

The Generation of Rifaat Al-Chaderchi Facades Using Standard Shape Grammars

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Abstract



The architecture of Rifaat Al-Chaderchi is of a distinct particularity with easily distinguished façades, they were artistically composed from rich traditional architectural elements and forms. He was one of the first Iraqi architects to experience the trend of critical regionalism as his works exhibit the interaction between the local traditions of Iraq and Western influences. On the other hand, the concept of shape grammars is of great importance in the field of architecture as it provides a fruitful approach for the study and analysis of the formal patterns of different artifacts belonging to certain architectural styles or architects. The current research focuses on the problem of studying the shape grammars of the architectural facades of Al-Chaderchi. It aims at defining the rules of the shape grammars that produced the form of those facades. Thus, the significance of this research stems from the disclosure of the shape rules that underlie the design of Al-Chaderchi facades and providing the possibility for re-application of the derived rules to generate those facades with the synthetic properties and formal relationships that distinguish certain facade from the others. The research adopts the method of standard shape grammars concerned with the structural and formal relationships of the façades compositions and their differences regardless the different criteria and dimensions associated with each facade. The research aim was achieved by the conclusion of the shape rules through which the facades of Al-Chaderchi have been composed. Then, the concluded rules were applied firstly, to derive those facades and secondly, to derive new facades that carry the same formal and elemental structure to test their application potentialities.

Keywords: Rifaat Al-Chaderchi, Double Facades, Standard Shape Grammars, Shape Rules, Iraqi Traditional Architecture, Critical Regionalism.

1. Introduction

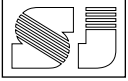
Rifaat Al-Chaderchi is one of the most prominent Iraqi architects. In his works, he resorted to the traditions and elements that emphasized the Iraqi character, its modern architecture, diversity in the use of heritage elements in his buildings' double facades and the emphasis on dealing with the external envelope of the building that abstracted traditional architecture in a modern artistic approach. This research intends to approach the architecture of Al-Chaderchi, his double facades specifically, from the concept of shape grammars. Shape Grammars is of clear significance for architecture, as it is a tool for the classification, characterization, generation and evaluation of architectural works. They have been invested for the objective descriptions of the formal structures of architectural products in order to reproduce those products, and also to determine the relevance of new products to the same formal language of previous productions together with an assessment of their novelty and creativity. While shape grammars were used previously to study the architectural artifacts of different architectural schools and different architects, this research comes as a new contribution in this context.

2. Literature Review

2.1. Studies on Shape Grammars

The literature of shape grammars includes many and diverse studies focused on the buildings of various functional types and time periods. Some dealt with the study of the facades of buildings in addition to their plans, while the other studies dealt with one of the elements of the facades, while the other studies to study the facade of



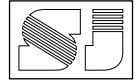


specific buildings using shape grammars. For example, (Duarte, 2001), adopted the parallel standard shape grammars for the generation of the houses plans and elevations of (Architect Siza) in a sequential and parallel process. AL-Kazzaz (2011) has developed a methodology to derive hybrid creative designs for traditional Islamic minarets and facades by using shape grammars for the architectural design process stages of analysis, synthesis and evaluation. Shape grammars have been used as an analytical and generative method to derive hybrid designs for twelve traditional Islamic minarets as well as an evaluative tool to measure the creativity of the generated hybrid designs. With the aim to reconstruct 80% of the buildings in the City Graz, (Hohmann, 2009) was a study for the generation of facades models of Graz in Austria automatically by analyzing the facades and reconstructing them using shape grammars interpreted in a hierarchical manner using computer software. Riemenschneider (2012) study examined the Cocke-Younger-Kasami algorithm (CYK), a dynamic programming algorithm that repeats all input sub-strings and all non-grammatical stations for the analysis and re-generation and comparison between the two types of facades, the first facades of low level represented by the architecture of Housman in Paris, the buildings (Paris 2010), and a second medium-level buildings of (Craz50), which combined the classic, the historical and Art Nouveau. In this study, split shape rules were used for the analysis and re-generation of facades.

2.2. Studies on Al-Chaderchi Architecture

The architecture of Rifaat Al-Chaderchi which has gained a distinguished presence within in Iraqi and Arab and international professional circles has been described and praised by many architects and scholars. Generally, many of the related studies have agreed unanimously that Al-Chaderchi was influenced by the works of the architects who were credited with crystallizing the international trends in art and architecture such as Le Corbusier, Mondrian and Mies van Der Rohe. However, he focused on the study of De-stijl, trying to reach a state of contemporary abstract art with an Iraqi version. This contributed to the preparation of Al-Chaderchi for

later stages of his career, as he, himself, stated that he started to interact with some of the old Iraqi and Islamic features, which he pondered in depth in the mosques of Baghdad, its alleyways, suques, khans and its traditional houses. He began also to match these features with some of the contemporary approaches that he had read in the works of Mondrian, Mies van and Corbusier (Al-Chaderchi, 1991. P.85). Al-Chaderchi usually tended to smelt and distill heritage features from the originals in an almost clear abstraction process. Thus the outcome of his work is a modern architecture, but influenced by the local and belongs to the values of heritage in terms of design treatment of the external envelope of the artifact. Thus he actually practiced what has been called later the critical regionalism of Postmodernism. Moreover, he deliberately emphasized the formulation of astonishing facades by the blatant contrast in the treatments on the one hand and the clarity and simplicity of the schemes behind them on the other hand (Al-Mullah Hweish, 1988). Al-Chaderchi style of solutions depended on traditional treatments and the use of heritage elements and their introduction into construction through indirect investment. He was interested in diversification at a more formal level than at the level of space organization. The method of diversification is through changes in the sizes, locations and texture of the main elements and details (Al-Zobaie, 2002, p.128). Al-Chaderchi resorted to the basic forms (cube, circle) to determine the shape of his structures within cubic configurations. This was based on the principle of repetition in the facades, as the openings are lined up according to the functional and environmental needs on the facades (Jaddo, 1993, p.120). In the following years, as in spite of his adherence to the principle of separating the façade from the main mass of the building, he began to manipulate it to a great extent, so that he would treat him as a sculptor, and try to conceal the usefulness of the building, as it negatively affects aesthetic acceptance. In his attempts to reach a sculptural architecture he attempted an experience of camouflage on the scale and a formulation of the compositions components according to their dimensions and relations in such a way that the general composition of the mass is not related to the size of the real scale of those components. The



beholder would not be able to estimate easily and clearly the real dimensions of those compositions. In this way, the elements of utilitarianism are transformed into sculptural components that lose their usefulness or scale to become part of a sculptural composition. The camouflage method on the scale has been achieved by hiding the openings behind an external wall of a double facade, in the corners and angles connecting this wall and the block of the building. The facade of the building became a hard cavernous wall that accepts the sculptural formation without contradicting the function of the utilitarian building. (Jaddo, 1993, p.121)

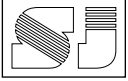
3. Research Problem, Aim and Hypothesis

The critical review of the previous studies on Al-Chaderchi architecture showed that most of them were of a descriptive nature as they dealt, almost only, with describing his style and the formal aspects and elements and the basic relationships between the elements that characterized his architecture. On the other hand, there were many studies which have focused on exploring the shape grammars of different architectural facades for different architects and different architectural styles. However, there is no study that analyzed the architectural facades of the local Iraqi architecture or Iraqi architects in terms of shape grammars in an approach which provide the possibility for being regenerated according to the rules and spatial relations that characterized them. Hence emerged the research problem as the absence of a study on the shape grammars of Al-Chaderchi architectural facades and accordingly, the research aims to discover the shape grammars of the architectural facades of Al-Chaderchi and the application of derived shape rules for the regeneration of those facades. The hypothesis to be explored is related to the following question: Are the architectural facades of Al-Chaderchi derived from one initial shape? Do these facades have certain consistent patterns of similar rules in their structural relations and different in spatial labels, through which these rules can generate different models of Al-Chaderchi facades?

4. The Concept of Shape Grammars in Architecture

4.1. The Significance of Shape Grammars for Architecture

The concept of Shape Grammars is of clear significance for architecture both at the cognitive theoretical and applied levels. Shape Grammars is a tool for describing, analyzing and generating designs. It is descriptive because it provides ways to explain the formal structure of the different designs. It is analytical as they can be used to find out if the new designs belong to the same design language of certain designer and it is generative because it is invested to create new compositions within the same language. (Duarte, 2012). For (Flemming, 1987), (Chase, 1996) shape grammars can be used to produce new designs and define what is called the Design Space, which consists of an unlimited number of possible designs that can be generated (Loomis, 2002). In addition to the richness of designs derived, Stiny stated that shape grammars enable the creation of multiple design solutions rather than a single solution. Although multiple solutions are important in themselves, what is more important is the raised possibility of comparison between different solutions for the purpose of reaching the best (Stiny, 1980). Moreover, shape grammars contribute to the transparency of the design process, as the use of shape grammars rather than intuition will not require the designer to rely on "subjective inspiration" or "individual genius" and thus clear design thinking. To answer the constant question: "Where do designs come from?" is to refer to the rules that generate those designs (Stiny, b1980). In addition to the ease and speed of the designs generated, the rules of shape can be designed to generate designs quickly and easily, not limited to a single design language, but also to the generation of new languages easily through the changes made by the designer on those rules (Knight, 1981, p.237). Shape grammars make easy to explore if certain work of unknown architect belong to specific architect, style or period. Also, shape grammars are significant for the reconstruction of architectural works destroyed in war times. This comes to be true for case of the current research as one of the famous artifacts of Al-Chaderchi (Insurance Building) is to be removed from the



center of Mosul City due to its extensive damage. If there is no documentation shape grammars will become useful for reconstruction of this building. Finally, it is not only the use of shape grammars to analyze, describe designs, but also to be an evaluation tool to measure the degree of creativity in the designs generated and compared (Al-Kazzaz, 2011).

4.2. Elements of Shape Grammars

Shape grammars consist of four elements: (Stiny, 1980, pp.345-347)

- 1- Shapes: Specific set of shapes S
- 2- Symbols: A specific set of symbols L, as it is through the symbols called (Labels); the different states of any shape can be distinguished and recognized. The Labeled Shape consists of two parts: the shape itself in addition to the labels.
- 3- Shape Rules: A specific set of the shape rules R, consisting of a pair of labeled shapes separated by arrows, in the form of $(\alpha \rightarrow \beta)$. It consists of the vocabulary of shapes and spatial relations between them. These relationships represent the synthetic ideas for the generation of designs and define the context of adding one shape to another or subtracting shape from another to create the design (Knight, 1994, p.706).
- 4- The initial shape: represents the initial shape from which the design starts. It is called "Labeled Shape I".

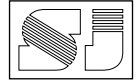
4.3. Types of Shape Grammars

The organization of formal patterns in architecture deals with topological and geometric properties and relationships, which requires the characterization of the pattern elements from the standpoints of both topology and geometry. Architectural studies have indicated that the designer deals, during the initial phase of the design, with the topological characteristics associated with the elements of the scheme as well as the spatial relations between them. Gero (1995) noted that the formal rules used for planning the design scheme of a particular pattern can be separated into two types: the topological and the geometrical. The topological are related to a set of formative rules generate the compositions of

architectural designs, while geometric rules are based on mathematical programming and the measurements and dimensions of the form (Gero, 1995). Steadman (1983) noted that the topological rules deal with the characteristics of the spaces that form the connecting parts of the scheme without relying on the size of those spaces. They relate to the location estimation and its characteristics of the plan elements, and do not include measurements and calculations for those locations such as adjacency, connectedness, and continuity. While Michalek (2001) noted that the topological rules refer to the logical relations between the components of the scheme and defined them as a set of relationships between rooms of the building that include connectivity which indicate that the rooms are connected directly or through an open path, in addition to the properties of openness, proximity, directionality (Michalek, 2001). On this basis, shape grammars are classified, according to their design properties, into two types:

- **First: Standard Shape Grammars:**

In this type, the rule is made up of a pair of shapes separated by an arrow. The left side of the rule represents part of the form to which the rule will apply, while the right side represents the resulting shape after the rule is being applied. The spatial relations in this type of rules are characterized by being fixed and specific (Stiny, 1985, p.8). Figure 1 shows the standard shape grammars, which illustrates the three rules method of deriving the design. The first rule is to determine the square as relative to the spatial label which represents the initial shape, the second rule is applied repeatedly to insert squares within squares according to the fixed spatial relationship, while the third rule is applied once to erase the symbol of the labeled shape to terminate the design. Thus, the standard shape grammars deal with the topological relations that determine the design properties of the shape and the spatial relations between the parts that form the design, regardless of the size of those parts. They are concerned with the early stages of the design process that give a clear picture of the general pattern of designs.



- **Second: Parametric Shape Grammars**

The parametric shape grammars extend the form of standard shape grammars by allowing shapes with the same topological characteristics to vary and be different in dimensions (Chen, 2005, p.65). The formal rules are replaced by a graphic scheme that allows recognize geometrically different shapes and extend secondary shape groups for rules to be applied on (Chen, 2005, p.35). The rules of this type are implicitly determined by a graph that allows for varying the lengths of lines and angles between lines in shapes. The values of parameters in this scheme are set to produce specific rules. These rules allow spatial relationships to be varied in relation to the variance of values (Stiny, 1985, p.8). Parametric shape grammars were used by researchers for their flexibility for shape recognition and potentiality to include many design variables in comparison with the standard shape grammars (Chen, 2005, p.78). On the other hand, spatial and position markers are used in both types of standard and parametric design derivation methods. In the standard rules, numbers are added to the shape as position markers while symbols are added as spatial markers. In both cases the rule is applied when both types of marks are present. The final design rule is the elimination of spatial and position markers. In parametric shape grammars, the use of spatial and position markers is more broadly to allow the rules be applied within the parametric limits of shapes. (Orsborn & Others, 2006, pp. 2017-2018)

5. Research Methodology & Procedures

The current research adopts standard shape grammars as it intends to focus on the first stage of the generation of Al-Chaderchi architectural facades. Accordingly, it will deal with the topological aspects and formal relations between the parts that give a clear picture of the relationships between the elements of the facades, regardless of the size and dimensions of the component parts. For the purpose of achieving the research objective, an analytical methodology will be adopted according to the following procedures:

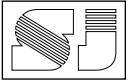
- Define the design language that characterizes Al-Chaderchi facade architecture.
- Analysis of a sample of facades chosen according to the general features of the basic vocabulary, and then the analysis of those facades (topologically) to define the relationships between the elements of its basic vocabulary.
- Extract and synthesize the shape rules used in the generation process.
- Application of the extracted shape rules on selected facades of Al-Chaderchi, then on new facades which supposedly belong to his style and design language.
- Results of the topological analysis, the extraction and synthesis of the shape rules and their application are to be discussed and the related conclusions to be attained and introduced.

5.1. Design Language of Al-Chaderchi Facades

To define the design language of Al-Chaderchi facades, it is important to adopt a classification of his works that fits the nature of the analysis required for the methodology of shape grammars. Many scholars have dealt with Al-Chaderchi work and its development across time. Al-Zobaie (2002) represented one of the almost clear studies on the developments in Al-Chaderchi architectural practice. Through a detailed review of his practices in architecture, based on the theoretical principles and the characteristics of the final output, Al-Chaderchi artifacts can be classified into three stages:

- 1- The phase of the international style that is sympathetic to the environment.
- 2- The phase of fusion with heritage in a contemporary abstract manner.
- 3- The phase of fusion with heritage in a contemporary rational manner.

The first phase was marked by the influence of the modern movement on Iraqi architecture, especially in the fifties and early sixties, during which Iraq witnessed great political and economic developments. It was noted through his designs at that stage that he paid special attention to the study of how to combine contemporary visions in modern architecture and inherited local

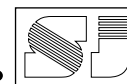


traditions. He discovered those important means of controlling the environment through insulation, ventilation and cold buildings that developed much of the possibility of adapting the harsh climate in the Middle East (Emmanuel & Others, 1981, p.158). Al-Chaderchi stated that in the era of 1952-1963, his first concern was to reach architectural solutions compatible with the existing social environment and with the development of the West and modernity, thus a distinct theory was not urgent at the time (Al-Chaderchi, 1991, p.15). The second phase, which was in the early seventies, was characterized by the technical treatment of the buildings designed by Al-Chaderchi in a clear attempt to experiment with the various new variations that occur in the development of international architectural thought and try to interpret them within the circumstances of the country and the nature of its determinants. For this reason those designs were imbued with the elegance of the architectural language and modernity in spite of the changes in the very structure of the architectural formations and their adaptation according to the requirements of the architectural meaning and function. (Al-Sultani, 2000, p.442). Al-Chaderchi pointed out that at that stage his interest was more in the desire to further develop the abstraction of the traditional local and national forms and their aesthetic values independently of the construction concept of the building (Emmanuel & Others, 1981, p.157). For him, abstraction was the interaction that took place through the subjectivity of the self-being. Since the external world as a whole is not self-reliant, then the sense and perception of things is not repeated in a completely identical manner and the resulting accumulative vision and the subsequent cognitions are, although similar but not identical completely. Those balances were settled with each other independently and the processes of self-settlement are intensified, transitioned and transformed from the primitive to the complex aggravations. Thus, the thing is realized as being separated from its own origin and the cognition of the thing becomes general. The awareness of the abstract is the transition from the specific to the general cognition of the individual and society (Al-Chaderchi, 1991, p.85). In his writings, Al-Chaderchi referred to the relationship between the arch and the wall, he pointed out that in the Iraqi

traditional architecture there are two associated arches, the pointed and the semi-circular, and the question of the adaptation and melting of this element to be in line with modern architecture of a sculptural nature is of a very complex task. At first he chose to start with the semi-circular arch as it doesn't generate vertical tension in the overall composition as compared to the pointed arch. It became clear to him after much analysis that the traditional Baghdadi architecture is essentially architecture of walls, meaning that when the arches are in sequence, they do not generate from the remaining dividing part between them, a column, or this is how it seems to us. Rather this separating part seems as if it completes the wall within which the arches occur. The arch is a hole in the wall or a series of holes, not the arches on the pillars, as in the Roman, Andalusian and Renaissance architecture. So the arch in the Baghdadi architecture is specific and the pillar is not the main element, but it is the wall that is the basic component of the composition (Al-Chaderchi, 1991, p.187). A collection of Al-Chaderchi artifacts produced in the second and third stages, according to (Al-Zobaie, 2002) classification have been selected as a sample for the purpose of concluding the shape rules used for the generation of the facades. Table (1)

5.2. Analysis of the Selected Facades

The selected facades are analyzed according to the general features and elements of their basic vocabulary, and then the topological analysis is carried on to find the relations between the elements of the basic vocabulary. Al-Chaderchi was inspired in his compositions by the traditional Baghdadi architecture. The walls containing the openings of the arches were emphasized as being holes in a wall, making each wall of the external form independent or seemed as such (Al-Chaderchi, 1991, p.187). In the second phase of his work, specifically in the building of the (Iraqi Aviation Association Building), we observe a group of similar openings in shape and dimensions generating a sequential rhythm in both horizontal and vertical directions, thus the center of the composition became an accessible axis. The envelope wall shows us some of the activities of the body through the central and side openings. The curved wall begins to rise until the



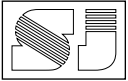
body completely disappears, but when it begins to decline in both sides, the body begins to come out gradually until it appears in full height, when the shell has completely subsided (Al-Chaderchi, 1991, p.80). In the (Union of Industries Building) in Baghdad and the (Insurance Building) in Mosul, Al-Chaderchi has generated effective spaces and envelop walls. The curved wall was divided into two parts in the two buildings. On this wall the holes were erupted in arbitrary relations and arched concrete balconies were sprung through the wall openings showing the compositional reactions hidden behind the wall. All these elements interact and balance with the second wall to generate a balanced symmetry. (Al-Chaderchi, 1991, p.112). The location of the (Insurance Building) in Mosul is very similar to the location of the (Union of Industries Building) in terms of the site shape on the one hand, in addition to that they were located in the heart of the city center where the the main axes of the movement intersected, so the formative treatments were very similar in the two buildings. The architecture of the traditional city of Mosul, its composition and methods of use of the stone material contributed to the completion of the final picture of the building. The project included an arcade formed by the envelope wall at the level of the ground floor, which would provide a suitable shopping environment for shops that behind it. The wall has been divided into two parts, making it reveal the middle of the enfolded mass (Al-Chaderchi, 1991, p.112). The works of the third phase appeared to be more calm and less expressive and remarkable, thus the sculptural trait was dimmed in favor of the modern (Monderianism) on the one side and the functional utilitarian plan. It was in (Dar Al-Hamad) in Kuwait, where the process of abstraction moved from the stage of spatial configurations to the two dimensional plane compositions. Here it has become possible for the viewer to deal with a panel of proportional shapes without the need to use the third dimension or perspective. They were the compositions which recalled the paintings by pioneer artists in their perceptions of the complex and Islamic city with simplified and abstract paintings, and at the same time, leaving the viewer enjoys his own interpretations that added a lot of subjectivity, the process that is entirely formulate the correct process of the subject

perception. (Al-Zobaie, 2002). The design of the (Rafidain Bank in Salheya) was one of the earliest attempts to use the recessed panels and retreated walls. Each retreated wall acquires specific weight and role in the composition, which gave it the characteristic of Mondrian effect. The composition was based on the division of the facades to vertical cells correspond to the structural concrete skeleton. This structure was covered by a brick layer to transform the composition into relations between the solid and void areas, that is, transforming the composition into panels and then filling it with interlocking elements. This composition was only an abstract translation of what was present in the traditional architecture of the panels and the retreated walls through which the relations between the cells were organized. The composition itself was a structure of columns and horizontal lintels (Al-Chaderchi, 1991, p. 124). In the Central Post Office (Communications Building) in Baghdad, a structural skeleton had to be created to accommodate the various functions, filled with spaces which were organized in such spatial structure according to the nature of those functions. Therefore, the commitment to clear construction, as similar to design situations in functional buildings, was often taken for granted within the framework of the concepts of contemporary architecture. However, Al-Chaderchi rejected this obligation, because he refused to adhere to the construction constraints at all. The principle was that it was not necessarily that the provisions of purely objective nature coincide with the judgments of aesthetics, because the provisions of objective nature are natural phenomena, while the aesthetics is the human perception of these phenomena and its provisions. (Al-Chaderchi, 1991, p. 500). As a conclusion from the critical analysis of what have been presented in the previous review, the main elements of Al-Chaderchi facades selected as cases for study can be extracted as in the following table (Table 2):

5.3. The Stage of Synthesis

5.3.1. Strategies of Shape Rules Derivation

After defining the geometric characteristics and the determination of the spatial relations between the main elements, the research moves to the synthesis stage in which the shape rules of Al-



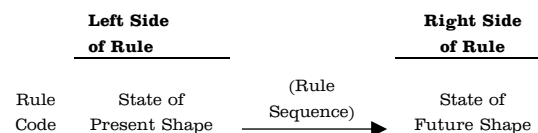
Chaderchi facades to be derived and extracted. Shape grammars studies have presented different strategies used as a result of the diversity of case studies (Stiny & Mitchell, 1978), (Stiny, 1977) and (Flemming, 1987). Given the flexibility of the shape rules as to adopt more than one type to generate designs, the following strategies are used:

1. Top-Down Strategy: This (strategy) is used to describe the general configuration of the shape rules. It starts with the outer boundaries of the shape of the facades up to the details of the openings and windows, thus the transition from the outside to the inside.
2. Division Strategy: After defining the outer boundaries, the general shape of the facade is divided into horizontal areas to determine the number of floors contained therein, in addition to dividing it vertically, thus dividing the facade into a number of secondary blocks to be processed to the subsequent strategy.
3. Subtraction/ Cut off Strategy: Dividing the facade to horizontal and vertical grid, blocks are identified in which the architectural elements are subtracted in various forms according to the characteristics of Al-Chaderchi style.
4. Addition Strategy: Generating the façade outer boundaries, determining the number of horizontal and vertical secondary divisions (blocks) and subtracting some of the parts of those blocks, the procedure moves to use the addition strategy to add elements that define or recognize the block or determine the item being cut off. This strategy is repeated on the secondary divisions generated until the comprehensive configuration is formulated.

As for Al-Chaderchi facades selected for the derivation of their shape rules, and according to the design properties and spatial relations that characterized those facades as a whole or at the level of the subtracted and added parts in the façade, the generation process may be divided into three principal stages. These stages give the comprehensive image that enables the distinction of one façade from the other. Some of these stages include secondary steps. The stages are classified according to the block or the design element offered or added. These stages are as in table (3)

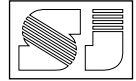
Before starting to define the content of the shape rules, it is necessary to clarify some notes related to the procedural aspects of the shape rules derivation:

- The initial shape consists of a (State Label) indicating the stage symbol (S1) with the vertical and horizontal coordinates. Figure (1):
- According to the literature of shape grammars, the shape generating rules range from the mandatory rules to be enforced and the optional rules the selection of which depends on the type of facade to be generated. Also, the (State Labels) play an important role in controlling the sequence of rules, as they control the transition between the stages and steps within, and work in conjunction with (Spatial labels) or (Markers) to determine the position in which the rule to be applied according to Euclidean transformations and effective parameters. The (State Labels) are encoded as letters and numbers indicating the stage of generation, the step and the shape status within that stage or step, as follows: (Sn) whereas (S: refers to the stage) and (n: consists of numbers and letters, the numbers the first part of them refers to the stage and be from (1-3), while the second part is represented by letters and numbers indicating the step inside the stage (A1, B, C1, ...). Every stage own spatial labels are shown in Table (4), as well as the use of letters that refer to symbols for the elements in the facade.
- Each shape rule is derived according to the mechanism as follows:



5.3.2. Generation Stages, Steps & Shape Rules

The geometrical analysis and the definition of the spatial relations that comprise the facades have led to the crystallization and synthesis of the shape rules for the generation of Al-Chaderchi facades. It is found that these shape rules are (10)



rules, including the termination one, and that those assigned to specific stages as follows: Figure (2)

Stage (1) DF: Define the Front Envelope

This Stage consists of four rules in which the outer boundaries of the facade are determined and divided into a matrix by adding a grid where the facade is cut into a set of horizontal and vertical parts. The rules of this stage are as follows:

- 1- The First Rule (DF1Rec), which is concerned with generating the outer boundaries of the facade by adding a regular quadratic shape, in which the facade width is greater or equal to its length ($W \geq L$).
- 2- The Second Rule (DF2DI), which is meant to divide the facade into a matrix of cells or parts. Due to the possibilities of irregular shapes of the facades on the side or upper boundaries of the selected models, it is sometimes possible to modify one or more of the outer boundaries to transform the regular facade regular to irregular by placing a (Marker) on the shape generated by the first rule to allow this transformation to be carried out in accordance with the specified criteria and ratios.
- 3- The third rule (DF3AD) is concerned with the generation of protruding walls in front of the facade.

To complete Stage (1), some transformations are carried out on the boundaries of the protruding walls to shape the final forms, including the lines and divisions of the façade before the addition of the architectural elements.

- 4- The fourth rule (DF4SL) is concerned with the transition to the second stage in which the (State Label) is converted to the label of the second stage and to start applying to the rules of the second stage.

Stage (2) MF: Manipulation of the Front Envelope

This stage is the most important as it gives a clear idea of the shape of the facade generated. Within this stage, the architectural elements may be added to or subtracted from the façade; the perpendicular protruding walls may be defined

horizontally or vertically. This stage consists of three steps with their corresponding formal rules:

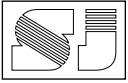
- 1- The fifth rule (MF1RE) corresponds to the first step of stage (2) to subtract or cut off design elements from the façade that represent windows openings and balconies or cut off parts of the protruding walls that cover parts of the facade.
- 2- The sixth rule (MF2AE), corresponds to the second step in stage (2), it is concerned with the addition of architectural elements; it is the sixth rule while the third step is the seventh rule (MF3AJ), which means to.
- 3- The seventh rule (MF3AJ), corresponds to the third step that is concerned with identification the perpendicular protruding walls on the façade in the horizontal and vertical directions
- 4- The eighth rule (MF4SL) is concerned with the transition to the third stage, in which the (State Labels) of the second stage are changed to the (State Label) marking the beginning of the third stage.

Stage (3) TE: Termination

Before this stage, the facades layouts and their design elements have been generated and reached the finishing stage where the spatial and state label, symbols and unwanted lines are removed. This stage consists of three rules, the first of which is the ninth rule in the general sequence of rules. This rule coded (TE1DE) is concerned with removing the lines that represent horizontal and vertical planes of the structural system when they are visible. The tenth rule coded (TE2DE) is concerned with eliminating the symbols of the facade parts, whereas the tenth rule (TE3DE) is concerned with removing the (State Label) and presenting the facade in its final shape.

6. Discussion of Results

The following paragraphs include a discussion of the results of the practical procedures in which the shape rules of Al-Chaderchi facades were derived, synthesized and then applied to generate those facades. :



6.1. Results Related to the Analysis of the Selected Facades

The results which come out from the geometrical and topological analysis of the selected facades can be discussed as follows:

- In general, although some of the results of the facades configurations are known in advance, the analytical approach adopted by the research has added more objectivity to the already existed knowledge. In addition, these results and the adopted methodology are necessary for the transition to the level of investing the existing texts for discovering the details of the process of the façade generation.
- The geometrical and the topological analysis of the façades show that most of them are regular shapes and a few are irregular shapes. The irregularity results from the addition of the irregular protruding walls to the regular shape, thus, the irregular facades hide behind their regular geometric shapes.
- Whereas Al-Chaderchi facades were characterized by regularity and clarity, the distribution of their elements composing them appeared coincident or arbitrary. It seems that such distribution has been intended to create a modern piece of architectural painting using traditional elements.
- Al-Chaderchi facades are characterized as integrated units. This is due to the use of the semicircular or semicircular arc, which is characterized by the traditional Iraqi architecture in general and the architecture of Al-Chaderchi in particular, with many variations in dimension and scale.
- Al-Chaderchi facades as classified chronologically are varied in terms of the degree of complexity that distinguishes each facade from another.

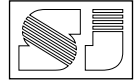
6.2. Results Related to the Generation Shape Rules of the Selected Facades

It can be seen from (Figure 2) that:

- In general, it can be seen that the total number of shape rules used in the generation of is (10) rules, and most of the facades

shared the same shape rules, but they varied in the conditions associated with each rule.

- There was little variation between AL-Chaderchi facades in the number of rules used to generate them, although there was no difference in the number of rules used according to the stages. The generation rules of (abstract fusion with heritage stage) was (10) rules and others (9) rules. This difference is due to the non-implementation of the protruding walls addition rules to some façades.
- For the first stage of the generation process, which is related to determining the outer boundaries of the facade, as well as the general appearance of the facade when adding the protruding walls (if any), and as this stage gives the overall picture of the facade shape and the features that distinguish it, the rule for generating the outer shape of the facade boundary was executed on all types of facades that are generated from a one initial shape. The rule for the generation of the added prominent walls was connected to four facades of a total of six selected facades.
- As for the second stage of the generation process, Al-Chaderchi facades differed at this stage between having simple architectural elements or other elements to be added to achieve complexity. The facades did not differ in the number of rules used to add architectural elements, but differed in the number of times the implementation of that rule to produce a complex façade. Five of the selected facades were distinguished by a relatively complex character compared to the other facades in which the addition rule was implemented to a lesser degree.
- As for the addition of vertically protruding walls, the façades were not very different either. The implementation of their corresponding rule was based on the implementation of the addition of horizontal protruding walls from the first stage. Four of the selected facades were characterized by the presence of protruding walls in the horizontal and vertical directions, while the vertical walls were not added to one of the facades. One facade was missing the protruding walls in both directions. Moreover, the density and

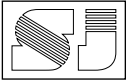


repetition of the protruding walls gave certain facades the complexity that distinguishes it from others. The stage of (Abstract Fusion with Heritage) has been distinguished as more complex than the stage of (Rational Fusion with Heritage) for the large implementation of the addition rule of protruding walls in both directions in all selected facades of the first stage as compared with the two facades of the second stage of which were characterized by relatively simple for the little or lack of implementation of the rule of the protruding walls on them.

7. Conclusions

The current research addressed the exploration of the design approach that Al-Chaderchi used to construct the facades of his buildings, and thus attempts to reach the deep structure of these facades, beyond their description formally and on the superficial surface. Discussing the results of the application of the derived rules on Al-Chaderchi facades, it is possible to draw the following final conclusions:

- As an answer to its basic question, the current research provides a reasonable support to the argument that despite the variance of the facades of Al-Chaderchi architecture according to their locations, design periods and stages, their different architectural characteristics in terms of their design elements and spatial relations between these elements, they are, in fact, products of the application of different shape rules with certain labels on one initial shape so that these facades can be considered as different situations or cases created by a systemized generation process.
- Whether or not Al-Chaderchi facades included protruding walls, they had the same formal characteristics that reflect a one design language with certain shape rules the content of which was defined by the current research.
- Practically, the features of Al-Chaderchi facades were of great diversity and undergone repeated dimensional transformations which were applied on few architectural elements. They were, in fact, the result of a generation process in which a limited number of shape rules are used and applied.
- It has been concluded that the complexity of Al-Chaderchi facades was not significantly correlated to the number of rules used to generate them. The variance can be traced back to the type of rule and the number of times it was used repeated, as well as the active conditions for the generation of uncomplicated facades compared to the complex facades that are characterized by the diversity and multiplicity of protruding walls and the architectural elements added.
- The absence of a clear discrepancy between the selected facades in the number of shape rules produced them implies that they belong to one category in terms of the shape grammars. This, actually, contradicts the previous studies regarding the existence of two different stages in the development of the design language of Al-Chaderchi. This statement calls for modification of the prevailing knowledge presented in the previous studies on the one hand, and, on the other hand, to verify and support the findings of the current research in future studies.
- It is possible to conclude, contrary to what has been suggested in previous studies, that what appeared to be an arbitrary or coincidental process that has led the spatial arrangement of the elements of Al-Chaderchi facades concealed, actually, a process of generation in which a number of uniform shape rules were applied with specific constraints. This process of shape generating worked at the deep level of the design thinking of Al-Chaderchi. This may explain that previous studies did not deal with this issue except at the level of the visible formality. In addition to the fact that Al-Chaderchi himself pointed out to the dealing with this issue intuitively, relying on his high levels of formal synthesis skills.
- The research showed out the practical ability and potentiality of the system of shape rules which it has adopted. This ability has been illustrated in the decomposition and generating the original Al-Chaderchi facades as a result of the application of these shape rules first, and in the possibility of

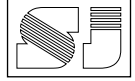


generating at least one new proposed facade that does not exist in reality and which, supposedly, belonged to Al-Chaderchi language of design.

- The research highlighted the possibility of approaching shape grammars to reveal the details of the design process that Al-Chaderchi was practicing, a process that has been studied until now, even in terms of form, at the surface level. On the other hand, the educational opportunities inherent in the approach of shape grammars may be enhanced by the possibility of generating new facades with a lot of novelty and creativity, away from the literal reproduction or copying of the previous facades as long as the basic underlying shape rules have been discovered and this is what the current research has tried to do.

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توليد واجهات رفعت الجادرجي باستخدام قواعد الشكل القياسية

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المستخلص

تتسم نتائج الجادرجي بخصوصية واضحة، إذ يمكن تمييز واجهاتها بسهولة، فهي تتشكل فنياً من مجموعة غنية من العناصر والأشكال المعمارية التقليدية. لقد كان الجادرجي من أوائل المعامير العراقيين الذين جربوا التوجه الإقليمي الناقد، إذ ظهر في أعماله التفاعل بين التقاليد المحلية العراقية والتأثيرات الغربية. من ناحية أخرى، فإن لقواعد الشكل أهمية كبيرة في مجال العمارة لأنها توفر طريقة مثمرة لدراسة وتحليل الأنماط الشكلية للنتائج المختلفة المنتمية لأساليب معمارية أو لمعماريين محددين. يركز البحث الحالي على دراسة قواعد الشكل لواجهات عمارة الجادرجي، ويهدف إلى تحديد الأحكام الشكلية للقواعد التي أنتجت شكل تلك الواجهات. تتمثل قيمة هذا البحث في أهمية استنتاج الأحكام الشكلية لقواعد الشكل التي تقوم عليها تصاميم واجهات الجادرجي وإمكانية إعادة تطبيقها لتوليد تلك الواجهات والتوصل إلى الخصائص التركيبية والعلاقات الشكلية التي تميز واجهات محددة عن غيرها. وقد تبني البحث استراتيجية القواعد الشكلية القياسية المعنوية بالعلاقات التركيبية والشكلية لتكوين الواجهات واختلافاتها بغض النظر عن المعايير المختلفة والأبعاد المرتبطة بكل واجهة. تم تحقيق هدف البحث من خلال استنتاج الأحكام الشكلية المكونة لواجهات الجادرجي وتطبيقها لاشتقاق واجهات الجادرجي أولاً وتوليد واجهات جديدة ثانياً تحمل الخصائص الشكلية والتركيبية نفسها لاختبار إمكانية تطبيق الأحكام المستنتجة.

الكلمات المفتاحية: رفعت الجادرجي، الواجهات المزدوجة، قواعد الشكل القياسية، الأحكام الشكلية، العمارة العراقية التقليدية، التوجه الإقليمي الناقد.

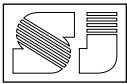
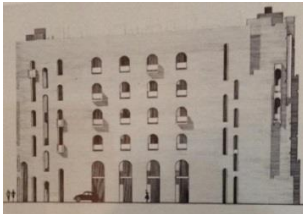
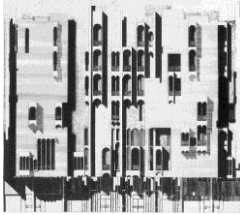
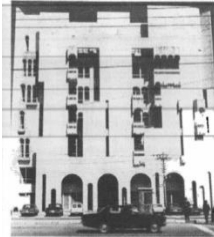
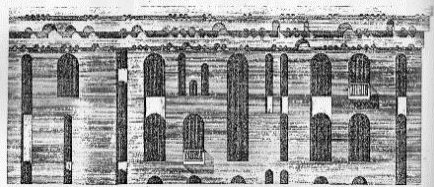
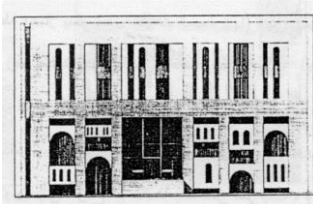



Table 1 : The Facades Selected for Analysis (Non-Corresponding Scales)

Stage	Selected Facades for Analysis	Code
International Style sympathetic with the environment	Excluded	
Abstract Fusion with Heritage	Iraqi Aviation Association Building, Baghdad, 1966 (Designed Project)	B1
		
	The Union of Industries Building, Baghdad, 1966	B2
		
The Insurance Building, Mosul, 1966	B3	
		
Realistic Fusion with Heritage	House of Al-Hamad, Kuwait, 1986	B4
		
	The Rafidain Bank, Baghdad, 1985	B5
		
The Central Communications Building, Baghdad, 1971	B6	
		

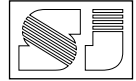


Table 2: The Main Vocabulary of the Selected Facades








The Architectural Artifact	Protruding Walls		Arches Semi-Circular			
	Vert.	Hori.				
Iraqi Aviation Association		√		√		
Union of Industries	√	√	√	√	√	
Insurance Building	√	√	√	√		
Al-Hamad House				√		√
Rafidain Bank in Salihya				√		
Communications Building	√	√		√		

Table 3: Generation Stages of Al-Chaderchi Facades

Stage	The Stage Title	Steps	Code
1	Define the External Envelope	A Generate the outer boundaries and their levels E	BE
		B Determination of joints and facade parts P	
		A Subtract Architectural elements R	
2	Manipulation of the External Envelope	B Add architectural elements E	AE
		C Select prominent walls on the front vertically and horizontally	AJ
		3 Termination	TE

Table 4: Spatial Labels Used in the Generation Process

Function of Formal & Functional Labels	Labels	General Treatment	Stage
dividing the facade into a grid adding the protruded walls		Dividing the facade into a grid of parts	First
subtracting/ adding design elements subtracting/ adding design elements		Processing of facade parts	second
adding design elements		Processing of design elements	Third
	Termination Phase		

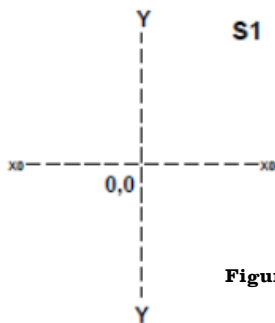


Figure 1: The Initial Shape for the Generation of Al-Chaderchi Facades.

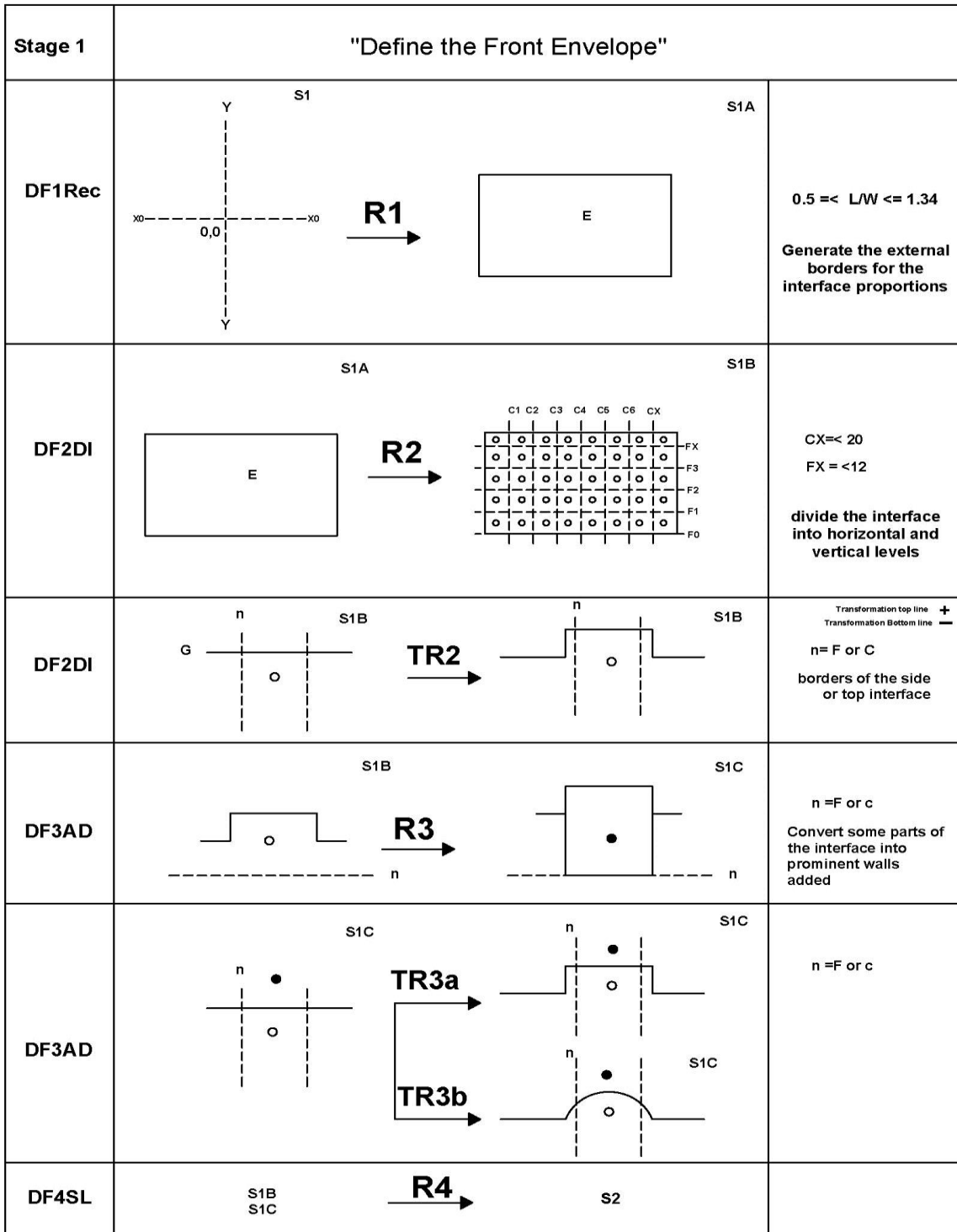
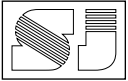


Figure 2: illustrates the outline of the shape rules and their sequence and movement within the three stages and steps within each stage.

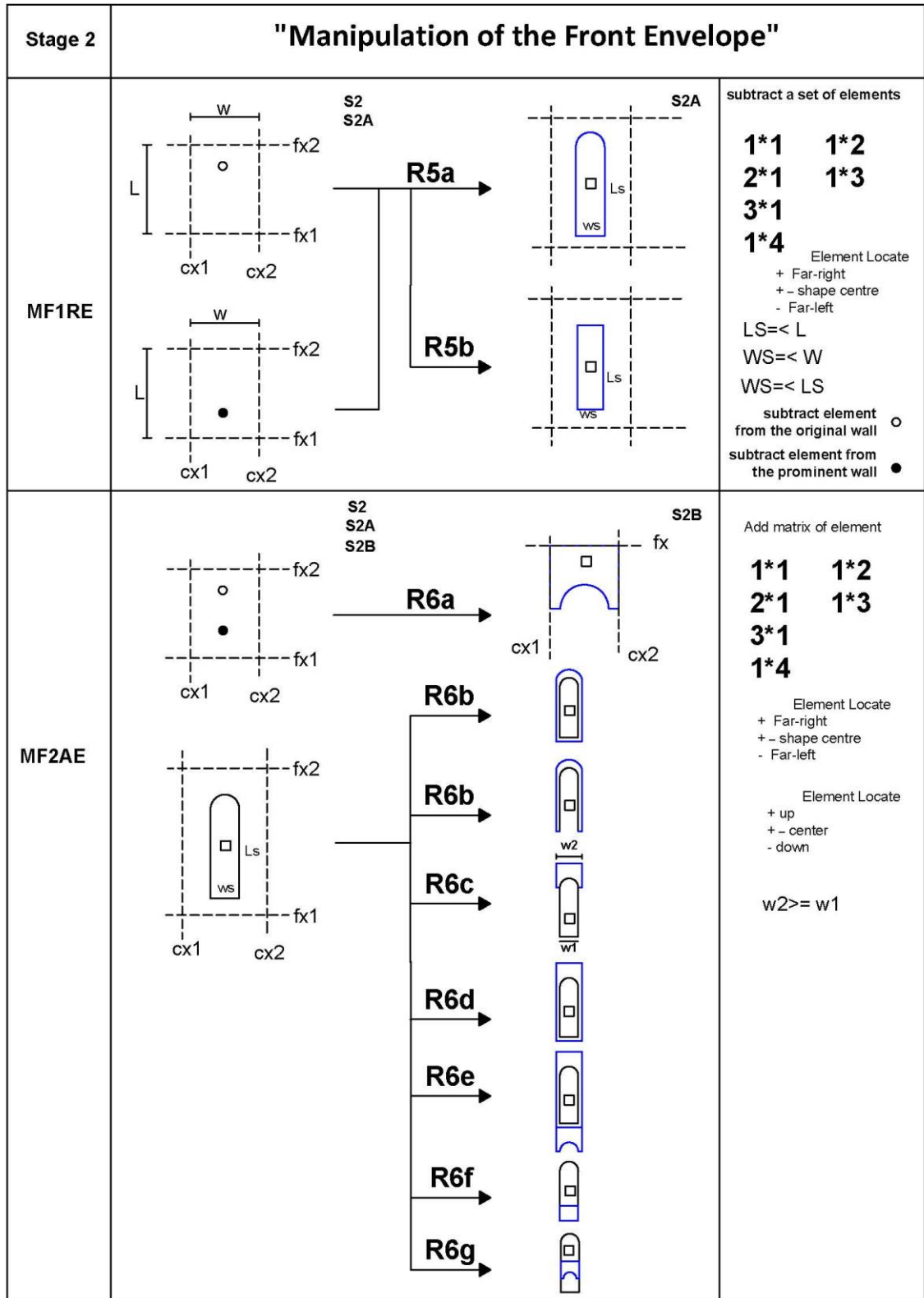
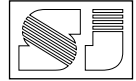
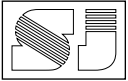


Figure (2-a)



<p>Stage 2</p>	<p align="center">"Manipulation of the Front Envelope"</p>	
<p>MF2AE</p>		<p>Add matrix of element</p> <p>1*1 1*2 2*1 1*3 3*1 1*4</p> <p>Element Locate + up + - center - down</p>
<p>MF3AJ</p>		
<p>MF4SL</p>		
<p>Stage 3</p>	<p align="center">"Termination"</p>	
<p>TE1DE</p>		
<p>TE2DE</p>		

Figure (2-b)

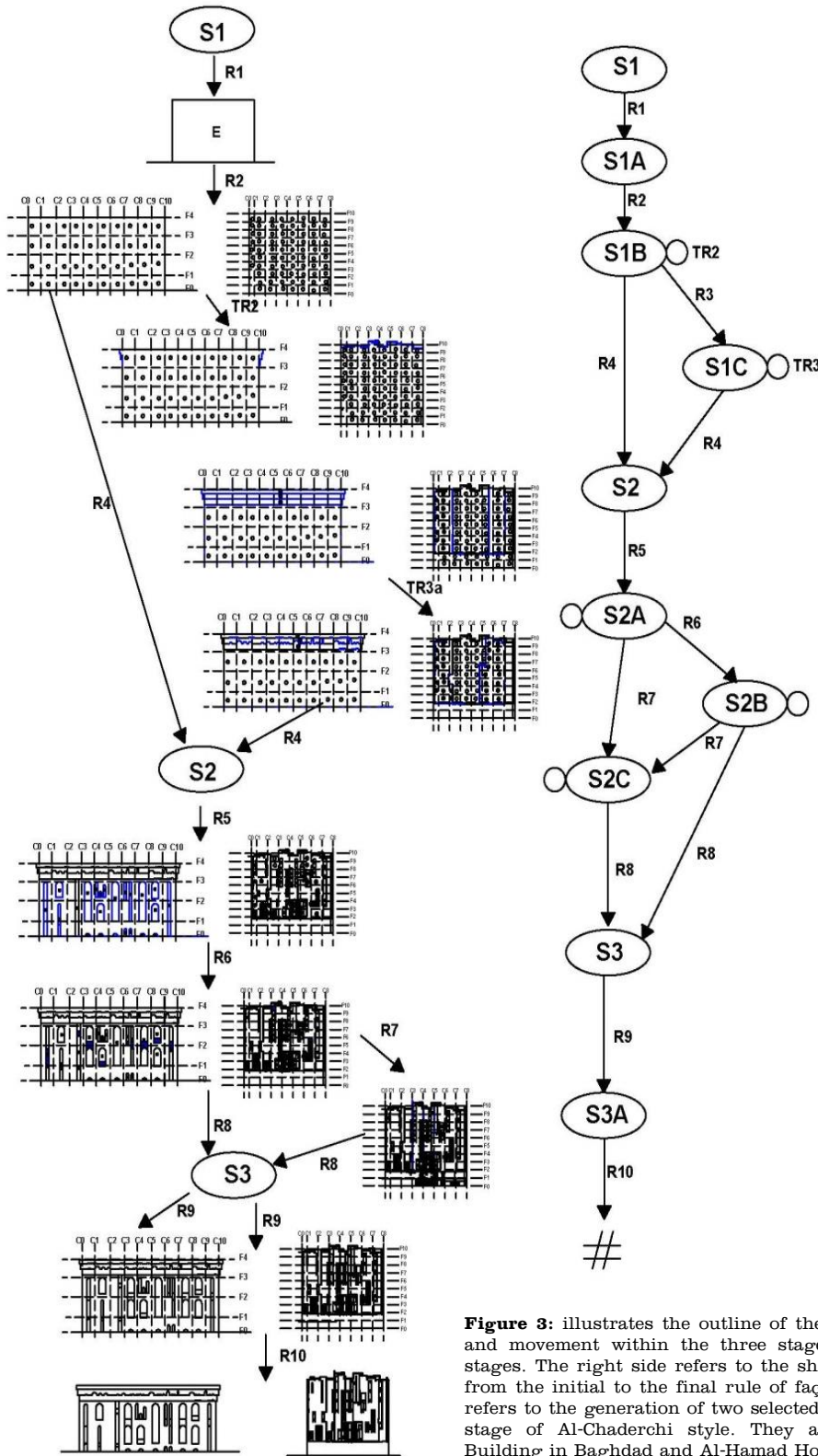
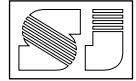


Figure 3: illustrates the outline of the shape rules, their sequence and movement within the three stages and the steps within the stages. The right side refers to the shape rules movement diagram from the initial to the final rule of façade generation. The left side refers to the generation of two selected artifacts each one from each stage of Al-Chaderchi style. They are the Union of Industries Building in Baghdad and Al-Hamad House in Kuwait.

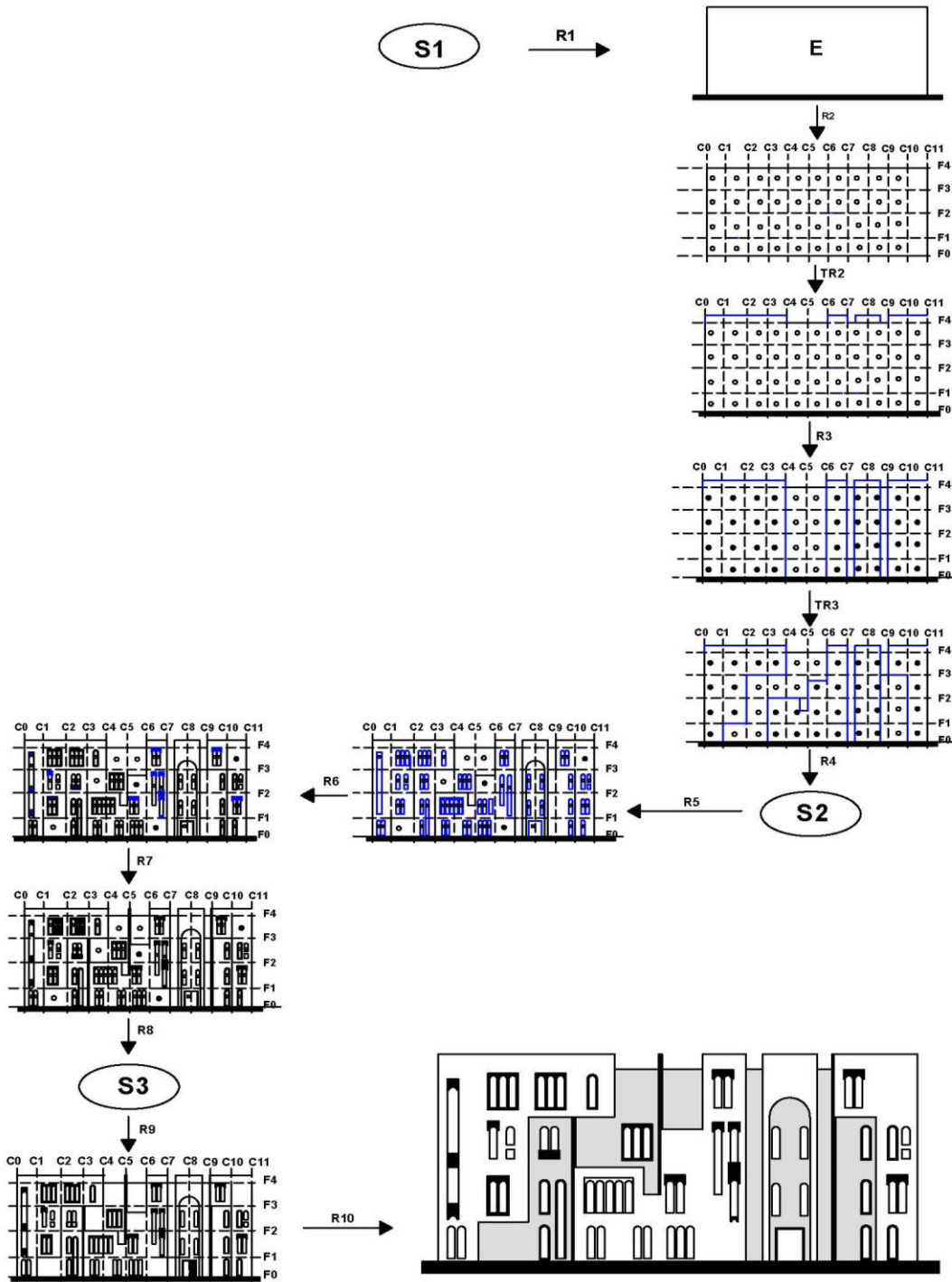
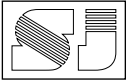


Figure 4: illustrates an application of the derived shape rules used in the generation process by Al-Chaderchi facades to generate a new suggested façade which belongs to the same formal language.