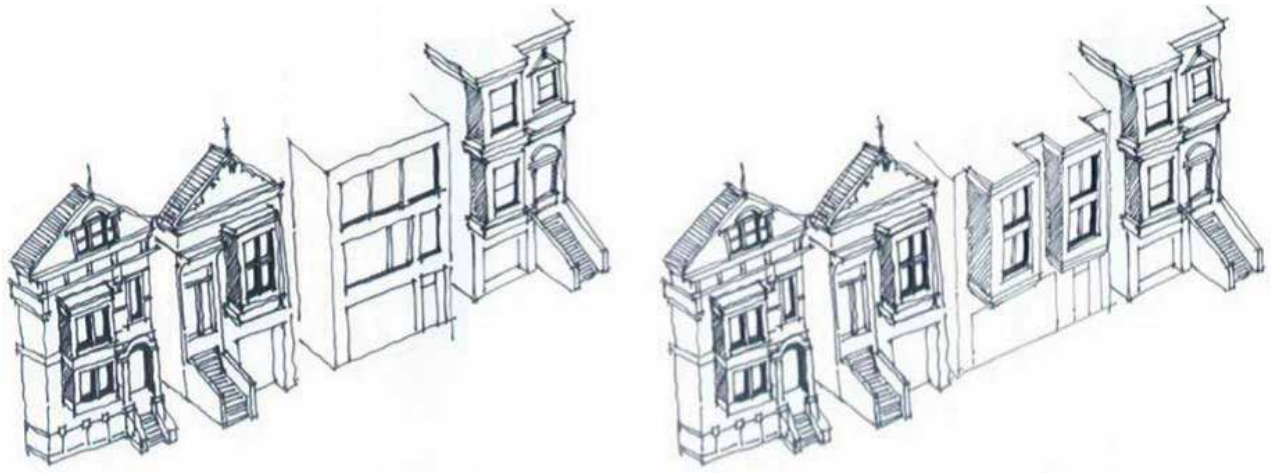


Fig. 3. A change in window proportions helps a building fit into its surroundings. Source: Punter, 1999, 132.

which have, for specific reasons, been built in larger sizes compared to their adjacent buildings, can be visually modified by breaking the tall walls in the openings or improving their harmony (in terms of order and size) with adjacent buildings (Fig. 4); (New South Wales Heritage Office and the Royal Australian Institute of Architects, 2005).

The height and width of contemporary buildings can obviously contribute to the visual character of the historic buildings and their surroundings. However, in order to be compatible with its surrounding environments, a contemporary building does not necessarily need to share the height and width of the surrounding buildings. Rather, these buildings simply need to be designed in such a way that they can respect the length and width of historic buildings. For example, constructing a four-story building in an urban area where all buildings are of the same height and have two floors can be an example of incompatibility with the surrounding environments, but a new building constructed in an area where the buildings are of different heights and range from two to five-storey apartments can be one floor taller or shorter than the average height of the surrounding buildings and be compatible with its surroundings at the same time (Fig. 5); (Wagner, Meyer & Montgomery, 1997).

In general, it can be argued that size encompasses the physical dimensions of the architectural form, such as length, width, and depth (Stamps, 1997). Similarly, Hu et al. (2017) have provided a series of sub-criteria for the size and proportion criteria of a given building. These sub-criteria are presented and described in Fig. 6.

Hu et al. believed that since each historical site is unique and the key features may vary from one historical context to another, a hierarchical system based on facade features should be designed for each context (ibid.). They investigated the infill buildings in 2-D urban facade settings and considered only 2-D proportions of the façade. Therefore, consideration of volumetric proportions of infill buildings and their relationship with the historic building can significantly contribute to the body of literature in this field. Such a study can also contribute to the design and evaluation of infill buildings.

- **Appearance of materials**

Compatibility with the materials used in neighboring buildings is another factor that must be taken into account in the design of infill buildings. Material selection in the design of infill buildings encompasses factors such as color, texture, and material. Hu et al. (2017) used the HSB model (Fig. 7) to analyze the coordination and relationship between colors. In this model, three indicators, namely hue, saturation, and brightness, are used to introduce each color, and three numbers define the properties of each color . Hue is defined by a number ranging from 0 to 360 in the color wheel and the degree of saturation and

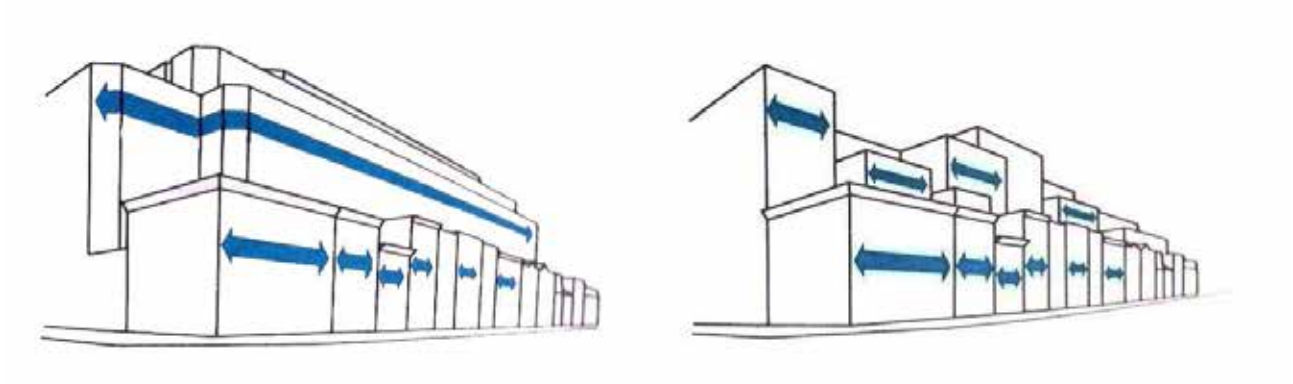


Fig. 4. Right: consideration of the proportions of the street-side buildings with the background building. Left: Ignorance of the proportions of street-side buildings with background buildings. Source: Hedman & Yaszewski, 2000, 2.

Fig. 5. Examples of out-of-character and compatible new buildings on a historic street. Source: Wagner et al., 1997.

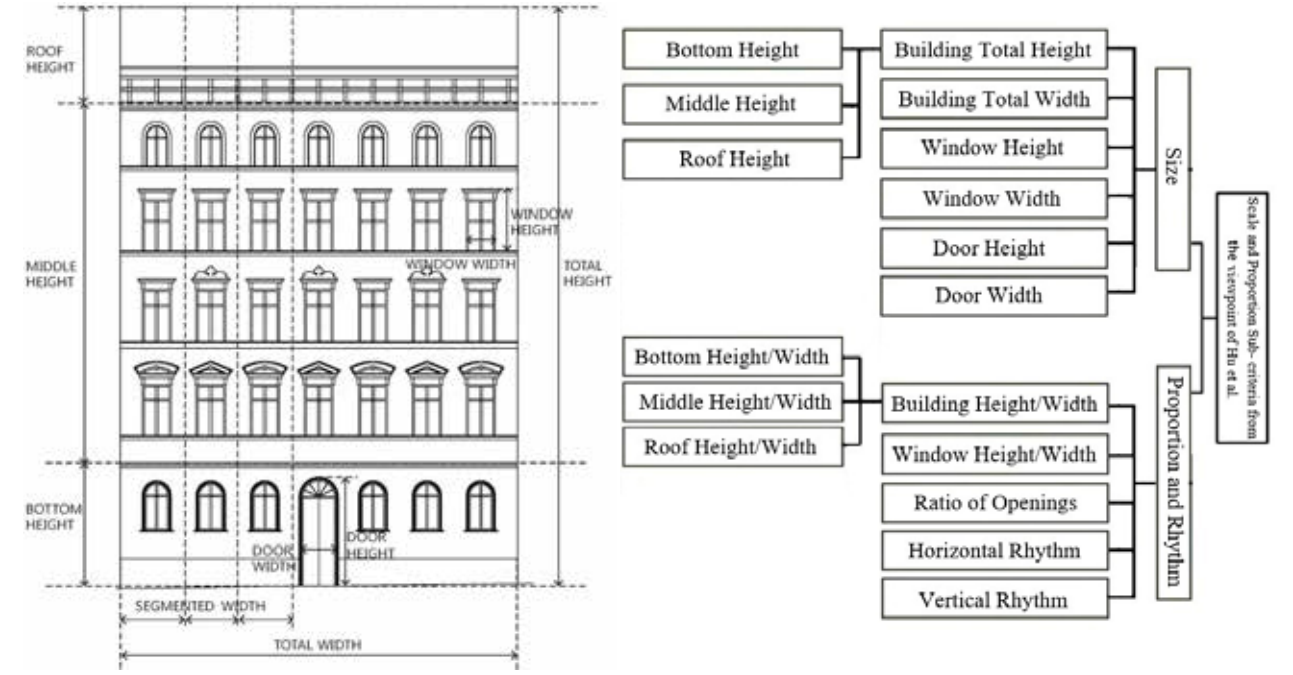


Fig. 6. Left: Data related to facade sizes in a building with a three-segmented facade. Right: Sub-criteria related to proportions and size. Source: Hu et al. 2017.

Left

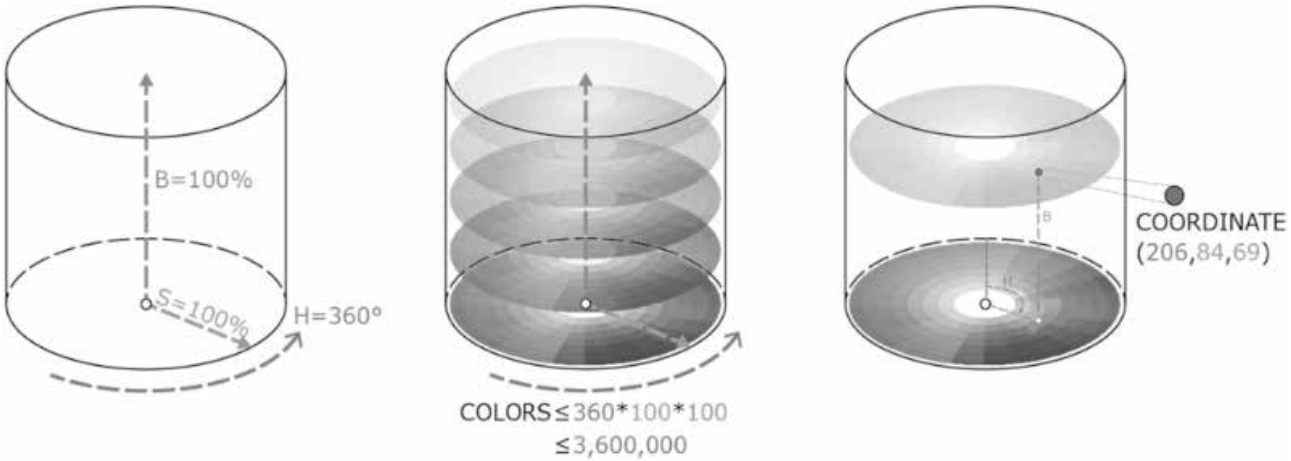


Fig. 7. HSB cylindrical coordinate system. Source: Hu et al. 2017.

brightness is defined by a number ranging from 1 to 100. This model, which is a cylindrical system, defines all the potential colors and has been used in this research.

In this system, the placement of colors in the cylinder and the distances they have from each other can help determine the degree of coordination. In other words, the closer the colors are to each other, the more coordinated they are. Moreover, since there may be many colors in a facade, the colors can be divided into two general categories: main colors and sub-colors. Main colors refer to the dominant color of the facade, which is more conspicuous, and secondary colors are the colors that are ranked second in terms of noticeability. The colors can also be classified into three other groups according to their area ratio. For example, in the following example, Fig. 8, the main colors and sub-colors of historical buildings and contemporary buildings are specified by three numbers (ibid.).

Fig. 9 shows the position of each color in the color cylinders (cube-shaped colors represent the color of the contemporary building and spherical-shaped colors represent the colors of historic buildings). The left cylinder corresponds to the main colors and the right cylinder corresponds to the sub-colors. As the figure shows, the short distances between the left cylinder's points indicate the coordination of the historic buildings' main colors with the original color of the contemporary building. The long distances between the right cylinder's points indicate a lack of coordination between the historic buildings' sub-colors and the contemporary building's sub-colors (ibid.).

Texture is a visual element that is recognized both through visual and tactile sensations. A real texture is characterized by both visual and tactile qualities, each bearing a unique kind of sensory news. But these two types of qualities are not necessarily interdependent, and each can be perceived alone. Of course, most of our sensory perceptions of texture are visual (Dondis, 2019). For example, consideration of Chiaroscuros resulting from the use of different materials can effectively contribute to thedefinition of a contemporary building. For example, the addition of a modern building with a façade made of polished marble in front or on the side of a historic building made of polished granite brings about nothing but an incompatible sight, though both buildings are made of stone (Shahteimori & Mazaherian, 2013). The materials need not be the same as those on the historic building, but they should be harmonious; they should not be so different that they stand out or distract from the historic building (Grimmer & Weeks, 1986).

When it comes to the quality of building material, features such as transparency and rigidity are recognized as important factors. Transparency allows for the presentation of details and elements through each other, while rigidity is just the opposite

Fig. 8. Block elevation with HSB information for facade colors. Source: Hu et al., 2017.

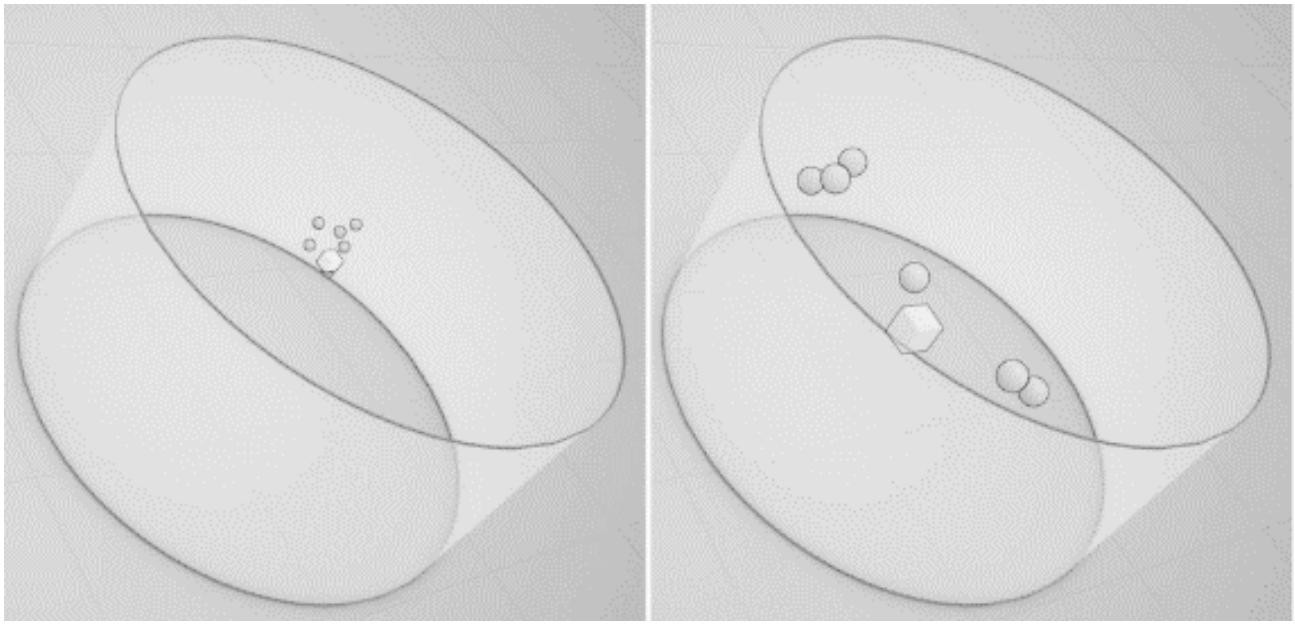


Fig. 9. Cylinder range of , left: main colors and, right: sub-colors. Source: Hu et al., 2017.

(Dondis, 2019). Since the transparency of materials used in the construction of infill buildings is of vital importance, this quality will be discussed in detail in Table 7. Although transparency has different types (actual, phenomenal, and semantic transparency), in this section of the study, transparency is used in its former sense (Actual transparency) because of its relationship to materials properties. This type of transparency causes light to pass through and create a vision. According to Peter Rice (Rice & Dutton, 1995) actual transparency can be classified into three groups: unilateral transparency, bilateral transparency, and transparent sheets. Table 8 describes different types of actual transparency and examples of their applications in infill buildings.

Findings

After discussing and reviewing the main criteria

Table 7. Different types of transparency and their application in infill structures. Source: Authors.

Row	Different types of actual transparency	Description	Example
1	One-sided	Results in the passage of light into the building through a thin membrane of semi-transparent materials or small pieces of glass; For example, one-sided transparency (small pieces of glass) was used in the development of the City Hall building in Murcia, Spain, to ensure coordination with historic buildings.	
2	Two-sided	An evolved version of the one-sided transparency influenced by technology and provides better views of the outdoor spaces. For example, in the Georges Pompidou center, large transparent pieces allow providing a fine view of technology in the historic site.	
3	Transparent sheets	A state that includes direct vertical enclosures and manifests itself in other dimensions at the same time. example, the use of transparency in all sides of the Louvre Pyramid	

Table 8. Addition of some new physical criteria resulting from the investigation in related sources with each of the four main criteria to complete the final criteria. Source: Authors.

	Addition of new physical sub-criteria resulting from the descriptive investigation in each of the main criteria of infill buildings **New items are marked with a line below them**			
Main criteria	Position	Form-Shape	Proportion &Scale	Materials
Sub-criteria of each of the main criteria	Buildings locating	Massing	Size	Color (Hue, Saturation, Brightness)
	Orientation	The shape of the blanks & fills in volumes & surfaces Relation between Mass &Space Facade Projection	Height, Width, Depth	Texture (Roughness and Softness)
	Street boundary line& Observance of distances	Surfaces	Window to wall ratio	Quality of Materials (Rigidity and Transparency)
	Entrance Location	Roof Profile, skyline & ground line	____	_____
	Landscapes	Ornaments	_____	_____
	_____	Openings	_____	_____

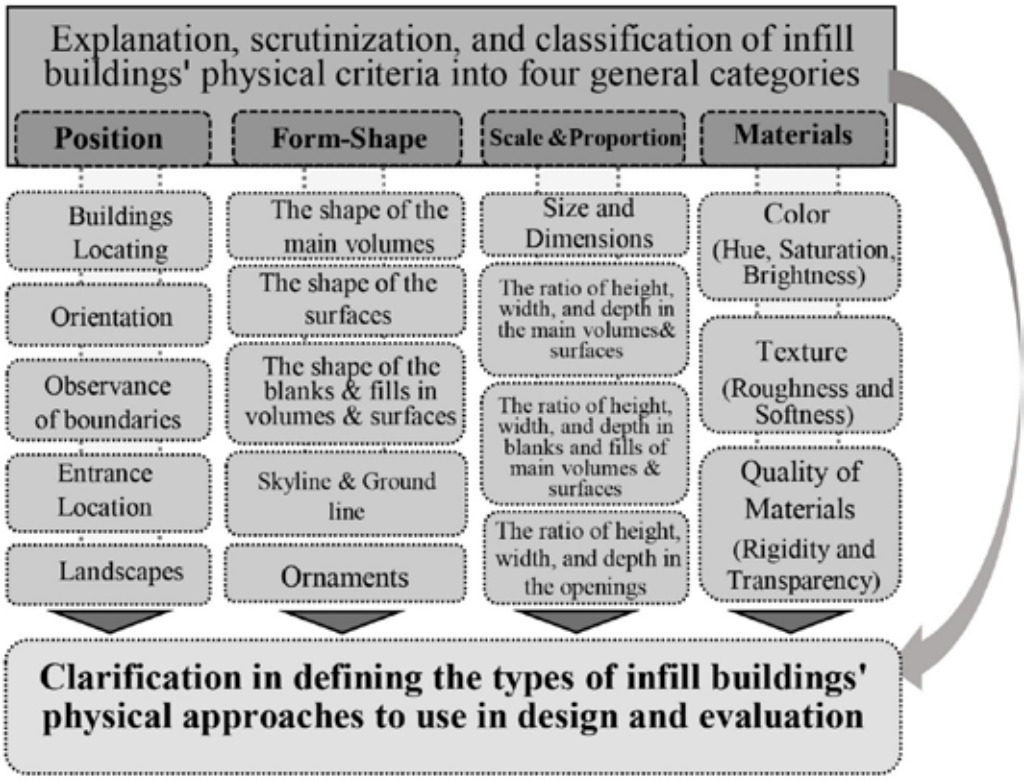


Fig. 10. Classification of the physical criteria of infill buildings into four main groups. Source: Authors.

mentioned above, we can finalize the list of criteria by identifying new physical criteria that can effectively contribute to the design of infill buildings and increase the accuracy of the main criteria (Table 8). Fig. 10 presented below is the outcome of the final review and edition of the criteria and sub-criteria that can be used to distinguish the physical criteria and sub-criteria from each other. This figure represents the classification of physical criteria of infill buildings into four main groups as well as the sub-criteria that can be taken into account to design and evaluate infill buildings. These criteria have a wide spectrum of applications, with the extremes being maximum fitness into historic buildings and maximum contrast to historic buildings. They can effectively contribute to the determination of approaches to infill buildings with different uses and conditions.

Conclusion

The present study was primarily an attempt to investigate, analyze and scrutinize the physical criteria that can effectively contribute to the design and evaluation of infill buildings, achieve a comprehensive set of these criteria and finally classify them into main criteria and sub-criteria. In order to find the answers to the research questions, the researchers first examined the theories (related to the physical criteria of infill structures) put forward by theorists and relevant organizations. Also, they extracted most of the relevant criteria from the literature. After removing repetitive criteria based on their frequency and significance, the researchers selected four criteria, namely 1. Position, 2. Form and shape, 3. Scale and proportions 4. Appearance of materials, as the main criteria (criteria with the highest frequency). In the next step, by analyzing, examining and inferring other criteria, the criteria that were homogeneous with each of the four main criteria were recognized as sub-criteria of the four main criteria. Afterward, some new criteria were added to the list. These criteria were scrutinized and

subjected to final analyses. This process led to the assignment of the physical criteria of infill buildings into four main classes, each encompassing a number of sub-criteria. For example, sitting, orientation, observance of boundaries, and entrance position fell within the category of the main criterion known as position. Also, items such as the form of the main volumes, their surfaces, fills and blanks, ornaments, skyline, and ground line were recognized as sub-categories of the main criterion known as form and shape. Items such as size and dimensions, the height, width and depth ratioof the main volumes, surfaces, fills and blanks, and the height, width and depth ratio of the openings were extracted as the sub-criteria of the main criterion known as scales and proportions. Finally, items such as color (hue, saturation, and brightness), texture (roughness and softness), and quality of materials (rigidity and transparency) fell within the category of the main criterion known as appearance of materials. Therefore, this classification can clarify the definitions of infill buildings approaches and help designers decide about the applications of physical criteria and their sub-criteria (ranging from maximum similarity to maximum contrast) depending on the infill buildings' uses and conditions in the existing historical sites. The above classification can also help researchers use a comprehensive, accurate, and categorized set of criteria to evaluate infill buildings.

Reference list

• Alfirevic, D. & Alfirevic, S. (2015). Infill architecture: Design approaches for in-between buildings and "bond" as integrative element. *Arhitektura i Urbanizam,* (41), 24-39.

• Alfirevic, D. (2012a). Primena metoda ekspresije na primeru enološkog centra u zaštićenom kompleksu Rajačkih pivnica. *ARD Review, br,* (39), 10-20.

• Alfirevic, D. (2012b). Expressionism as The Radical Creative Tendency in Architecture. *Arhitektura i Urbanizam,* (34), 14-27.

• Brolin, B .(1980). *Architecture in Context: Fitting New Buildings with Old*. The Harvard Architecture Review. Cambridge: MIT Press.

• Brolin, B. (2007). *Architecture in context: Fitting new buildings with old ones* (R. Rezazadeh Trans.). Isfahan: Khak publications.

• Cañas Guerrero, I., AyugaTellez, F. & OrtizSanz, J. (1995). The visual impact of agricultural buildings on landscape: a method to assess it. *Informes de la construcción*, 47 (441), 27–37.

• Carmona, M., Tiesdell S., Heat, T. & Oc, T. (2003). *Public places, Urban spaces: The dimention of urban design*. Oxford, UK: Architectural Press.

• Carmona, M., Tiesdell, S., Heat, T. & Oc, T. (2010). *Public places, Urban spaces: The dimention of urban design.* (2nd ed.). Oxford, UK: Architectural Press.

• Ching, F. D. K. (2007). *Architecture: Form, space, and order*. (2nd ed.). Hoboken, NJ: John Wiley & Sons Press.

• Cloquell-Ballester, V. A., Torres-Sibille, A. C. & SantamarinaSiurana, M. C. (2012). Human alteration of the rural landscape: variations in visual perception. *Environmental Impact Assessment Review,* (32), 50–60.

• Council of Europe (1975). *European Charter of the Architectural Heritage.* Adopted by the Committee of Ministers on 26 September 1975, Amsterdam.

• Declaration of Amsterdam (1975). *Congress on the European Architectural Heritage.* Amsterdam. Retrieved July 20, 2019, from http://www.international.icomos.org/en/charters-and-texts/179-articles-en-francais/ressources/charters-and-standards/169-the-declaration-of-amsterdam.

• Dondis, D. (2019). *Primers of Visual Literacy* (M. Sepehr Trans.). Tehran: Soroush.

• Feilden, B. M. & Jokilehto, J. (1983). *Management Guidelines for World Cultural Heritage Sites.* Rome: ICCROM/ UNESCO/ ICOMOS.

• Grimmer, A. E. & Weeks, K. D. (1986). *New Exterior Additions to Historic Buildings: Preservation Concerns (Preservatio Briefs#14)*. Washington, DC: U. S. Department of the interior/ National Park Service Cultural Resources: Heritage Preservation Services.

• Guzmán T. & Zasha, N. (2009). *Historic buildings and contemporary additions: the elements of a cohesive design relationship*. (Unpublished master's thesis). School of Architecture Planning and Preservation, University of Maryland, Maryland, USA.

• Hedman, R. & Yaszewski, A. (2000). *Basics of Urban Design* (R. Rezazadeh & M. Abbaszadegan, Trans.). Tehran: University of Science and Technology.

• Hu, Y., Heat, T., Tang, Y. & Zhang, Q. (2017). Using Quantitative Analysis to assess the Appropriateness of Infill Buildings in Historic Settings. *Journal of Architectural and Planning Research*, 34 (2), 91-113.

• ICOMOS. (1931). *The Athens Charter for the Restoration of Historic Monuments,* Athen.

• ICOMOS. (1964). *International Charter for the Conservation and Restoration of Monuments and Sites* (The Venice Charter), Venice.
• ICOMOS. (1972). *Resolutions of the Symposium on the Introduction of Contemporary Architecture into Ancient Groups of Buildings,* Budapest.
• ICOMOS. (1987). *The International Charter for the Conservation of Historic Towns and Urban Areas* (Washington Charter), Washington.
• ICOMOS. (1996). *The Australia ICOMOS Charter for the Conservation of Places of Cultural significance* (The Burra Charter), Burra.
• ICOMOS. (2005). *Xi'an Declaration on the Conservation of Setting of Heritage Structures,* Sites and Areas, Adopted in Xi'an, China.
• ICOMOS. (2010). *The Conservation of Places of Cultural Heritage Value*, (The New Zealand Charter), New Zealand.
• ICOMOS. (2011a). *Approaches for the Conservation of Twentieth Century Architectural Heritage*, (Madrid Document), Madrid.
• ICOMOS. (2011b). *The Valletta Principles for the Safeguarding and Management of Historic Cities*, Towns and Urban Areas, Paris.
• ICOMOS. (2011c). *The Paris Declaration on Heritage as a Driver of Development,* Paris.
• ICOMOS. (2013). *The Australia ICOMOS Charter for Places of Cultural Significance* (The Burra Charter), Burwood. Retrieved June 10, 2019, from http://australia.icomos.org/wp-content/uploads/The-Burra-Charter-2013-Adopted-31.10.2013.pdf.
• Karimimoshaver, M. & Winkemann, P. (2018). Aframework for assessing tall buildings' impact on the city skylin: aesthetic, visibility and meaning dimensions. *Environmental Impact Assessment Review*, (73), 164–176.
• Lambe, N. & Dongre, A. (2017). A shape grammar approach to contextual design: A case study of the Pol houses of Ahmedabad, Environment and Planning B. *Urban Analytics and City Science*, 0(0), 1–17.
• Marić, I., Niković, A. & Manić, B. (2010). Transformation of the New Belgrade urban tissue: Filling the space instead of interpolation. *SPATIUM*, (22), 47-56.
• Mehdizadeh Saradj, F. (2016), Compatible development solutions in the context of historical settings in Iran, *Urbanism Architecture Constructions*,7 (4), 285-300.
• Nasr, T. (2015). *Criteria for Contextualism in Architecture, LinkedIn*. Retrieved January 5, 2020, from https://www.linkedin.com/pulse/criteria-contextualism-architecture-tracy-nasr
• New South Wales Heritage Office and the Royal Australian Institute of Architects . (2005). *Design in context: Guidelines for infill development in the historic environment*. Retrieved March 14, 2019 from www.environment.nsw.gov.au/resources/heritage branch/heritage/ Design in Context.pdf.
• Panic, P. & Dinulovic, R. (2009). Odnos nove I stare architecture: Projektovanje novith objekata u istorijskom okruzenju. *Zbornik radova Fakulteta Tehnickih nauka,* (5), 1731-1734.
• Penn, W. (2007). *Sense of Place: Design Guidelines for New Construction In Historic Districts.* A Publication of the Preservation Alliance for Greater Philadelphia.
• Punter, J. (1999). *Design guidelines in American cities: A review of design policies and guidance in five west coast cities.* Liverpool: Liverpool University Press.
• Rice, P. & Dutton, H. (1995). *Structural Glass.* London: Taylor & Francis.
• Riza, M. & Doratli, N. (2015). The critical lacuna between new contextually juxtaposed and freestyle Buildings in historic settings. *Journal of Architectural and Planning Research*, 32(3), 234-257.
• Rodwell, D. (2007). *Conservation and sustainability in historic cities*. Oxford, UK: Blackwell Publishing.
• Schermann, K. (2005). The Old and the New, Again - About the Layers of Conversation. *Outline*, (31), 70-85.
• Semes, S. W. (2009). The Future of the Past: A Conservation Ethic for Architecture, *Urbanism, and Historic Preservation*. New York: W.W. Norton & Co. Press.
• Serra, J., Llinares, C., Iñarra, S., Torres, A. & Llopis, J. (2020). Improvement of the integration of visually impacting architectures in historical urban scene, an application of semantic differencial method. *Environmental Impact Assessment Review*, 81, 1-12.
• Shahteimori, Y. & Mazaherian, H. (2013). Design Guidelines for New Constructions in Historic Context. *Honar-ha-ye-Ziba Memary-va-Shahrsaz*i, 17(4), 29 – 40.
• Sotoudeh, H. & Wan Abdullah. W. M. Z. (2012). Affected Variables on Successful Infill Design in Urban Historic Context. *Arts and Design Studies*, 3 (9), 7-12.
• Stamps, A. E. (1997). A paradigm for distinguishing significant from nonsignificant visual impacts: Theory, implementation, case histories. *Environmental Impact Assessment*, 17 (4), 249-293.
• Vitruvius, P. (1914). *The ten books on architecture* (M.H. Morgan, Trans.). Retrieved Jun 16, 2017 from http://academics.triton.edu/faculty/fheitzman/Vitruvius_the_Ten_Books_on_Architectur.
• Wagner, R. D., Meyer, J. B. & Montgomery, S. W. (1997).

District of Columbia historic preservation guidelines. Washington, DC: Office of Planning. Historic Preservation Division.

• Weeks, K. D. & Grimmer, A. E. (1995). *The Secretary of the Interior standards for the treatment of historic properties with guidelines for preserving.* rehabilitating, restoring and reconstructing historic buildings. Retrieved December 12, 2013 from http://www. Nps.gov/tps/standards/four-treatment-guidelines.

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