International Journal of Human Capital in Urban Management
(IJHCUM)

Homepage: http://www.ijhcum.net/

ORIGINAL RESEARCH PAPER

Investigating the effective factors on place attachment in residential environments: Post-Occupancy Evaluation of the 600-unit residential complex

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ARTICLE INFO

Article History:
Received 28 November 2022
Revised 21 February 2023
Accepted 12 April 2023

Keywords:
Physical factors
Place attachment
Post-Occupancy Evaluation
Residential environment
Residential facility programming

ABSTRACT

BACKGROUND AND OBJECTIVES: Place attachment is among the most important aspects of the interaction between people and their places, to keep residential environments safe, sustained, and resilient. This study aims to identify the factors that influence the creation and enhancement of place attachment in residential settings, with a focus on physical elements. Given the significance of these factors in architecture and facility programming, the study aims to provide architects and designers with effective strategies for designing and redesigning residential environments. The results of this study on place attachment can be utilized in the architectural facility programming process and design decision-making.

METHODS: This study proposed a theoretical framework in which the relationship between subjective and objective physical and individual characteristics and time were the main components of making sense of place attachment. Using a survey method, the study investigated the significance of place attachment among residents of the 600-unit residential complex in Mashhad, Iran, through a questionnaire divided into three sections. The first section focused on individual characteristics and time spent in the complex, while the second and third sections measured the objective and subjective physical characteristics and the extent of people's attachment to the complex, respectively. The data from 158 participants were analyzed using SPSS and SmartPLS software.

FINDINGS: Results of SPSS analysis showed objective physical characteristics ($p<.01$, $r=.241$), as well as the subjective physical characteristics ($p<.01$, $r=.223$) and time ($p<.01$, $r=.237$), were the most important components affecting place attachment, highlighting the role of physical strategies used in the residential complex for creating and developing this feeling. Considering these physical factors affecting the establishment and enhancement of place attachment emphasizes the role of architects and planners in satisfying this crucial human need which directly affects people's personal and social health.

CONCLUSION: The results revealed time, subjective, and objective physical characteristics are three factors that have a direct impact on place attachment. Objective physical characteristics have a direct impact on place attachment and also indirectly impact it through their effect on subjective physical characteristics. On the other hand, the relationship between individual characteristics and place attachment is indirect, as individual characteristics affect the time spent in a place, and an increase in time spent leads to a stronger place attachment. The findings can be employed extensively in architectural programming in residential environments to improve the quality of life.

DOI: 10.22034/IJHCUM.2023.03.06

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
87	10	7

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Note: Discussion period for this manuscript open until October 1, 2023 on IJHCUM website at the "Show Article.

INTRODUCTION

Place attachment, a key theory in the exploration of human–land relationships, is a positive emotional relationship between an individual and a place (Feng *et al*., 2022; Lebrusán and Gómez, 2022). According to a study by Beyer *et al*. (2020), emotions and affective experiences play a significant role in shaping our mental image of a place and our attachment to it. The process of attachment is a psychological phenomenon that connects individuals to their environment across various levels, including home, neighborhood, city, and country, and in diverse settings, such as workplaces, educational institutions, public spaces, and recreational areas. (Lewicka, 2010; Heidari *et al*., 2019;). Residential environments represent a crucial aspect of individuals' life and well-being as they provide a primary context for daily living and social interaction (Maller *et al*., 2006). Thus, they are the most important place people may attach to in their lifetime (Bonaiuto *et al*., 2003). People's needs for belonging are fundamental to creating place attachments (Pirbabaei *et al*., 2015; Javan Forouzande and Motalebi, 2011) that can support the revitalization of declining neighborhoods at both social and physical levels (Brown *et al*., 2003). Place attachment is one of the essential factors in assessing the human-environment relationship and creating high-quality human environments. It plays a crucial role in increasing human responsibility, cooperation, and quality of life. Conversely, a lack of attachment to a place can result in insufficient investment in maintenance, leading to increased life cycle costs and reduced usefulness of residential buildings. By analyzing the existing literature on place attachments, this study proposes a theoretical framework using an analytical method. The present study investigates the physical, individual, and time factors affecting the creation and reinforcement of place attachment in residential complexes. The first part of the study, using a deductive approach, examines existing theories and models of place attachment and proposes a theoretical framework for how people perceive and examine the factors affecting place attachments. The second part of the research analytically examines the proposed hypotheses using survey research. Data were collected using a questionnaire. SPSS (Statistical Package for the Social Sciences) and PLS software (Partial Least Squares) were used for data analysis, measuring the relationship between variables. The main question of this study is: "What are the main effective factors that contribute to creating and reinforcing place attachment among the residents of residential complexes?" The findings of this research on the effects of the objective and subjective physical factors on place attachment is a Post-Occupancy Evaluation (POE) to be used in the facility and architectural programming process. Facility programming is a phase of the building planning process (Preiser and Vischer, 2004; Sanoff, 1989; Popov, 2004). Facility programming is a critical phase in designing new or renovated facilities such as residential complexes, defining the problem to be solved, and providing architectural designers with information about building user needs and patterns of activities that occur in space (Sanoff, 1977). The primary phase of facility programming is evaluation, which is used for learning from existing facilities to improve functional and physical characteristics in residential environments for smart growth (Federal Facilities Council, 2002; Preiser, 2001; Preiser *et al*., 2018).

Literature review

Attachment, as one of the most prominent concepts of contemporary psychology, refers to the process of forming emotional bonds between humans. John Bowlby formulated this theory's basic principles, drawing on concepts from ethology, cybernetics, information processing, developmental psychology, and psychoanalysts (Mikulincer and Shaver, 2012; Bretherton, 1992). The theoretical foundations and main themes of Attachment Theory were presented by John Bowlby in the three-volume series "Attachment and Loss" in 1979, 1980, and 1982. Based on This theory, long-term emotional bonds to particular individuals are a fundamental part of human nature. An attachment bond to someone provides feelings of security and well-being in the presence of that person (Bowlby, 1974). According to developmental psychology, an individual's social, emotional, cognitive, and behavioural structures are configured by previous experiences in life. These structures increase conscious and unconscious decisions and preferences. In reference to their experiences, people endeavour to create predictability, stability, and order in their lives (Weiner *et al*., 2012). In Hashas's (2004) attachment model, an individual's social, emotional, cognitive, and behavioural configurations constitute

an individual's self. According to this model (Fig. 1), all new experiences are perceived, organized, classified, and remembered under the configuration of the self. Besides, the "self" design also stimulates one's behavioural motivations. Each individual's expectations and needs are established as the self is constructed. When those needs and expectations are satisfied by an object or subject, the person feels safe and comfortable and continues to expect his or her needs to be satisfied by the object or subject. In this way, the individual becomes attached to the object or subject. The individual starts having hopes and making plans based on the attachment figure. As an expression of their affection, they care for, pay attention to, and support the attachment figure based on the satisfaction of the individual and people's needs. Despite their complexity and different meanings and definitions, this thinking and its indicators are widely used in environmental studies and are of particular importance. Based on Hashas's model, it can be said that if a place could satisfy an individual's expectations and needs, the person feels safe and comfortable and continues to expect his or her needs to be satisfied by that place.

Dimensions of place attachment

Attachment to place is a complex and multifaceted concept that goes beyond the narrow definition of attachment in psychology, which focuses primarily on the formation of emotional bonds between individuals. Instead, place attachment encompasses a broader range of psychological, social, and cultural factors that contribute to a sense of belonging and connection to particular places. (Devine-Wright, 2013; Giuliani, 2003). The use of place attachment in many studies has led to many definitions (Table 1). Despite these numerous definitions, it can be said that place attachment generally refers to links people make between themselves and places (Lewicka, 2008). The definitions presented in the early years of the concept of place attachment examined it as a product, meaning "feel attached" in individuals or groups to a place. As the studies expanded and the importance of How and Why of attachment to places became relevant, the process and reasons for attachment to places were also studied as integral dimensions of the concept of place attachment.

Numerous studies have attempted to measure place attachment, which is a subjective and sentimental relationship people have with a place. Scholars have identified various dimensions and forms of place attachment,(Scannell and Gifford, 2010a; Daneshpour *et al.*, 2009) with most conceptualizations attempting to describe the range of emotions people associate with specific environments. (Kyle *et al.*, 2005). There are two dominant traditional and recent views on explaining place attachment dimensions. The traditional view of place attachment considers it to have two dimensions, place identity and place dependence, (Williams and Vaske, 2003) which respectively refer to the self-defining aspects of a person's identity in relation to the physical environment and the functional aspects of a place in fulfilling an individual's needs and goals (Larson *et al.*, 2018; Daryanto and Song, 2021). The two-dimensional model of place attachment has been criticized for neglecting the collective dimension and the role of society, as well as trivializing natural environments. Scholars have emphasized the need to understand the social context of spatial links, leading to the development of models that account for the social and cultural dimensions of making place attachments, as well as the functional and physical dimensions. This study focuses on these

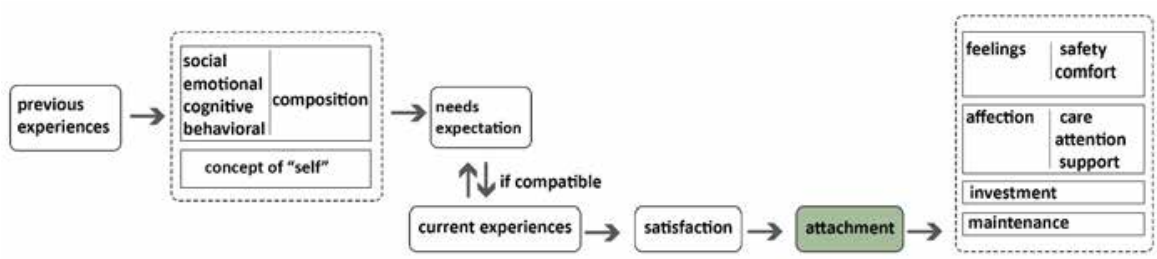

Fig. 1: Attachment theory based on human needs (Hashas, 2004)

Table 1: Definitions of place attachment

Theorist	Definitions of place attachment
Relph (1976)	A need for a long and deep experience of a place, and preferably involvement in the place
Shumaker and Taylor (1983)	The positive affective bond between individuals and their residential environment
Proshansky *et al*. (1983)	A potpourri of memories, conceptions, interpretations, ideas, and related feelings about specific physical settings
Shamai (1991)	A personal and collective experience in combination with the meaning of place and its symbols to create a 'Personality' of the place
Altman and Low (1992)	The interplay of effects and emotions, knowledge and beliefs, and behaviors and actions refers to a place
Hummon (1992)	Emotional involvement with places
Brown and Perkins (1992)	Positively experienced bonds, sometimes without awareness
Ahrentzen (1992)	Relationships among place, individual, social knowledge, and his/her beliefs
Jacobs (1995)	Deep human character, the concept of giving a place a home
Bonaiuto *et al*. (1999)	Emotional attachment to a particular place, transforming the individual as part of the identity of the place
Hidalgo and Hernández (2001)	A positive affective bond between an individual and a specific place
Stedman (2003)	A positive emotional bond that develops between people and their environment
Giuliani (2003)	The bonding that occurs between individuals and their meaningful environments
Kyle *et al*. (2004)	The cognitive connection between the self and the physical environment
Manzo (2005)	An 'experience-in-place' that creates meaning
Scannell and Gifford (2010a)	A multidimensional construct that includes affective, cognitive, and behavioral components reflecting an individual's psychological connection to a specific place
Lewicka (2011)	The emotional and psychological ties that individuals develop towards specific places, and contribute to the formation of their identity and sense of belonging
Devine-Wright (2013)	The cognitive and emotional connection that individuals have to a particular place, reflecting the meanings and values they ascribe to it, the experiences they have had there, and the sense of identity that they derive from their connection to it
Ramkissoon *et al*. (2013)	A multidimensional construct that reflects the bonds between individuals and their physical environments, characterized by cognitive, affective, and behavioral dimensions
Masso *et al*. (2019)	The bonding of people to all kinds of places at various scales that various mobilities affect and re-configure it
Manzo and Devine-Wright (2020)	The enduring emotional bond that individuals develop with specific places or environments, characterized by a sense of connection, meaning, and belonging
Hernández *et al.* (2020)	A positive and affective bond between individuals and places that arises from the meaningful and memorable experiences, social interactions, and identity-related processes that take place within those place

aspects of place attachment. Scannell and Gifford (2010a) proposed a three-dimensional "person-place-process" framework of place attachment, which includes person, psychological process, and place dimensions. Raymond *et al*. (2010) also proposed a three-pole concept of place attachment, which includes personal, community, and natural environment dimensions. Place identity and place dependence are included in the one pole (personal context) because those dimensions are related to highly personalized connections to place, either symbolic (identity) or functional (dependence) in nature. Both models proposed that connections to a place can be based on social or physical attributes. However, there is a difference between the two presented models. Whereas in Raymond *et al.*'s model, affect, cognition and behavior are not manifested in place attachment, Scannell and Gifford's tripartite place attachment framework considers the psychological process as a separate dimension of place attachment. This difference may come out from the scale of the two studies. Whereas the former model was tested at the regional scale, the latter model was tested at the community scale (Raymond *et al*., 2010; Scannell and Gifford, 2010a). Kyle *et al*. (2005) also proposed a three-dimensional model of place attachment, which includes place identity, place dependence, and social bonding dimensions. When a

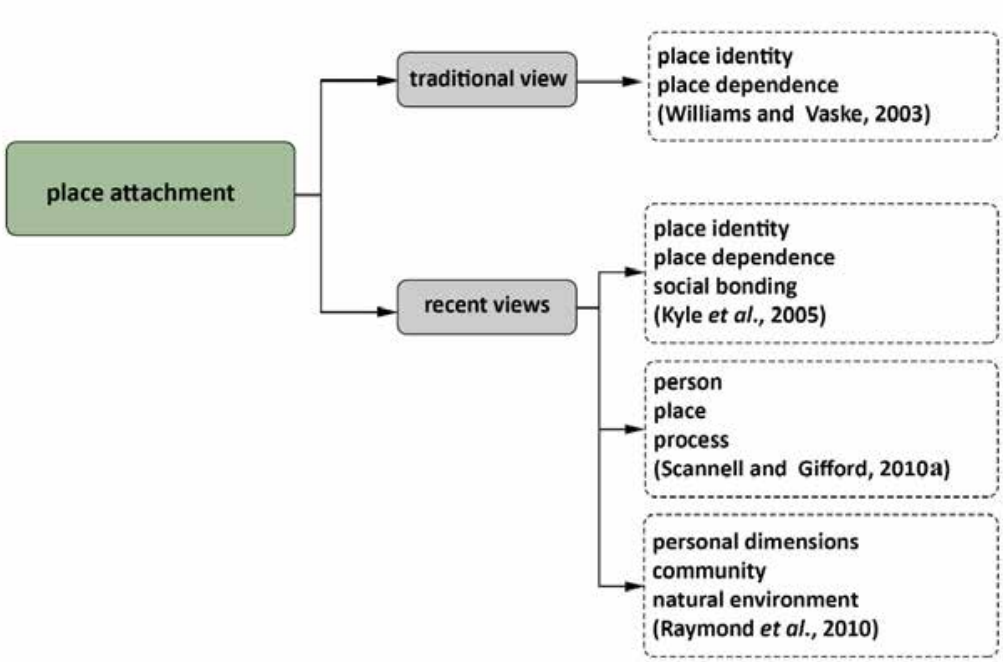

Fig. 2: Different theories on place attachment, Based on: (Williams and Vaske, 2003; Kyle *et al.*, 1989; Scannell and Gifford, 2010a; Raymond *et al.*, 2010)

place for a person has the role of social connection, the person sees the environment as a place for his/her social meetings, the place becomes important to the person, and the person develops emotional and sentimental connections with that place (Fathebaghali *et al.*, 2016). Different studies have focused on the social aspect of place attachment (Low and Altman, 1992; Gieling *et al.*, 2018). However, due to the importance of physical characteristics in architecture and facility programming, this research mainly focuses on physical aspects of place attachment. Although the model presented by Raymond et al. has had a significant contribution to the place attachment literature and its implication in environmental management at a macro scale, Kyle et al.'s model of place attachment inclusively refers to the functional and physical characteristics which can be employed directly into the facility programming of community or residential environments and increasing quality of life of the residents. Fig.2 illustrates the traditional and recent models of place attachment studied in this section.

Conceptual model of research

The conceptual model of this research is based on Kyle *et al.*'s (2005) three-dimensional model and Scannell and Gifford's 'person', 'place', and 'process' dimensions in their tripartite place attachment framework. There are similarities between 'place identity' and 'place dependence' in Kyle et al.'s model and 'person' and 'place' in Scannell and Gifford's model, respectively (Fig. 3). In addition, based on recent studies, the component of "time" can also be considered as an influential factor in forming and strengthening place attachment (through social bonding and other possible processes), along with the two factors of person and place (Scannell and Gifford, 2010b; Hernández *et al.*, 2007; Lewicka, 2005, 2010; Raymond *et al.*, 2010; Stedman, 2006; Anton and Lawrence, 2014; Shamai and Ilatov, 2005) (Fig. 3). Thus, this study investigates the relationship between the three components of individual characteristics (person), physical characteristics (place), and time with place attachment. The main focus here is on the physical characteristics, divided into objective and subjective groups. Some factors, for instance, accessibility, facilities, and quality of materials are objectively physical, and some factors, such as Peace and safety (Ayati *et al.*, 2016; Waxman, 2006) are the subjective output of the physical

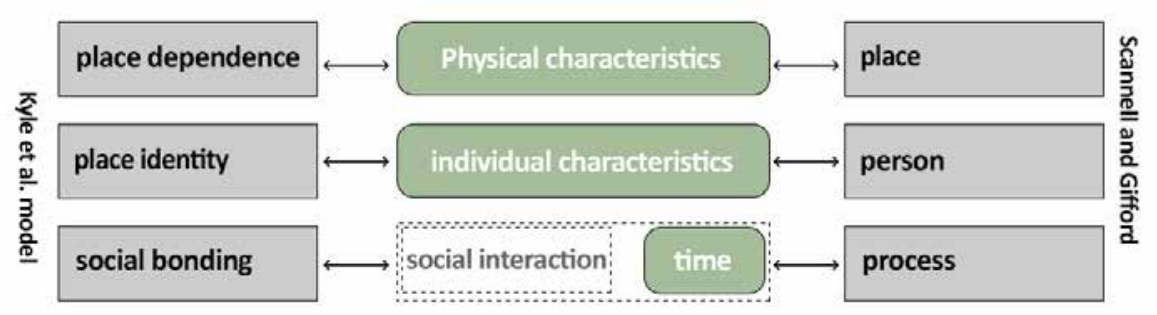

Fig.3: Base of designing the conceptual model of the research

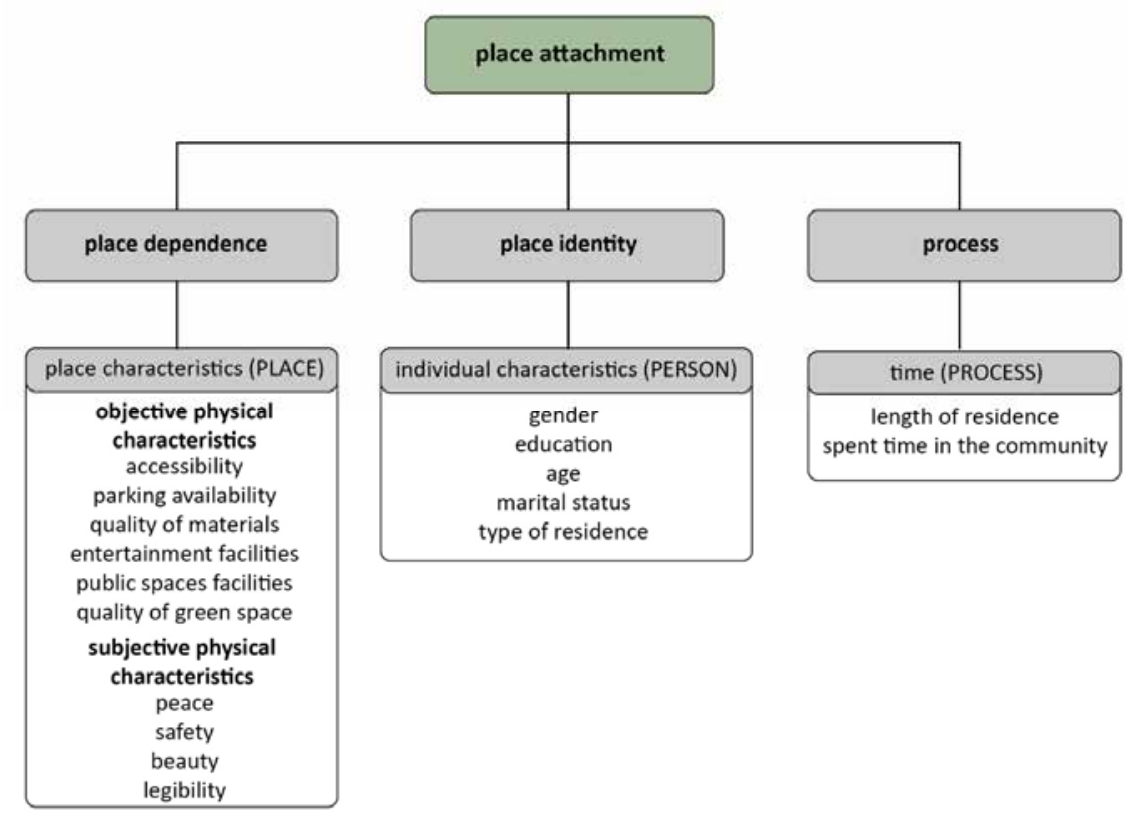

Fig. 4: The Conceptual model of the research

environment. As mentioned before, Social interaction (social bonding), is not the focus of this research, and further studies are needed to consider its effect on creating place attachment in residential complexes. Fig. 4 illustrates the conceptual model of the research and the effective factors on the place attachment in this model are also defined in Table 2.

In this study, people's perception of physical characteristics was measured in objective and subjective groups. The findings can be utilized in the architectural facility programming process and design decision-making to help designers, architects, and architectural programmers design or redesign the existing residential environments in a way that

Table 2: The category of effective factors on the place attachment

	Factor	Theorist	Description
Individual Characteristics	Type of residence (owning one's home)	(Brown *et al*., 2003; Lewicka, 2010; Hay, 1998; Mesch and Manor, 1998, Lin *et al*., 2020a)	- People who own their own homes have invested in their local areas, making it likely that they will live there in the long term, which is also a predictor of place attachment.
	Age	(Bonaiuto *et al*., 1999; Hidalgo and Hernández, 2001; Lewicka, 2010; Lewicka, 2011; Dallago *et al*., 2009; Shamai and Ilatov, 2005)	- Older people are often found to be more attached than younger people.
	Education	(Taylor *et al*., 1985; Lin *et al*., 2020a)	- Higher educated people were more attached than people with less education.
		(Williams *et al*.,1992; Anton and Lawrence, 2014)	- Attachment was correlated with low income and low education.
	Gender	(Hidalgo and Hernández, 2001; Rollero and De Piccoli, 2010)	- Women report being more attached to their homes than men.
		(Anton and Lawrence, 2014)	- Sex cannot predict home place attachment.
	Marital status	(Brown *et al*.,2004)	- Marriage status was positively related to home attachment.
Time	length of residence	(Hernández *et al*., 2007; Lewicka, 2005, 2010; Jorgensen and Stedman, 2006; Raymond *et al*., 2010; Stedman, 2006; Scannell and Gifford, 2010b; Anton and Lawrence, 2014; Shamai and Ilatov, 2005; Brown *et al*., 2004)	There is a correlation between place attachment and length of residence.
	Spent time in the community	(Stedman, 2006; Scannell and Gifford, 2010b; Daryanto and Song, 2021)	- The more people are attached to a place, the more they Spend time participating in property-related recreational and local association activities.
		(Aliakbarzade Arani *et al., 2021*; Sun *et* al., 2020; Hay, 1998)	- As people grow older and have more time to spend in their community, they become more aware of the importance of their sense of place and increase their involvement in the community.
Physical Characteristics	Objective Physical Characteristics	(Reese, 2019; Gieryn, 2000; Lewicka, 2010; Lin *et al*., 2020b)	- Place attachment is positively related to objective physical characteristics of building and neighborhood
	Subjective Physical Characteristics	(Waxman, 2006; Bonaiuto *et al*., 1999)	- Place attachment is related to subjective physical characteristics

improves the sense of place attachment among its residents and the quality of life. The research survey was conducted in the "600-unit residential complex" in Mashhad, Iran in 2020.

MATERIALS AND METHODS

Survey design and data collection

Based on the objectives of the study, the following question was raised:

What are the main effective factors that contribute to creating and reinforcing place attachment among the residents of residential complexes?

Drawing on the literature review, the following sub-questions were defined to answer the primary research question:

- Is there a significant relationship between the objective physical characteristics of the place and place attachment in the residential complexes?
- Is there a significant relationship between the subjective physical characteristics of the place and place attachment in the residential complexes?
- Is there a significant relationship between the individual characteristics of the residents and place attachment in the residential complexes?
- Is there a significant relationship between the component of time and place attachment in the residential complexes?

In order to investigate the research questions, one main hypothesis and four sub-hypotheses were presented.

Objective and subjective physical characteristics of the place, individual characteristics, and the component of time contribute to creating and reinforcing place attachment among the residents of

residential complexes.

- There is a significant relationship between the objective physical characteristics of the place and place attachment in the residential complexes.
- There is a significant relationship between the subjective physical characteristics of the place and place attachment in the residential complexes.
- There is a significant relationship between the individual characteristics of the residents and place attachment in the residential complexes.
- There is a significant relationship between the component of time and place attachment in the residential complexes.

A multi-step approach was used for evaluating the aforementioned hypotheses. To this end, this study examined the theoretical framework of the concept of place attachment. Then, analyzing different theories, the conceptual model of this research is made for developing a questionnaire to study the effects of individual, physical, and time factors on place attachment in a residential complex. Then, the survey method was used to evaluate the variables. Questionnaire studies are commonly used in environmental psychology (for instance, in Kyle *et al*., 2004; Raymond *et al*., 2010) because they are a direct way to gather information about attitudes, feelings, perceptions, anticipations, and values, and they have high external validity and are relatively easy to administer and analyze. However, they may suffer from response bias and social desirability effects (Podsakoff *et al.,* 2003). These flaws cannot be avoided, but more than one approach and method may be used to bear on each aspect of a problem. Other approaches for collecting data in the context of this study were to observe visible behavior and interview, which have their own flaws and additionally were difficult or even impossible, because this research was conducted during the Covid-19 pandemic, when the presence of people in public places was limited and controlled, and it was not possible to observe the behaviors in the context of social life. Therefore, a paper survey was used. One advantage of the paper survey is the participation rate. Generally, response rates are greater in comparison to the online survey method. This questionnaire was designed and revised based on both the exemplars (Hidalgo and Hernández, 2001; Ujang, 2012; Jorgensen and Stedman, 2001; Lewicka, 2010), and comments received by a group of experts in social sciences. After fixing the defects, questionnaires were distributed to the 52 residents of the residential complex (as a pilot study) for validation and re-examination, and then the ultimate corrections were made to the final draft of the questionnaires. The final sample size was 158 (excluding the pilot test samples). The questionnaire items were categorized into three main sections according to the findings from the literature review (Table 2) (Fig. 4) and were rated on a 5-point Likert Scale. The first section was developed to study the individual characteristics of the residents and the time spent in the complex; the second section measured the perceived objective and subjective physical characteristics of the complex, and in the third section, using attachment items, the extent of people's attachment to the residential complex was investigated. As this residential complex, as a neighborhood-garden has unique physical features that should be taken into consideration in studying the impact of objective and subjective physical characteristics on place attachment, some of the characteristics evaluated arequantity and quality of green spaces, accessibility (pedestrian and vehicular), public space facilities, entertainment facilities, legibility, safety, etc. Additionally, according to the conceptual model of the research, in the third section, place attachment is measured through three different categories of items (related to place identity, social bonding and place dependence). SPSS and SmartPLS 3 software were used to analyze the data and measure the variables' relationship.

Study area

This research surveyed a residential complex named "600-unit", which is located in Mashhad, Razavi Khorasan Province, Iran (Fig. 5). This complex is housed within a 12-hectare plot of land. The four-story apartment buildings are built between 1971 and 1975.

The complex is located in the center of Mashhad, surrounded by Ershad Boulevard in the south, Ferdowsi Boulevard in the north, Dehkhoda Boulevard in the west, and Shahid Sadeghi Boulevard in the east (Fig. 6). The overall structure of this complex is demonstrated in Fig.7 and Fig. 8.

Statistical population and sampling method

The statistical population of this study consisted of all families living in the 600-unit complex, and with

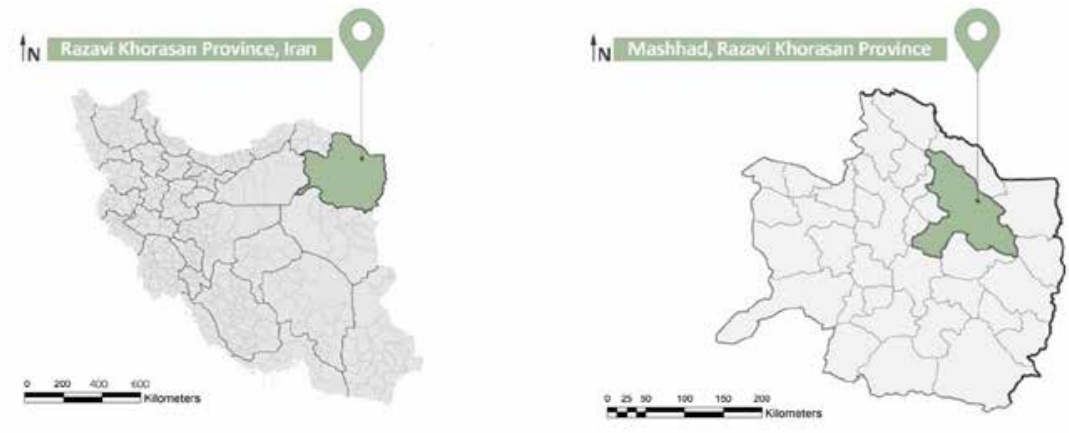

Fig. 5: The location of the case study in Mashhad, Razavi Khorasan, Iran

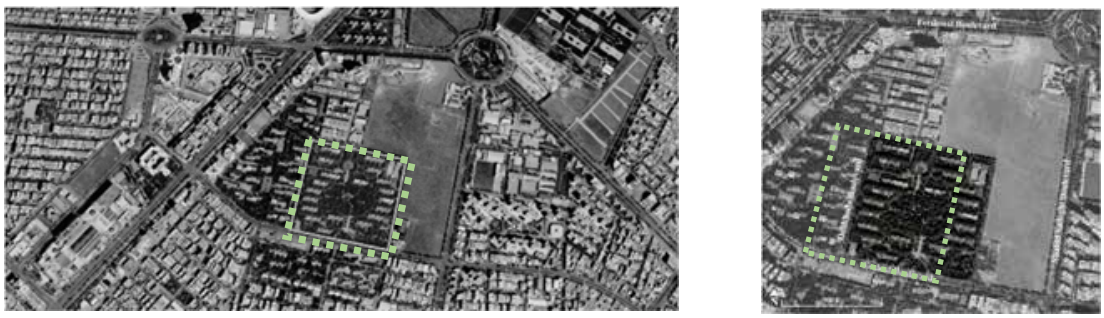

Fig. 6: The location of the 600-unit residential complex (Google Earth)

Fig. 7: The overall structure of the 600-unit complex.

Fig. 8: The 600-unit complex.

Table 3: Reliability of the variables

Concept	Component	Number of questions	Cronbach's alpha coefficients
Physical characteristics	Objective Factors	6	0.719
	Subjective factors	4	0.721
Place attachment	Place identity	7	0.202
	Place dependence	4	0.721
	Process	4	0.764

Table 4: Demographic information of the participants

Variable	Gender		Education						Age						Marital status		Type of residence		Length of residence				
	Female	Male	Less than a diploma	Diploma	Associate Degree	Bachelor's Degree	Master's Degree	Ph.D.	Less than 20 years	21-30 years	31-40 years	41-50 years	51-60 years	More than 60 years	Single	Married (without children)	Married (without children)	Owned	Rented	Less than 5 years	6-10 years	11-15 years	16-20 years	21-30 years	Over 30 years
Frequency (%)	49.7	50.3	4.8	26.9	14.5	33.8	16.6	3.4	0.7	21.4	35.2	26.2	8.3	8.3	24.8	9.7	65.5	73.8	26.2	26.9	19.3	11.7	12.4	18.6	11.0

a household size of 3.39 (Parsoumash Consultant Engineering, 2010) is 2034 (=600*3.39). According to the Cochran formula (with an error coefficient of .07 and response distribution rate of .5), the minimum reliable sample size is 154. As mentioned in Section 3, the sample size is 158 (excluding the pilot test samples) in this study. The Cochran formula computation is as Eq. 1:

$$n = \frac{\frac{z^2 pq}{d^2}}{1 + \frac{1}{N} \times \left(\frac{z^2 pq}{d^2} - 1 \right)} \quad (1)$$

$$n = \frac{\frac{1.812^2 * 0.5 * 0.5}{0.07^2}}{1 + \frac{1}{2034} \times \left(\frac{1.812^2 * 0.5 * 0.5}{0.07^2} - 1 \right)} = 154.84$$

Eq. 1: Cochran formula computation, Based on: (Cochran, 1977)

RESULTS AND DISCUSSION

Reliability

Various approaches are used to calculate reliability, including test-retest, parallel or peer-to-peer, and Cronbach's alpha. Cronbach's alpha is the most common measure of internal consistency ("reliability"). It is most commonly used when multiple Likert questions in a survey/questionnaire exist that form a scale and to determine if the scale is reliable. So, in this study, Cronbach's alpha test was used to measure data reliability. This coefficient for the components of physical factors (subjective and objective factors) and place attachment (place identity, social bonding, and place attachment) is shown in Table 3.

Demographic information

As shown, Cronbach's alpha coefficient is higher than 0.7 for all components, which indicates the reliability of the measurement tool for evaluating the variables.

The sample's demographic characteristics, such as type of residence, gender, education, age, marital status, and length of residence, are shown in Table 4.

Table 5: Tests of normality

		kolmogorov-smirnov[a]			shapiro-wilk		
		statistic	df	sig.	statistic	df	sig.
Place attachment		.062	158	.200*	.987	158	.216
Subjective characteristics	physical	.107	158	.000	.962	158	.000
Objective characteristics	physical	.111	158	.000	.983	158	.068
Age		.221	158	.000	.893	158	.000
Gender		.342	158	.000	.636	158	.000
Education		.217	158	.000	.911	158	.000
Marital status		.409	158	.000	.636	158	.000
Type of residence		.461	158	.000	.550	158	.000
Length of residence		.191	158	.000	.874	158	.000
Spent time		.229	158	.000	.877	158	.000

df: Degree of Freedom
sig: Significance Level

Data analysis

The data were analyzed by SPSS and SmartPLS software. The first case was used to provide descriptive and inferential statistics. The second case was used for assessing the strength of the relationships between the variables and examining other possible (hidden) relationships.

Inferential statistics

To test the mentioned hypotheses in section 3, first, the normality of data is examined using the Kolmogorov-Smirnov as well as the Shapiro-Wilk test. Since the sample size is bigger than 50, Kolmogorov-Smirnov is more appropriate to rely on when the results of those two do not match (Table 5).

The Kolmogorov-Smirnov test is used to test the null hypothesis that a set of data comes from a normal distribution. However, SIG.<0.05 suggests strong evidence of non-normality. According to this, non-parametric tests are used to test the relations between place attachment with different variables. The test to be used depends upon the type of research question being asked. The other determining factors are the type of data being analyzed and the number of groups or data sets involved in the study (Parikh *et al.*; 2010). In this study, to measure the relationships between place attachment and objective physical characteristics, subjective physical characteristics, as well as the component of time, Spearman Correlation is used. Additionally, Spearman Correlation, Mann- Whitney U, and Kruskal- Wallis H are used to test different individual characteristics (depending on the types of variables). Table 6 shows the result of these tests.

The results show that there are significant relationships between Objective Physical Characteristics and Place Attachment (with a 99% probability), Subjective Physical Characteristics and Place Attachment (with a 99% probability), and Time and Place attachment (with a 98% probability). This means that by increasing the quality of objective and subjective physical characteristics and increasing the amount of time connecting with the place in non-gated residential complexes, residents' attachment to the environment will be strengthened. To determine the effects of mentioned variables and their strength on the formation of place attachment in non-gated residential complexes, and to find other hidden indirect relationships, structural equations were prepared using PLS software.

Structural equations

Path analysis and causal modeling were introduced by Wright in the 1920s. It can model latent constructs uncontaminated by measurement error (Hair, 1998; Wang *et al.*, 2004) under conditions of non-normality and small to medium sample sizes. PLS path modeling can be used for analyzing the multiple-block structure of variables when the data has these features: causal relationship, small sample, missing values, or display of co-linearity (Wixom and Watson, 2001). In order to discover the relationships of hidden variables, besides the four mentioned hypotheses, four other hypotheses were defined to form the structural model for place attachment. These hypotheses are mentioned below:

H1.1: Objective physical characteristics are related

Table 6: The result of the analysis tests

	Hypothesis	Test	Sig. (p)	Correlation coefficient (r)	Z	Mann-Whitney U	Kruskal-Wallis H	df	Result
H-1.1	There is a significant relationship between the objective physical characteristics of the place and place attachment in the residential complexes.	Spearman	**.004**	.241**	-	-	-	-	Valid
H-1.2	There is a significant relationship between the subjective physical characteristics of the place and place attachment in the residential complexes.	Spearman	**.007**	.223**	-	-	-	-	Valid
H-1.3	There is a significant difference between place attachment in men and women.	Mann-Whitney U	**.704**	-	-.380	2532.000	-	-	Invalid
H-1.3	There is a significant difference between place attachment in owners and tenants.	Mann-Whitney U	**.024**	-	-2.264	1560.000	-	-	Valid
H-1.3	There is a significant difference between place attachment among people with different education levels.	Kruskal-Wallis H	**.180**	-	-	-	7.592	5	Invalid
H-1.3	There is a significant difference between place attachment among people with different marital statuses.	Kruskal-Wallis H	**.327**	-	-	-	2.223	2	Invalid
H-1.3	There is a significant relationship between age of residents and place attachment in the residential complexes.	Spearman	**.131**	.126	-	-	-	-	Invalid
H-1.4	There is a significant relationship between the length of residence and place attachment in the residential complexes.	Spearman	**.004**	.237**	-	-	-	-	Valid
H-1.4	There is a significant relationship between the amount of time spent in the complexes' public spaces and place attachment in the residential complexes.	Spearman	**.021**	.192*	-	-	-	-	Valid

df: Degree of Freedom
sig: Significance Level
z: z-score

to Place attachment.

H1.2: Subjective physical characteristics are related to Place attachment.

H1.3: Individual characteristics are related to Place attachment.

H1.4: Time is related to Place attachment.

H1.5: Objective physical characteristics are related to time.

H1.6: Subjective physical characteristics are related to time.

H1.7: Individual characteristics are related to time.

H1.8: Individual characteristics are related to subjective physical characteristics.

H1.9: Objective physical characteristics are related to subjective physical characteristics.

The conceptual framework of place attachment modeling is defined based on these hypotheses and is shown in Fig. 9. In fact, this model demonstrates the possible hidden relationships between different variables of this study. Further analysis and calculation with Smart PLS software will examine whether these hypotheses are correct or not.

The path coefficients for the structural model and the weights for the measurement model are obtained by SmartPLS 3.0 software. The result of the bootstrap resampling technique, which was used to determine the statistical significance of the paths, shows that five of these paths are significant. Table 7 shows the path coefficients and significance

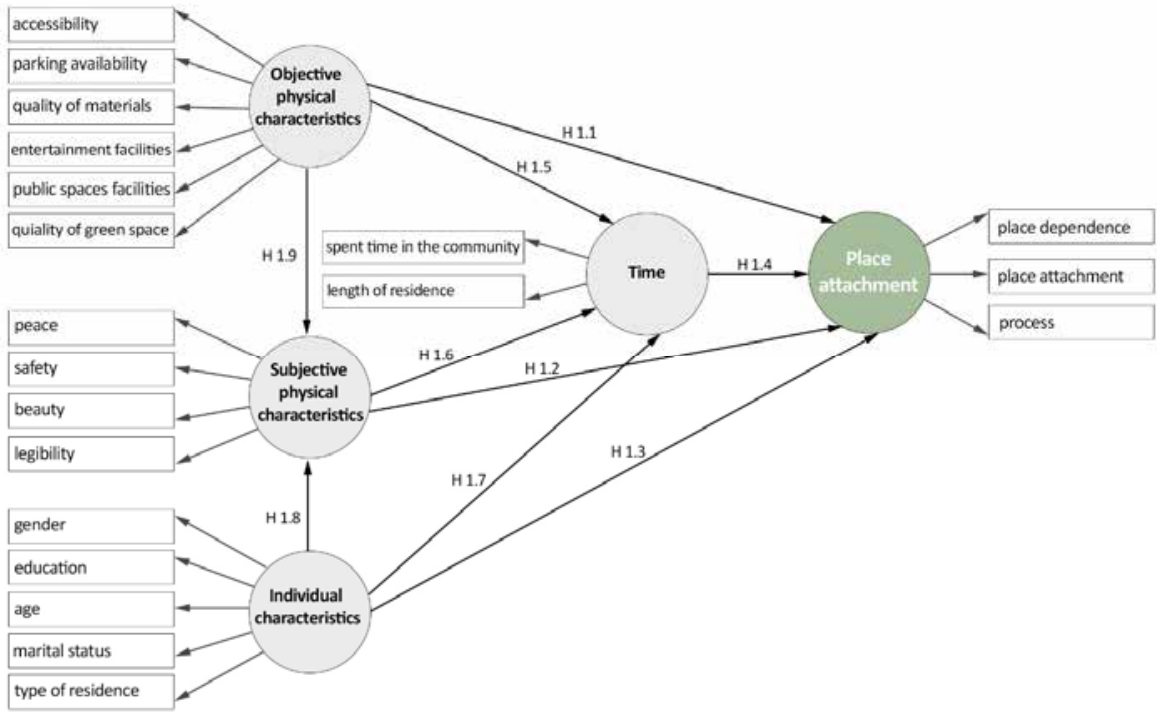

Fig. 9: The conceptual framework of PLS path model based on the hypotheses

Table 7: Path coefficients (mean, Standard deviation, T Statistics and P values)

	Hypotheses	Sample mean	Standard deviation	T statistics	P value	parameter	**Conclusion**
H1.1	Objective physical characteristics → Place attachment	0.403	0.102	3.896	0.000	3.896	Supported
H1.2	Subjective physical characteristics → Place attachment	0.187	0.105	1.876	0.030	1.876	Supported
H1.3	Individual characteristics → Place attachment	0.000	0.154	0.244	0.404	0.244	Not supported
H1.4	Time → Place attachment	0.234	0.129	1.926	0.027	1.926	Supported
H1.5	Objective physical characteristics → Time	0.065	0.111	0.570	0.284	0.570	Not supported
H1.6	Subjective physical characteristics →Time	0.000	0.108	0.181	0.428	0.181	Not supported
H1.7	Individual characteristics → Time	-0.476	0.351	1.700	0.045	1.700	Supported
H1.8	Individual characteristics → Subjective physical characteristics	-0.036	0.112	0.426	0.335	0.426	Not supported
H1.9	Objective physical characteristics → Subjective physical characteristics	0.501	0.090	5.365	0.000	5.365	Supported

levels. The path coefficients are ranked as follows (from highest to lowest): “Objective physical characteristics ® Subjective physical characteristics” (5.365), “Objective physical characteristics ® Place attachment” (3.896), “Time ® Place attachment” (1.926), “Subjective physical characteristics ® Place attachment” (1.876), “Individual characteristics ® Time” (1.700).

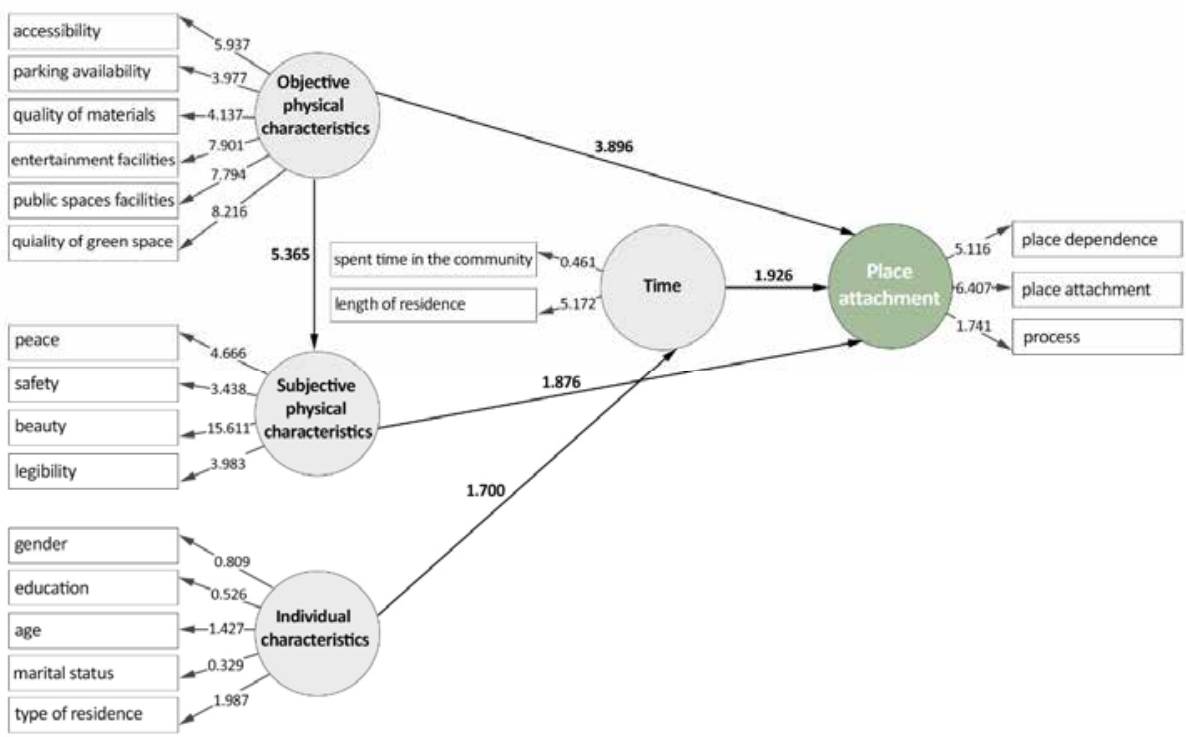

Fig. 10: The result of the PLS path model

The results demonstrate that "Objective physical characteristics" not only directly affect "Place attachment", but also indirectly impact it by affecting "Subjective physical characteristics" in residential complexes. "Time" and "Subjective physical characteristics" have a direct influence on "Place attachment", while the impact of "Individual characteristics" on "Place attachment" is indirect. In fact, "Individual characteristics" affect the "time" people spend in a place, and an increase in this "time" factor leads to an increase in "Place attachment". Based on these findings, the initial conceptual model has been modified, and the final path flow with the parameters of each path is illustrated in Fig. 10.

CONCLUSION

Place attachment is important in assessing how people connect with their environment, and it contributes to creating better residential areas that encourage responsibility, cooperation, and an overall improvement in quality of life. This study focuses on identifying the factors that promote and strengthen place attachment in residential complexes, using the 600-unit residential complex in Mashhad as a case study due to its unique environmental features. This complex is unique in its environmental features and design, which is based on the neighborhood-garden concept and shares common facilities with the urban environment, such as green spaces and entertainment facilities. Although the complex was constructed around 50 years ago, its residents still have a strong attachment to the environment, which has resulted in efforts to maintain and improve the surroundings, leading to a longer useful life for the residential buildings. This research investigates the impact of three general components, namely the physical characteristics of the residential environment (objective and subjective), the individual characteristics of the residents, and time, on place attachment in the 600-unit residential complex, utilizing SPSS and PLS software. The first case (SPSS) was used to provide descriptive and inferential statistics. The second case (PLS) was used to assess the strength of the variables' relationships and examine

other possible (hidden) relationships. Both methods yielded completely compatible results, indicating that three factors, namely time, subjective, and objective physical characteristics, have a direct impact on place attachment. Objective physical characteristics not only directly influence place attachment but also indirectly affect it by influencing subjective physical characteristics in residential complexes. The relationship between individual characteristics and place attachment is indirect. It means that individual characteristics impact the time people relate to a place, and an increase in this time factor leads to an increase in place attachment. As represented in Table 6, among the individual characteristics, type of residence is the only effective factor with a significant relationship with place attachment. Landlords have more place attachment than tenants. This also directly relates to the time people live in the complex. The average landlord's length of residency in the complex is significantly longer than tenants. The findings of the study reveal that the residents of the 600-unit residential complex are mainly attached to the place due to its distinct physical features. The loadings of the physical characteristic's components demonstrated that the quality of green spaces, entertainment facilities, public space facilities, and accessibility were the most important components determining objective physical characteristics, and beauty, peace, legibility, and safety were the most influential factors determining subjective physical characteristics, respectively. These findings highlight the crucial role of architects and planners in designing high-quality residential environments that satisfy people's needs, improve their quality of life, and enhance their sense of place attachment. To this end, architects and planners in designing or redesigning residential complexes should consider factors such as recreational and sports facilities, facilities needed for public spaces, security, legibility, beauty, and pleasantness of spaces. Providing these facilities, not only fulfills functional needs but also strengthens place dependency and increases people's presence in the environment. Increased presence enhances the likelihood of social interactions and strengthens social links within the place, leading to greater place attachment. These results can be used in architectural programming within the design process of similar residential complexes or in redesigning residential complexes with similar characteristics to the 600-unit complex. However, place attachment is a complex and multidimensional concept that involves various aspects. Therefore, understanding and measuring place attachment requires a comprehensive and multidimensional approach and further research could investigate the effectiveness of social features in residential complexes for addressing concerns such as raising the level of human responsibility and cooperation in residential environments. Overall, this research provides significant insights into the development and strengthening of place attachment in residential settings, highlighting the significance of designing high-quality residential environments that cater to people's needs and promote their overall well-being.

AUTHOR CONTRIBUTIONS

Gh. Motalebi; A. Khajuei and F. Fanaei Sheykholeslami designed the model and the computational framework and analyzed the data. All the authors conceived the study and were in charge of the overall direction and planning.

ACKNOWLEDGEMENT

The authors would like to extend their gratitude and special thanks to all the percipient people of 600 Residential complex who contributed to this research

CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the authors.

PUBLISHER'S NOTE

ABBREVIATIONS (NOMENCLATURE)

PLS	Partial Least Squares
POE	Post-Occupancy Evaluation
SPSS	Statistical Package for the Social Sciences

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HOW TO CITE THIS ARTICLE

Motalebi, Gh.; Khajuei, A.; Fanaei Sheykholeslami, F., (2023). Investigating the effective factors on place attachment in residential environments: A Post-occupancy evaluation of 600-unit residential complex. Int. J. Hum. Capital Urban Manage., 8(3): 373-390.

DOI: 10.22034/IJHCUM.2023.03.06

URL: https://www.ijhcum.net/article_704244.html