

## Original Research Article

**Middle-Class Housing Analysis in the Second Pahlavi Period Based on the Shape Grammar****(Case Study: Narmak Neighborhood and Ekbatan Town of Tehran)\***Sara Gholami<sup>1</sup>, Jamaledin Soheili<sup>2\*\*</sup>, Kamal Rahbari Manesh<sup>3</sup>

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**Abstract**

**Problem statement:** The social and cultural areas of Iran have undergone extensive changes during the second Pahlavi era. One of the most important influential indicators in these developments is modernism in the intellectual society system. The formation of a new middle-class in the second Pahlavi period is a sign of modernism achievements. Even the housing types of this social class also reflect their fundamental changes during this period. The present article intends to model the new middle-class housing of the second Pahlavi and suggests new models for contemporary middle-class housing.

**Research objective:** This research seeks to achieve new middle-class housing rules in the second Pahlavi period by using grammar and develop a variety of design patterns in the housing of today's middle classes. In this regard, Narmak neighborhood from the middle period and Ekbatan town from the last period of the second Pahlavi were selected as a sample community and were evaluated according to the socio-cultural indicators of housing.

**Research method:** The basis of this qualitative research method is interpretive history; at the beginning of this article, during a historiographical study, the effect of social classes on the structure of houses has been studied, and then the physical-spatial dimensions of houses have been discussed by the descriptive-analytical method. The method of data analysis in this research is shape grammar. The information required in this research has been collected through field observations, library studies, and documentation.

**Conclusion:** According to the results of the research, the components of the houses of this period have been influenced by modern Western ideas and architecture and have undergone fundamental changes in comparison with the traditional housing of Tehran. The micro-spaces of the dwellings are reduced to a minimum and follow a basic shape grammar: arrangement of spaces in these houses is based on the location of a basic element. The basic shape was considered to be multipurpose spaces (living and dining areas) and then other spaces were added to the basic shape based on a set of rules. Finally, based on the algorithmic process of shape grammar led to the creation of various patterns for the modern housing design.

**Keywords:** *Second Pahlavi period, Middle-class, Housing typology, Shape grammar.*

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supervision of Dr. Jamaledin Soheili and advisement of Dr. Kamal Rahbari Manesh in "Faculty of Architecture and Urban Planning, Qazvin Branch, Islamic Azad University" in 2021.

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## Introduction and problem statement

One of the ups and downs of historical periods in Iran is the reign of King Mohammad Reza Pahlavi. This period (the second Pahlavi) began with the resignation of Reza Khan from the monarchy in 1941. In the historical division of the second Pahlavi period based on social and cultural developments, three distinct periods have been identified; The early period, which is the beginning of the reign of King Mohammad Reza (1941-1953); Middle period (1953-1963); Final period (1963-1979).

Multiple reforms of Mohammad Reza Pahlavi and the process of socio-cultural modernization of this period caused extensive social and cultural changes that affected the structure of social classes of society. These changes, due to the rapid and large-scale urbanization trend in the country in the middle and final period of the second Pahlavi period, took place quickly and on a large scale. Following the population increase and migration from rural to urban areas, a new social class emerged in Iran, called the new middle-class. In this research, the social class in question is this new middle class.

If the only criterion in determining the concept of the middle-class is economic criteria, we must inevitably place broad sections of society under the heading of the middle class. Such as craftsmen, people with small businesses, etc., which are usually referred to as the traditional middle classes (Rahmatollahi & Mousavizadeh, 2012, 7) but the concept of the middle-class in this research is a new middle-class that is based on modern tendencies. New lifestyle developments in the form of modern architecture and following Western culture affected the spatial structure of the new class housing more than other classes.

Therefore, this article intends to study and analyze the types of housing of the new middle-class of society in the second Pahlavi period. The main research purpose is to understand how the new middle-class's role contributes to their architectural houses' shape formation. In this regard, to analyze the form of two examples of middle-class housing, Narmak neighborhood from the middle period and Ekbatan town from the last Pahlavi period were selected as the sample population and the impact of quasi-modernism on the structure of houses of this social

class of society using shape grammar have been evaluated to conclude with a specific pattern of housing.

Shape grammar is a way to check shapes in terms of computational rules. Shape grammar is a set of rules that allows analysis elements and to combine shapes to produce schemas. It is based on parametric changes, seeks a way to obtain different shapes. Using shape grammar, which is a method of formal analysis in architecture, it is possible to classify the architecture of a historical period or a social class. Due to the influence of modernity on the mindset of society, middle-class housing in the Pahlavi period was formally separated from traditional housing and took on a modern form. Therefore, to study the rules of shape production in a period of Iranian architectural history, this research identifies the new middle-class housing types of the second Pahlavi period.

## Research questions and hypotheses

Research questions include:

- What role did the new types of middle-class housing in the second Pahlavi period play in promoting modern architecture in Iran?
- What have been the characteristics of middle-class housing types based on shape grammar analysis?

To answer the research questions, hypotheses are as follows:

- In the second Pahlavi period, the formation of a new middle-class of society has been the most important factor for the entry of modern architecture in Iranian housing.
- In the second Pahlavi period, the formal rules that led to the formation of new middle-class housing species followed a basic formal grammar.

## Research background

Table 1 lists some of the most important researches on the theoretical foundations of the research: The first part is about the history and socio-cultural developments of the second Pahlavi; the second part is about housing in the Pahlavi period; the third part is about the shape grammar. Examining the items listed in this table, it is clear that the present research is innovative by focusing on the analysis and classification of middle-class housing in the middle

and final period of the second Pahlavi by using the shape grammar.

## Theoretical foundations of research

### • General information about shape grammar

Shape grammar is a set of shape rules applied in a step-by-step way to generate a set of language designs. It gives the designer the ability to show their design process and design rules by shapes rather than text. Shape grammar is

spatial, rather than textual or symbolic, algorithmic. Shape grammar is a set of rules applied to the initial shape to generate designs. The rules are designed to transform the initial shapes, so the user may decide which rule can be used to achieve the desired outcome. Since the designed shape may consist of different shapes, and there could be different rules for different shapes (Prakash & Shekhawat & Goyal, 2017, 293). In other words, “Shape Grammar is based on the language form and rules and a deployment

Table 1. Research background. Source: Authors.

Row	The name of the research and its date	Author(s)	Description
1	Book: The political economy of modern Iran, despotism, and pseudo-modernism (1995)	Mohammad Ali Homayoun Katouzian	This book has a detailed study of historical-social-cultural issues of the Pahlavi period.
2	Book: History of social and political development in Iran (2005)	Alireza Azghandi	In this book, he deals with the political and social developments from 1941 to 1979.
3	Book: Social classes, State and Revolution in Iran (2008)	Ahmad Ashraf and Ali Banuazizi	This book is a study of social classes in Islamic Iran, the Middle Ages, the Qajar period, and the Pahlavi period
4	Book: The Middle-class and Political Developments in Contemporary Iran 1941-2001 (2016)	Mohammad Hossein Bahrani	Seeks to evaluate the existing political discourses in the middle strata of Iranian society from 1320 to 1380 with a sociological approach
5	Book: Iranian Contemporary architecture (2009)	Amir Bani Masoud	In this book, the biographies of important architects and buildings from the beginning of the Qajar era until now have been studied.
6	Book: The advent of new architecture in Iran (2009)	Cyrus Bavar	It is related to architecture and prominent buildings in the Pahlavi era.
7	Book: The heritage of modern architecture of Iran (2011)	Eskandar Mokhtari Taleghani	Describes the buildings of the Pahlavi era and the Islamic Republic.
8	Booklet: Study on the characteristics of dormitories and houses in 9 neighborhoods of Tehran (1972)	Khadijeh Kiakajori	9 residential alleys have examined the time of the second Pahlavi and have provided maps of their plans.
9	Ph.D. Thesis: Evolution of Tehran Housing Architecture in the Pahlavi Era (2001)	Behrooz Janipour	First, he studied the traditional housing of Tehran, and then he studied the different types of housing that changed during the Pahlavi era
10	Book: House in culture and nature of Iran (2009)	Mohammad Reza Haeri	This book examines the category of houses before 1921 and after 1961 in Iran.
11	Article: Shape Grammars and the Generative Specification of Painting and Sculpture (1972)	George Stiny & James Gips	The basis of shape grammar is defined in this article
12	Book: Algorithmic aesthetics: Computer models for criticism and design in the arts (1978)	George Stiny & James Gips	It is about discovering an algorithm for artworks that shape grammar is the rules for creating shapes.
13	Article: A shape grammar: The language of traditional Turkish houses (1996)	Gulen Cagdas	He has studied the shape grammar in houses and has created architectural grammar by classifying the plan elements into rooms, halls, and stairs and categorizing the types of plans.
14	Book: Shape: Talking about Seeing and Doing (2006)	George Stiny	This book first explains how using rules, seeing, and counting is different and then shows how to calculate with shapes and provide details.
15	Article: Shape grammar in contemporary architectural theory and design (2012)	Bojan Tepavcevic & Vesna Stojakovic.	The role of shape grammar as a tool for architectural design and analysis and its impact on contemporary architectural theory was investigated in this article.
16	Article: Re-read of Court's Form and Related Spaces with Shape Grammar Case Study: 100 Houses of Qajar Dynasty in Kashan City (2017)	Kianoush Hasani & Vida Norouz Borazjani & Mohammadreza Nassir Salami	Interprets the houses of Kashan by shape grammar and examines the three elements of open and closed space and porch in these houses.
17	Article: A Specification of a New Pattern of Shape Grammar in Architecture of Today's houses; Case study: Qajar houses in Tabriz and Tehran (2018)	Kianoush Hasani & Vida Norouz Borazjani	Explains the new pattern using shape grammar and examines how to create basic shapes in Qajar houses.

system which leads to design. This is a method of deriving complex shapes from simple elements (Hasani & Norouz Borazjani, 2018, 37).

Shape grammars are rule-based systems for describing and generating designs (Stiny, 2006). Shape grammars are distinctive for their visual approach. They generate designs by computing directly with shapes in two or three dimensions, rather than with symbols, words, numbers, or other abstract structures that represent visual shapes indirectly. Over the years, shape grammars have been developed to tackle a continuum of design tasks from analysis to synthesis. They have been applied successfully in these tasks across virtually all areas of design from urban design to architecture to landscape design to craft to painting to product design to mechanical design (Knight & Stiny, 2015, 10). Experts' views on the shape grammar can be summarized in Table 2.

In general, it can be said that in shape grammar, the method chosen for construction includes grammar with defined rules. The idea is that embossed shapes should be identified and preserved and then manipulated into new shapes. In fact, the goal is to use the concept of computational design. Shape grammar considers the form of design not as an intellectual activity but as a kind of construction.

The rules of a shape grammar have a general pattern that can be represented as Fig. 1:

$A \rightarrow B$  where A and B refer to shapes and the arrow shows "Replace".

The steps shown in Fig. 2 are generally followed in the

given temporal order, but the user has full control over each step and can make adjustments at any time as desired. The shape grammar rules are applied to the shapes and result in a new design.

Generalities on the impact of social and cultural developments on middle-class housing species in the middle and final period of the second Pahlavi

Social and political conditions in Iran from 1941 to 1979 with the removal of Reza Pahlavi during the occupation of Iran by Britain and Russia and the beginning of the government of Mohammad Reza Pahlavi, was accompanied by a change in the political system. In the historical division of the second Pahlavi period based on social and political developments, three periods are identified, which are introduced in Table 3.

#### - The early period: 1941-1953

The first period of the second Pahlavi (1941 to 1953), "was the period of occupation of the country by foreigners, instability, intensification of conflicts, disorder, and insecurity" (Homayoun Katouzian, 1995, 201). "During this period, on the one hand, the modernization and westernization of society, which was started by the first Pahlavi, continued, and on the other hand, some of his actions were stopped due to the dispersal of power" (Bahrani, 2016, 98).

#### - The middle period: 1953-1963

The period after the coup of 1953, led to an increase in the influence of the US government and an increase in the country's foreign exchange earnings from the establishment of oil exports and the wider economic

Table 2. Experts' views on the shape grammar. Source: Retrived from Hasani & Norouz Borazjani, 2018, 37- 38.

Row	Experts	Define the shape grammar
1	Tepavcevic & Stojakovic, 2012	The term shape grammar is generally subdivided into the two forms of visual and computational data. In the computational component, the organized group of expert systems produces geometric shapes.
2	Ozker, 2009	Shape grammar also refers to visual design as was mentioned. In this sense, shape grammar back into the world of form, not through the imposition of the complexity of the forklift, but through practical means at that point in time.
3	Knight, 2000	Shape grammar is a production design method (Method in which the drawings are generated by applying a set of algorithm rules, allowing the exploration of new concepts and solutions) and with a set of rules of transformation applied recursively to an initial form, generating new forms
4	Stiny, 1976	The most unique feature of shape grammar is the ability to set a finite number of rules and shapes while allowing the production of an infinite number of design solutions. In addition, shape grammar is used as a tool for generating complex forms from simple shapes. Shape grammar produces forms that arise from the forms in the collection and in accordance with their spatial relationships.
5	Stiny, 1980	In Shape grammar, forms combine with the shape rules to manufacture a set of designs with desirable characteristics

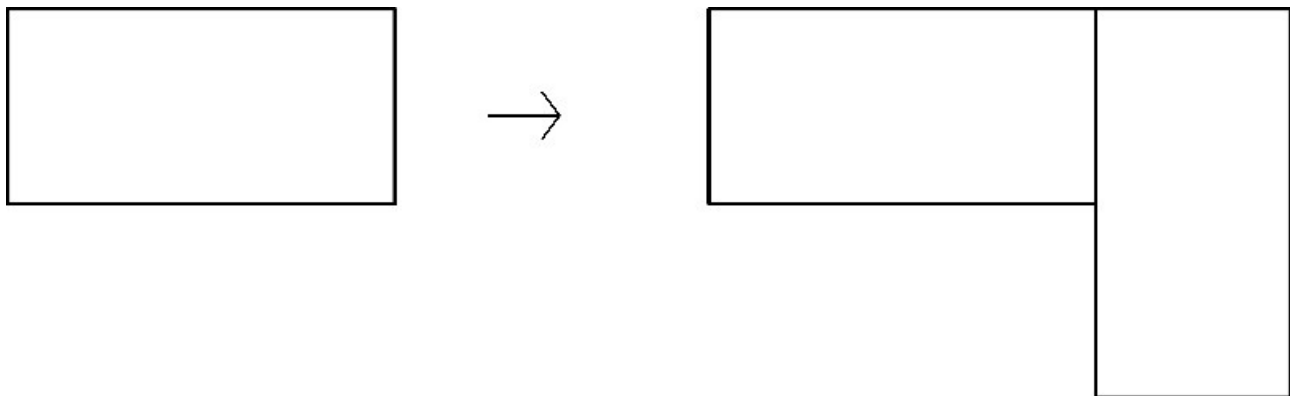


Fig. 1. A shape grammar rule. Source: Authors.

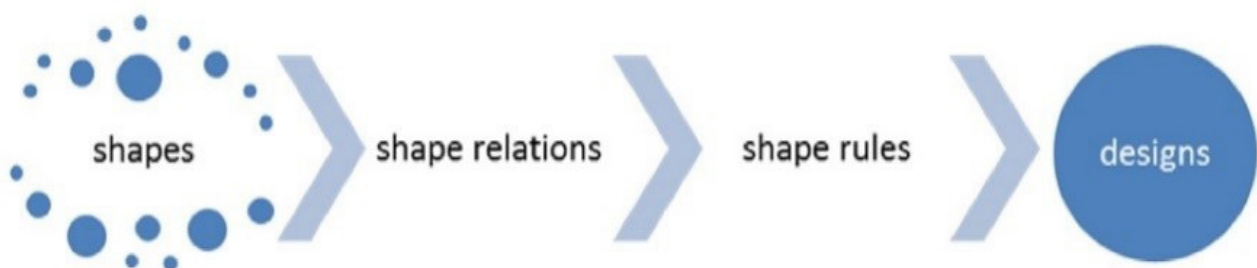


Fig. 2. Stages in shape grammar design. Source: Prakash et al., 2017, 293.

relationship between Iran and the West. “The political-economic plans of the government, especially in the form of the implementation of the White Revolution, led to the rapid expansion of cities. This trend expanded the number of privileged urban strata and created more diversity in their hierarchy” (Ashraf & Banuazizi, 2008, 111).

#### - The final period: 1963-1979

“Some scholars have called the 15 years, 1963-1979, a quasi-modernist period based on oil (oil tyranny)” (Homayoun Katouzian, 2013, 297). With regard to land reform, the king, while strengthening his position among the villagers, had removed the landed class from the scene and, on the other hand, pursued socio-economic modernization and sought to recruit a new middle class” (Rahmatollahi & Mousavizadeh, 2012, 27).

#### • New middle class

“Political, cultural, and administrative institutions have evolved since the formation of the modern government in Iran. Renovation in all areas was considered by the authorities. As a result, alongside the traditional middle class, a class was formed that had a special place apart from the traditional power relations” (Adibi, 1979, 122);

that was the new middle class. “The socio-economic logic of the government’s policy on political economy was to strive to create a ‘middle class’ as the regime’s social base. This policy, because it led to the emergence of hypothetical factors of economic development and liberal democracy, was in line with the Western liberal version” (Homayoun Katouzian, 1995, 253). “A review of published statistics shows that since 1966, Iranian society has had a high coefficient of growth in the number of educated people. Compared to the number of economic sector actors, the services sector has grown significantly, unlike the agricultural and industrial sectors. This shows the strengthening of the social body of Iran’s new middle class” (Hosseinzadeh, 2008, 247-248). “The quasi-middle class is inherently economically deeply dependent on the government because when we think of the real meaning of the middle class, the main element that comes to mind is the economic element” (Amini & Sotoudeh, 2012, 96). Table 4 shows the middle-class structure of this period. Factors influencing lifestyle change include cultural, social and economic factors of society and “housing as the most primitive and popular structure of the city, reflects



Table 3. Historical periods of Iran in the second Pahlavi period. Source: Hassanpour &amp; Soltanzadeh, 2017, 40.

Historical periods	Periods of Iran in the second Pahlavi period
The early period	Between the beginning of the reign of Mohammad Reza Pahlavi 1941 until the coup of 1953.
The middle period	The second Pahlavi era of authoritarian rule from 1953 until the land reform, the White Revolution and the suppression of protests of Clergymen in 1963.
The final period	Between 1963 to the overthrow of the Pahlavi dynasty in the Islamic Revolution of 1979.

the social, aesthetic, cultural and economic conditions prevailing in the society in its own period, which is due to the architect (builder) finds a physical and objective appearance” (Bani Masoud, 2009, 287). In general, the cultural, social, and economic characteristics of the new middle-class of society in the second Pahlavi period can be summarized in Table 5.

The impact of these intangible features of the new middle-class on housing architecture can be clearly seen in Table 6.

## Research method

This research is qualitative and the method of data analysis is based on shape grammar. This method has two analytical and production dimensions that use systems and algorithms based on rules to analyze or produce designs. At the beginning of this research, the required information was obtained by studying documents and libraries, as well as interviewing people who are aware of historical events. In the second part, by studying the currents of contemporary Iranian architecture in documents and field studies, the typology of middle classes housing of the second Pahlavi period was done. Since access to complete information about residential alleys was limited by documentary and field sources, the following were considered in the selection of samples: first, the possibility of visiting and photographing, second, the possibility of access to background information, third, the possibility of access to Map of houses located in a residential alley or survey and drawing a part of it, fourth, the possibility of classifying the houses of that alley according to the shape grammar. Therefore, Narmak neighborhood and Ekbatan town have been selected as two examples of middle-class housing in the middle and final periods of the second Pahlavi.

## Research findings

In the present research, the effect of the characteristics

of the middle-class of the society on the housing types of the middle-class of the second Pahlavi period has been investigated. Since these effects are often reflected in the architecture of houses, in the first place, the effects of the formation of a new middle class of the second Pahlavi period are determined by the formal analysis of two examples of middle-class housing. Then, using the grammar of the figure, the specific pattern of housing in this period is explained. Among the housing types of the middle-class of the second Pahlavi period, the Narmak neighborhood, which was built for teachers from the middle of the second Pahlavi period, and Ekbatan town from the end of the second Pahlavi period has been selected as a sample.

### • Typology of various components of spaces in Narmak houses

“With the coming to power of Dr. Mossadegh’s national government and the formulation of government housing programs, the idea of constructing housing alley for the general public and government employees and workers was raised. Narmak neighborhood in east Tehran was one of the first measures at that time” (Janipour, 2001, 122). This alley was built for middle-income groups and to house teachers in 1954. Fig. 3 analyzes some Narmak houses as examples.

“The characteristic of the multipurpose spaces is the lack of definition for the component of spaces. The spatial boundaries of the entrance, dining and living room are not clear and it has been tried to define or assign spatial boundaries by arranging objects and furniture” (Haeri, 2009, 152). The kitchen is located inside the closed part of Narmak houses. Bedrooms in Narmak houses, on average, occupy about one-third to one-half of the total infrastructure of residential units. Based on the spatial evolution resulting from the change in lifestyle, lavatory and toilets and sometimes bathrooms in contemporary homes, including Narmak, have been formed in one space.

Table 4. The stratification structure of the middle-class of Iran in the second Pahlavi period. Source: Retrived from Bahrani, 2016, 103 &amp; 118.

Social class	Rural cortex	Urban cortex	
		Traditional middle class	New middle class
Middle-class (early and middle period of the second Pahlavi)	Wealthy Peasants, stewards, headmen, middle peasants	Clerics, middle merchants, craftsmen and businessmen (petty bourgeoisie)	Independent and semi-independent professionals, middle managers and government and private sector employees, the military and new intellectuals
Middle-class (final period of the second Pahlavi)	Smallholders, traders, lenders, agricultural machinery owners and government agents, and middle peasants	Clergy, local merchants and market employees and other shopkeepers, craftsmen and businessmen (petty bourgeoisie)	Independent and semi-independent professionals, middle managers and public and private employees, military, technicians and intellectuals

Table 5. Characteristics of the new middle-class in the second Pahlavi period. Source: Authors.

Characteristics of the new middle-class in the second Pahlavi era	
Cultural characteristics of the new middle-class	1- Tendency to modern values and modernization of society (according to the beginning of the process of modernization in the western way from the time of Reza Pahlavi) 2- Spreading Iranian nationalism against Islamic Iran (weakening religious beliefs in families) 3- Changing cultural habits and traditional customs 4- Demand for cultural goods and healthy entertainment 5- Looking to enjoy life
Social characteristics of the new middle-class	1- The White Revolution and the expansion of education and public health 2- Increasing the urban population 3- Expanding education and increasing the number of educated people among the middle classes (literate and educated urban social forces) 4- Increasing the share and role of women in society 5- Active participation in the political arena of the society
Economic characteristics of the new middle-class	1- Appropriate financial income (due to land reform and economic reforms resulting from oil revenue) 2- Modeling the consumption characteristics of the capitalist class

### • Typology of various components of spaces in Ekbatan houses

“Ekbatan town is one of the largest residential complexes in the Middle East and is located in the west of Tehran. This complex was established in the 1960s with the aim of housing middle-income and educated groups, and the applicants for housing at that time were modernists who wanted to live in modern apartment units” (Rafat Jah, 2007, 47).

Spatial patterns in Ekbatan houses (Fig. 4) have been designed and implemented to meet the cultural and social needs of the middle class. The kitchen is sometimes located inside the closed part and sometimes openly in the spatial organization of Ekbatan houses and is close to the main entrance of the house so that the raw materials purchased from outside the house can be transferred to the kitchen faster and on the other hand, an attempt has been made to place this space next to a space dedicated to food and, if possible, to install an opening or an independent

door in the common wall between the kitchen and the dining room.

### • Shape Grammar and its role in the analysis of Narmak and Ekbatan housing species

In the first step, to examine the selected houses using the shape grammar, the main spaces of the houses are categorized. Then one of these spaces is selected as the base shape due to its greater importance. The rules of grammar apply to that basic element. In this way, these houses are analyzed according to the set of grammar rules of the shape and the pattern of spatial relations of these houses is presented.

The common feature of these houses is the existence of three main spaces in them that are consistently present in each sample: living room (multipurpose spaces), kitchen and toilet space (service space), and bedroom (private space). To make it easier to define the shape grammar, some houses details are ignored. The spaces in the designs are shown as polygons. living room (hall) is the most

Table 6. Changes in the formation of new middle-class housing in the second Pahlavi period. Source: Authors.

Changes in the formation of new middle-class housing		
Macro architecture pattern	The middle period	<ul style="list-style-type: none"> <li>- The arrival of modern architecture with the start of construction of affordable government housing (which became practically suitable for the middle class) <ul style="list-style-type: none"> <li>- Functional extraversion</li> </ul> </li> <li>- Formation of residential settlements</li> </ul>
	The final period	<ul style="list-style-type: none"> <li>- Expansion of modern architecture with the design of apartments and residential towns</li> <li>- Extraversion and high-rise building</li> <li>- Designing comprehensive urban plans</li> </ul>
General pattern of spaces	The middle period	<ul style="list-style-type: none"> <li>- Separation of public, semi-public, private areas</li> <li>- Considering a lot of space for corridors (to separate areas)</li> <li>- Access to the bedrooms from a central hall space without direct view of the living room</li> <li>- Closed kitchens</li> <li>- Locating the lavatory and toilet in one space</li> <li>- Interference of public and private privacy</li> </ul>
	The final period	<ul style="list-style-type: none"> <li>- Access to bedrooms from the living room with direct view</li> <li>- Open kitchens combined with living room</li> <li>- Sometimes the location of the lavatory and toilet and bathroom in one space</li> </ul>
Detailed pattern of spaces	The middle period	<ul style="list-style-type: none"> <li>- Simplicity of form</li> <li>- Shrinking houses and fading the role of the yard</li> <li>- Remove component spaces (connection of architectural spaces without intermediaries)</li> <li>- Remove traditional decorations</li> <li>- Elimination of yards and emphasis on closed space</li> </ul>
	The final period	<ul style="list-style-type: none"> <li>- Defining spaces using furniture (for example, separating the dining space from the living room with furniture)</li> <li>- Using modern architectural materials to decorate the building</li> </ul>

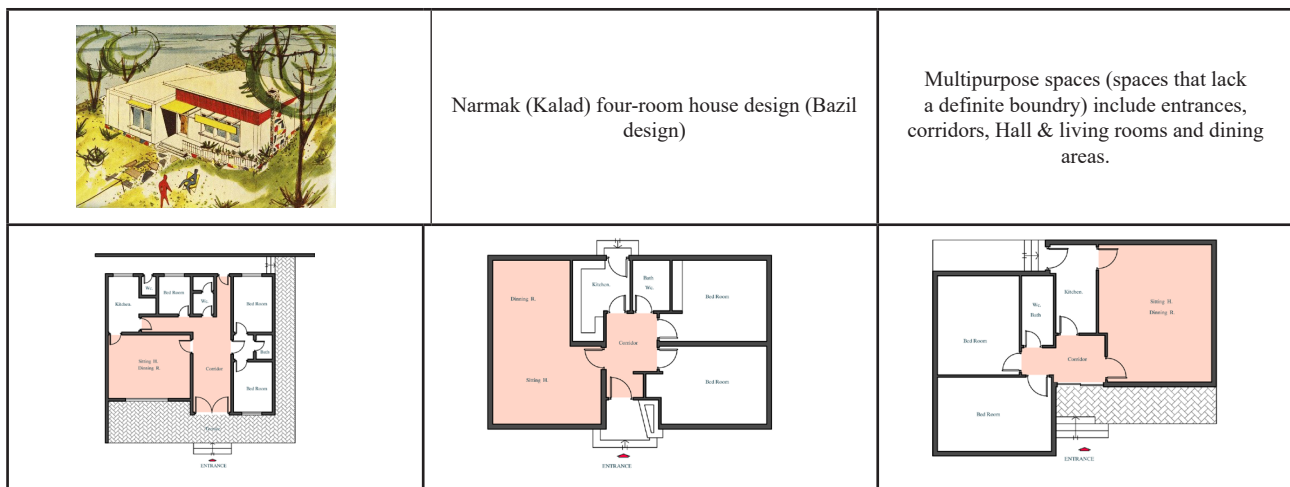


Fig. 3. Typology of component types of spaces in Narmak houses. Source: Authors.

influential element in the composition of Iranian houses, the shape and location of which affect the shapes and types of houses. Therefore, by considering the living room or hall (multipurpose spaces) as the basic form, through a set of hierarchical rules, the process of producing shapes begins with the location of other spaces next to the basic space. In fact, the process of producing shape grammar begins with the location of the living room. The process in this grammar is such that a space is added to the original space. Therefore, in the next stage, the bedroom is added

to the basic shape (living room or hall) and in the last stage, the service spaces are located next to the basic shape.

The first stage of analysis of Narmak houses with shape grammar: In Narmak houses, which is related to the middle Pahlavi period, in Fig. 5, the basic element was identified first and other spaces were located next to the basic element. It can be seen that there is a spatial separation between the living room and the corridors and an enclosed room is considered as a hall (living room). (It should be noted that the hatch space in the pictures



Multipurpose spaces (spaces that lack a definite boundary) include entrances, corridors, Hall & living rooms and dining areas.



Fig. 4. Typology of types of space components in Ekbatan houses. Source: Authors.

indicates multipurpose spaces, numbered spaces represent bedrooms, and crossed space represents service spaces).

The first stage of analysis of Ekbatan houses with shape grammar: In Ekbatan houses, which is related to the final Pahlavi period, we are faced with a variety of plans that can be classified into four groups:

- With an all-round hall;
  - With an L-shaped hall;
  - With a separate hall;
  - With a separate hall and communication corridors to other spaces;
- Considering the hall (living room) as the basic shape and

the location of other spaces (bedrooms and service spaces) to the basic shape, in Fig. 5, the spatial relationship of the elements of Ekbatan houses next to the basic shape (hall) was determined.

In the second stage of examining the selected houses using the shape grammar, by using the matrix, the spatial elements of the houses are represented as graphic representations. It is essential to use matrices to convert symbolic representations to graphical outputs. In fact, each matrix represents a polygon, and using the matrices, the elements of the house can be transformed into the main geometric shapes, ie square or rectangle, or triangle. In the matrix, zero (0) represents empty cells, one (1) represents full cells, and one zero one (101) represents half-full cells (Fig. 7). In the next step, the main geometric shapes in the matrices can be expanded to sub-shapes (Fig. 8). In the final step, it should be able to display the proximity of shapes side by side in the matrix (Fig. 9).

(From left to right: communication in the corners, communication in part and complete communication)

Now, according to the explanations about the transformation of spatial elements of houses into main and secondary geometric shapes in matrices and how to show the proximity of spaces in matrices, the second stage of the process of analyzing selected houses can be done with shape grammar. In Fig. 6, the living room/hall (multipurpose spaces) of 3 selected houses in two case samples is located as the initial form of shape grammar in the first column with the titles N1, N2, and N 3 for Narmak neighborhood and E1, E2 and E 3 for Ekbatan town. Due to the transformation of this space (basic shape) into the main geometric shapes, the living room/hall is graphically represented in the second column with a matrix. In the next step, using the rules of addition, the rooms are added to one or both sides of the living space/hall. In continuation of this production design method, service spaces are also added. All these steps to convert space into a major geometric shape are shown in Fig. 6 with the matrix. In this way, a production process can be achieved by adding and subtracting forms.

### Interpretation and analysis of data

At this stage, a set of rules is formed. Given that H represents the hall, S represents the service space, R

represents the room, C represents the corridors; the rules of shape grammar can be named with these letters. Since the living room/hall and corridors in this research are considered to be multipurpose spaces, it is possible to ignore the title of communication spaces in the name of rules. The set of shape grammar rules in selected houses can be called with the general title of rules (HSR). The first rule in the design process is to convert a point to a space. This rule is called HSR 11 (the rule that applies to a point and turns it into a space). Now in the process of converting the relations of house elements into shape grammar rules, according to the six selected houses and the drawing matrices for them in Table 11, each step of adding architectural elements can be written as a new rule. With the help of this step of shape grammar, the relationships of spaces can be displayed in the simplest possible way.

As we saw in the previous table (Fig. 6), the 3 selected houses in two case samples are named in the first column with the titles N1, N2, and N<sup>3</sup> for Narmak neighborhood and E1, E2, and E 3 for Ekbatan town. For example, in House No. 1 in Narmak, which is referred to as N1, HSR<sup>22</sup> is the rule for adding a “communication corridor” to a “hall (multipurpose spaces)”. According to HSR23, rooms are added to the basic form of multipurpose spaces (a combination of living room and communication corridor), and according to HSR24, service spaces are added to multipurpose spaces and bedrooms. Similarly, the rules of all 6 selected houses are shown in Fig. 10.

### Create new designs using shape grammar

Shape grammar expresses design knowledge through shapes and produces different types of designs using a set of rules. The decision tree diagram (Fig. 11) is an algorithm that shows the possibility of producing different designs. In this diagram, the numbers displayed on the line indicate the application of the new rule to the previous step. These rules are extracted from Fig. 10 (for example, the number 23 on the line indicates the application of HSR23).

Using different combinations of these rules, various designs can be created. Several examples of the new design process can be seen in Fig. 12 by combining the

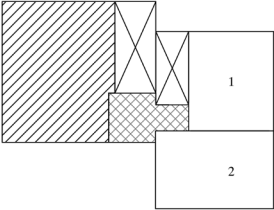
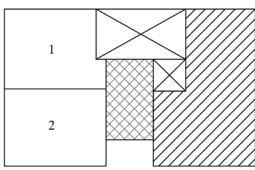
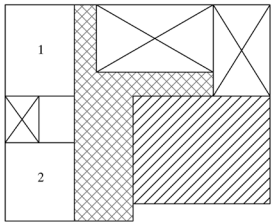
Narmak houses		1	2	3
A1	Plan type with a enclosed Hall as a room			

Fig.5. The first step in the process of creating shape grammar in Narmak houses. Source: Authors.

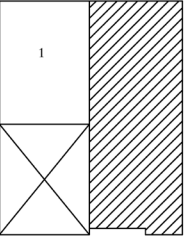
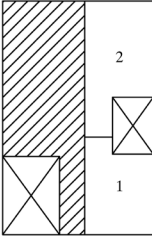

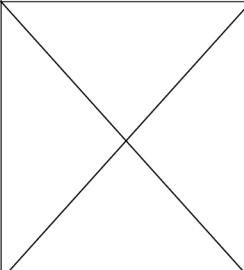
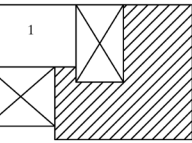
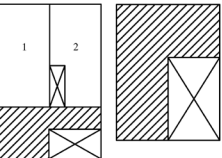
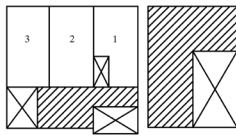
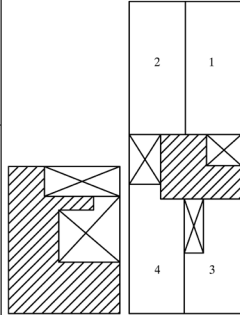
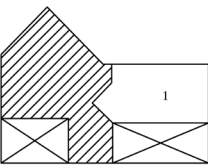
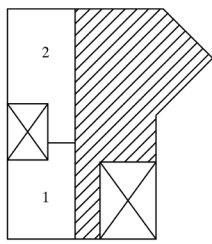
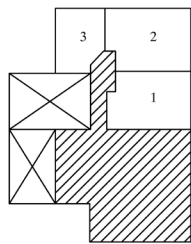
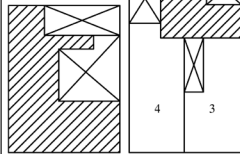
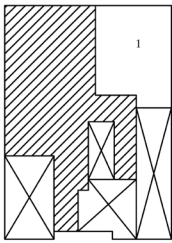
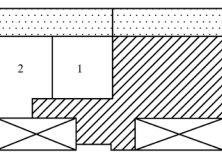
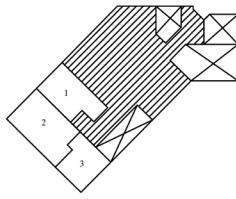
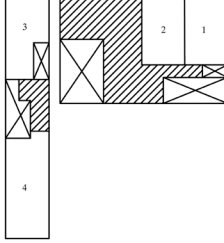
Ekbatan houses		1	2	3	4
		One bedroom	Two bedrooms	Three bedrooms	Four bedrooms
B1	Plan type with an all-round Hall				
B2	Plan type with an L-shaped Hall				
B3	Plan type with a separate Hall				
B4	Plan type with a separate Hall and communication corridors				

Fig. 6. The first stage of the process of creating shape grammar in Ekbatan houses. Source: Authors.

rules of the 6 selected cells. These rules have led to new designs that no home has ever had. Then, by applying

different rules, different and infinite designs can be achieved.

	Basic element (multipurpose space)	Multipurpose spaces matrix	Add the bedrooms	Bedrooms matrix	Add the services space	Services space matrix																																																																																																																																																				
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Fig. 6. The second stage of the process of creating shape grammar in Narmak and Ekbatan houses (a set of basic shapes in house plans). Source: Authors.

## Conclusion

Social class and cultural characteristics of the new middle-class of society who were looking for modern ideas have a direct impact on the housing architecture of this group. According to the table of shape grammar rules governing the selected houses of the new middle-class in the middle and final Pahlavi period and the characteristics of the decision tree of these houses, the following points can

be understood: The houses components of this period are influenced by modern western architecture have undergone fundamental changes in comparison with the traditional housing architecture of Tehran. In these houses, the micro-living spaces are reduced to a minimum and follow a basic grammar: in a basic form (multipurpose spaces), bedrooms and service are added.

The pattern of middle-class housing in the Middle Pahlavi

period was medium-sized two to four-bedroom villas, sometimes in the form of apartments. With the shape grammar method, it can be seen that in these houses, living spaces are properly formed and the privacy of service spaces is also considered. The residents of these houses, new middle-class people, seem to have a quasi-modernist style. In these houses, some patterns of traditional housing architecture as well as modern housing architecture have been ignored and instead provided the facilities and spaces of its inhabitants.

The pattern of middle-class housing in the last Pahlavi period is to provide housing commensurate with the increase in population, apartments, and towers, and large residential complexes such as apartments of pioneers of modern architects. In the middle-class buildings of this period, modern housing explicitly replaced traditional housing, and even modern elements, materials, and construction methods were used in concept and facades. With the shape grammar, it can be seen that in these houses, living rooms/halls do not have a specific shape

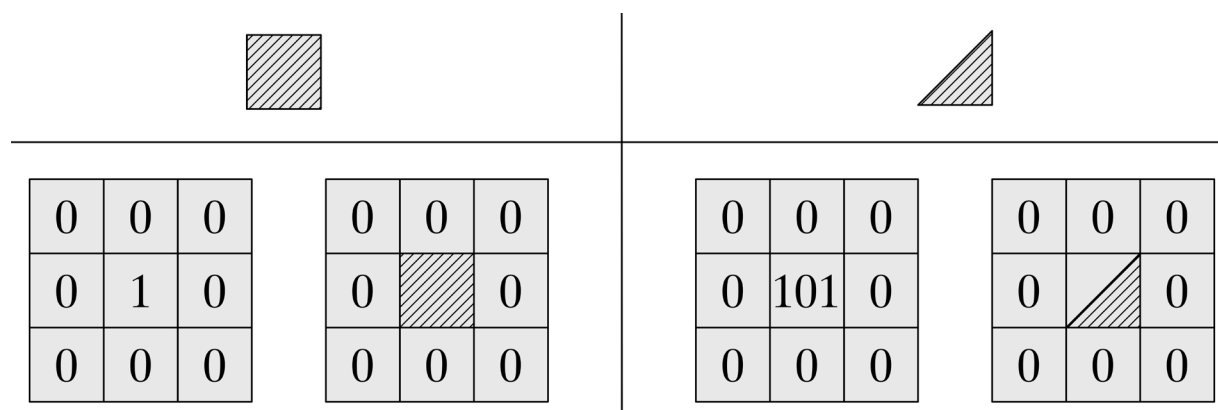


Fig. 7. Showing the main geometric shapes in the ninth matrices. Source: Authors.

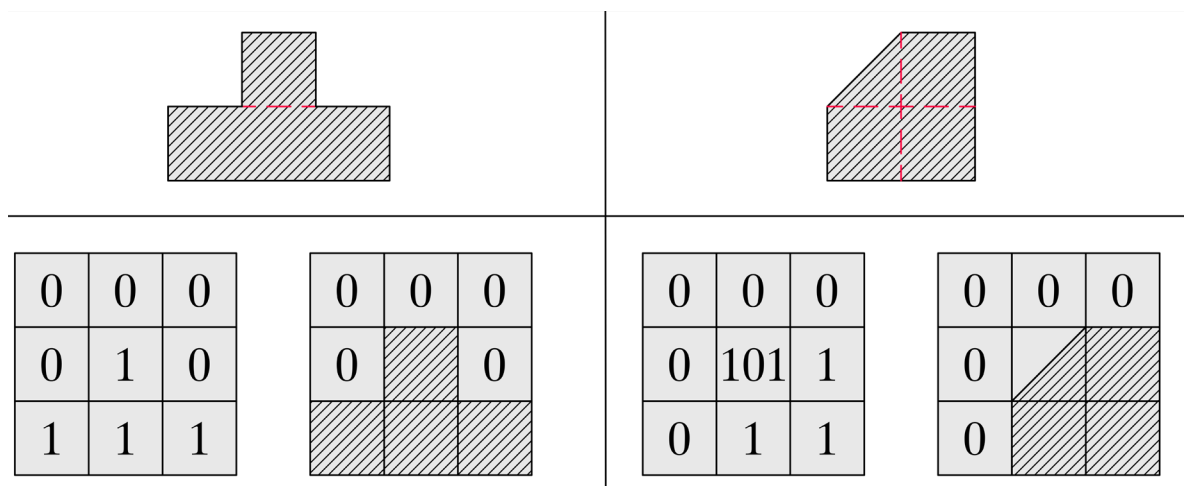


Fig. 8. Shapes derived from the original geometric shapes and their representation in the ninth matrices. Source: Authors.

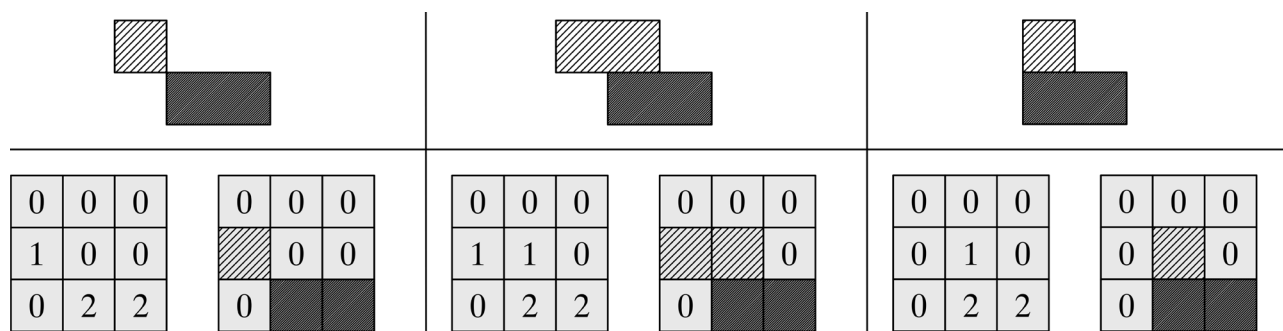


Fig. 9. Showing neighborhood relationships in ninth matrices. Source: Authors.



HSR	$\bullet \rightarrow \boxed{H}$ HSR11		
N(1)	$\boxed{H} \rightarrow \boxed{C H}$ HSR22	$\boxed{C H} \rightarrow \begin{array}{c} \boxed{R C H} \\ \boxed{R} \end{array}$ HSR23	$\begin{array}{c} \boxed{R C H} \\ \boxed{R} \end{array} \rightarrow \begin{array}{c} \boxed{S} \\ \boxed{R C H} \\ \boxed{R} \end{array}$ HSR24
N(2)	$\boxed{H} \rightarrow \boxed{H C}$ HSR33	$\boxed{H C} \rightarrow \begin{array}{c} \boxed{H C} \\ \boxed{R} \end{array}$ HSR34	$\begin{array}{c} \boxed{H C} \\ \boxed{R} \end{array} \rightarrow \begin{array}{c} \boxed{S} \\ \boxed{H C} \\ \boxed{R} \end{array}$ HSR35
N(3)	$\boxed{H} \rightarrow \boxed{H C}$ HSR44	$\boxed{H C} \rightarrow \begin{array}{c} \boxed{C R} \\ \boxed{H C R} \end{array}$ HSR45	$\begin{array}{c} \boxed{C R} \\ \boxed{H C R} \end{array} \rightarrow \begin{array}{c} \boxed{S} \\ \boxed{S C R} \\ \boxed{H C R} \end{array}$ HSR46
E(1)	$\boxed{H} \rightarrow \boxed{H R}$ HSR55	$\boxed{H R} \rightarrow \begin{array}{c} \boxed{S} \\ \boxed{H R} \end{array}$ HSR56	NO RULE
E(2)	$\boxed{H} \rightarrow \boxed{H C}$ HSR66	$\boxed{H C} \rightarrow \begin{array}{c} \boxed{R R} \\ \boxed{H C C} \end{array}$ HSR67	$\begin{array}{c} \boxed{R R} \\ \boxed{H C C} \end{array} \rightarrow \begin{array}{c} \boxed{R R} \\ \boxed{H C C} \\ \boxed{S C S} \end{array}$ HSR68
E(3)	$\boxed{H} \rightarrow \begin{array}{c} \boxed{C} \\ \boxed{H} \end{array}$ HSR77	$\begin{array}{c} \boxed{C} \\ \boxed{H} \end{array} \rightarrow \begin{array}{c} \boxed{R C R} \\ \boxed{R C} \\ \boxed{H} \end{array}$ HSR78	$\begin{array}{c} \boxed{R C R} \\ \boxed{R C} \\ \boxed{H} \end{array} \rightarrow \begin{array}{c} \boxed{R C R} \\ \boxed{R C S} \\ \boxed{H S} \end{array}$ HSR79

Fig. 10. Set of rules in selected houses of Narmak and Ekbatan. Source: Authors.

and definition and are introduced as multipurpose spaces and in combination with service spaces and bedrooms with both living and communicating uses are introduced. The privacy of service spaces that used to be a feature of traditional Iranian housing architecture, has been completely eliminated in this period. This privacy was seen even in the middle period of the second Pahlavi. During the last Pahlavi period, kitchens were designed in the style of modern architecture, openly and in combination with living and dining rooms. The private area of the bedroom is separated from the public area of the living room, occasionally with the corridor and sometimes in direct connection. Finally, in the algorithmic process of shape grammar, new designs were created in the decision tree. Since the basic forms of the selected houses were the housing pattern of the second Pahlavi middle class, as a result, the spaces created by the shape grammar also create spaces in line with the culture of the same period.

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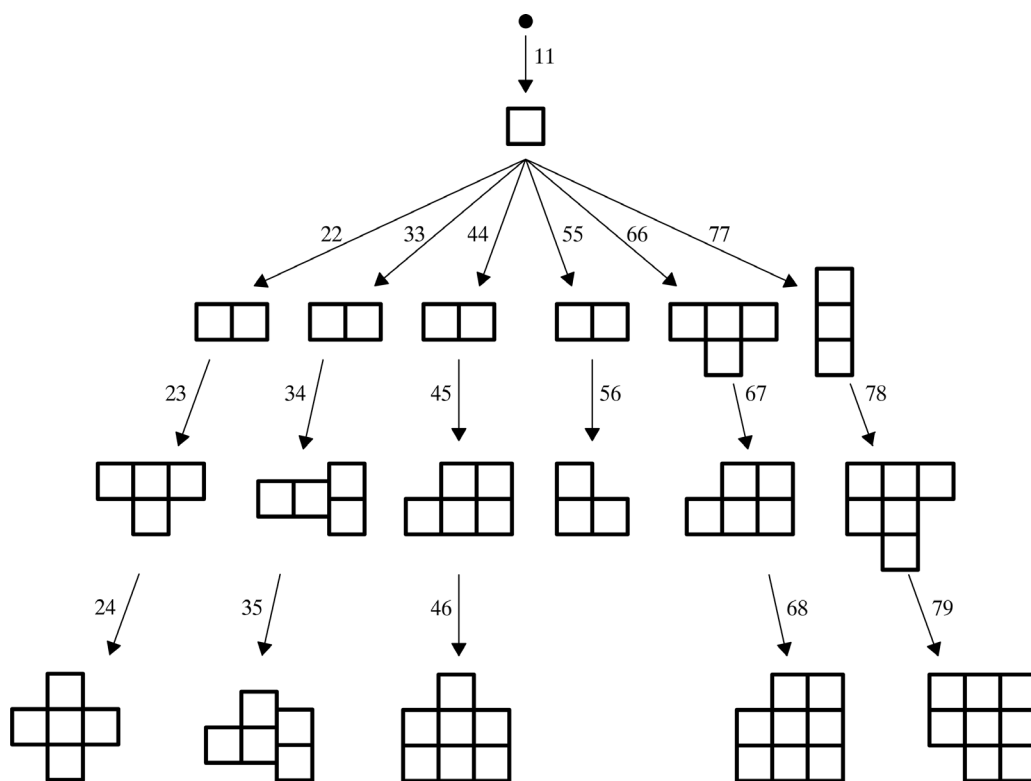


Fig. 11. Decision tree in selected houses of Narmak and Ekbatan. Source: Authors.

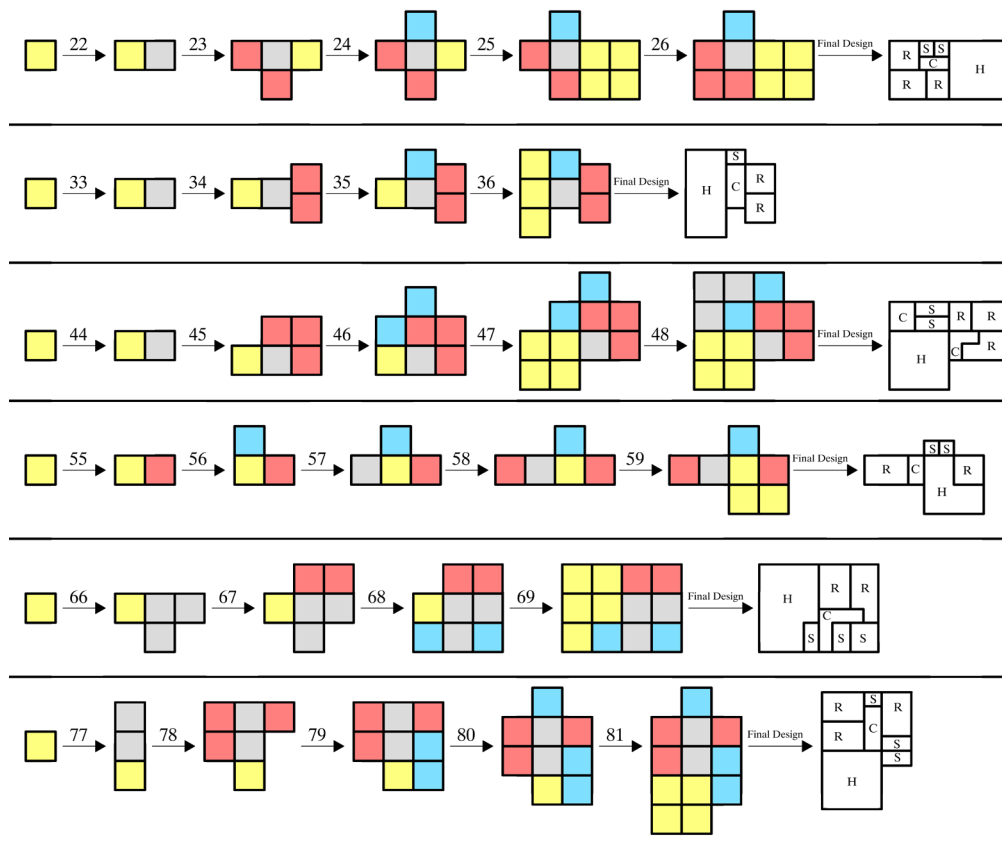


Fig. 12. An example of a new design using the rules of selected houses in the shape grammar (living room/hall: yellow; communication channels: gray; bedroom space: red; service spaces: blue). Source: Authors.

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