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Abstract	Keywords	Reference	Full Article
Citation	<b>Yuniarto Agus Winoko, Sandra Santosa</b> "The Improvement Of After Burning System By Utilize Zeolite Catalyst To Reduce The Engine Exhaust Emissions" published at <i>International Journal of Engineering Research and Development, Volume 12, Issue 2 (February 2016)</i>		
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Abstract	Keywords	Reference	Full Article
Citation	<b>Imtiyaz Murtaza, Omi Laila, Shah Ubaid-ullah</b> "DNA Microarray: A Miniaturized High Throughput Technology" published at <i>International Journal of Engineering Research and Development, Volume 12, Issue 2 (February 2016)</i>		
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**Sujatha Kamepalli, Raja Sekhara Rao Kurra and Sundara Krishna.Y.K**

### A Novel Method based on AND logic for Frequent, Infrequent and Non-present Item set mining in Transactional Data bases

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**Dhini Dewiyanti, Budi Faisal**

### Deciphering the Language of Space at the Salman Mosque, Bandung, Indonesia through the Multi-Sensory Approach

Abstract	Keywords	Reference	Full Article
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### Ethanol Production by Simultaneous Saccharification and Fermentation using Co-culture and Maximising Efficiency by Channelizing the By-Products and Its Subsequent Application as an Alternative Fuel.

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Citation	<b>Picasso Sengupta, Rajdeep Mukherjee, S.Theneshkumar</b> "Ethanol Production by Simultaneous Saccharification and Fermentation using Co-culture and Maximising Efficiency by Channelizing the By-Products and Its Subsequent Application as an Alternative Fuel." published at <i>International Journal of Engineering Research and Development</i> , Volume 12, Issue 02 (February 2016)		
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Abstract	Keywords	Reference	Full Article
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### Eric M. Baer and Mushtak T. Jabbar

## Evaluation of Spatial Soil Loss with the aid of Geo-information Techniques in the southern part of King County In Washington, USA

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## Deciphering the Language of Space at the Salman Mosque, Bandung, Indonesia through the Multi-Sensory Approach

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**Abstract:-** Architecture is a man-made artefact that contains rich communicative messages. As in any other languages, the architectural language contained within the communicative messages includes semantic, syntactic, and pragmatic components. The semantic one reveals signs and meanings; the syntactic one shows order and consistency; while the pragmatic one is the user's interpretation of process and details. All of these could only be understood if people occupying a space are willing to open their hearts to appreciate them. In the context of a place of worship, understanding the language of space can help users develop their heart's readiness to conduct religious activities as soon as they enter the building grounds. This research aims to decipher the language of space at the Salman Mosque based on the user's spatial experience. The Salman Mosque was chosen as the object of study because it appears in the face of modern architecture which challenges people's ideas about how mosque architecture can be designed. Since the architecture does not fit the traditional expectations, the Salman Mosque is accused of having lost many its essential values. The qualitative research method was used in this study. It included asking users to appreciate the mosque using all of their senses (the multi-sensory approach), converting their experience into a structured text and analyzing it. The results showed that even with its modern appearance, the Salman Mosque's communicative messages can be interpreted by users.

**Keywords:-** *language of space; multi-sensory approach; modern architecture.*

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### I. INTRODUCTION

Architecture accommodates human activities, is functional, and has certain values, such as beauty that can touch human emotions. The building, as a form of architecture, is not like any other work of art that can only be enjoyed visually. Although our eyes are very important and function as the dominant factor in understanding an architectural piece, depending on sight alone can lead to some weaknesses when it comes to deciphering the language of space. By only depending on the visual sense, users would not be able to express empathy, emotion towards or involvement with a particular building. In order to be able to appreciate the most essential value of an architecture piece, users must open up and let all their senses experience the spaces within [1, 2]. These senses include sight, hearing, smell, taste, and in the architectural spatial language it also involves the more multisensory elements of touch, skeleton, and muscles. Using these senses together to perceive a piece of architecture is referred to as a multi-sensory approach [3]. An architectural piece could deeply evoke the user's emotion, creating beautiful (amorous dimensions), poetic, and memorable images only when the users use all their senses [4, 5].

Modernity in architecture is viewed as a concept that narrows the sensitivity of humans when experiencing space because in the past, the visual approach (emphasizing the use of visual tools such as pictures and decoration) was used as the basis of designing an architectural piece. Thus, when modern architecture emerged with all its simplicity (minimizing the use of ornaments and preferring the formality of shape and functionality rather than just looking extravagant), it gave people the impression of being cold and stiff. In the end, a modern architectural piece is accused of putting aside users' needs for experiencing enjoyment of a temporal and spatial journey together with the building.

When designing an architectural piece, it is, of course, only proper to consider the human visual aspect. However, basing it solely on the visual sense would lessen the users' chance to appreciate the piece completely as eyes are only able to catch two dimensional impressions and exterior aspects as the only expression of the building. Thus, when a modern architecture piece is read through the "lense" of all human senses, users should be able to 'see' beyond the exteriority and receive the rich communicative messages contained within all other elements of the building.

In terms of appreciating the architecture of a place of worship, experiencing space using the multi-sensory approach is believed to be very useful for users. When those experiencing the architecture appreciate the



space using all of their senses, they are able to experience deep feelings towards the building, which will impact them through empathy and emotion. In the end, this will help their physical, mental, and spiritual preparation prior to conducting their worship.

This paper addresses the spatial experience in the Salman Mosque using a multi-sensory approach. This mosque was built with a concept that is in accord with the modern architecture era of 1960 [6, 7]. This modern concept includes formality of shape, functionality, simplicity, and honesty of the materials used. The expression of the Salman Mosque which is minimalist, with a flat concrete roof, open floor plan, and without supporting columns seems to ignore the stereotypical mosque design of that time (adorned with a dome and many ornaments). Nevertheless, this mosque has become the source of inspiration for mosque designs in the years following.

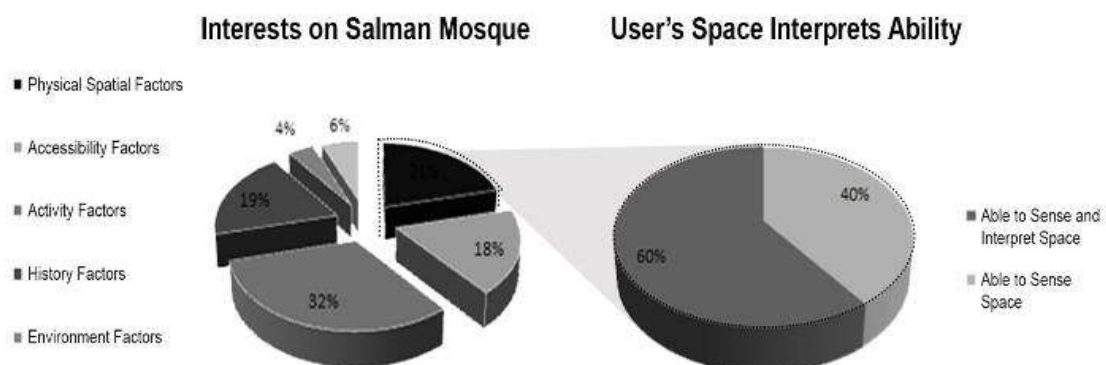
The objective of this research is to show that the space within a mosque of modern architecture could be translated into a language that contains a number of communicative texts when read using the correct tools (multi-sensory approach). The goal of this research is to enrich the architectural theory of meaning that is based not only on a visual concept but also on all other human senses. It is also hoped that this research may serve as input to mosque users about how to appreciate the mosque as an architectural piece, as well as influence mosque designers for future mosque designs.

## II. MATERIALS AND METHODS

The Salman Mosque, located in Bandung, Indonesia, has been chosen as the object of this study. This mosque is located across from the campus of Institut Teknologi Bandung (ITB/Bandung Institute of Technology). It was built in 1965-1972 and became the pioneer of a mosque design that broke the traditional Muslim view in Indonesia in regard to the physical form of a mosque building. The architect, Ahmad Noeman, believed that the simplicity of modern architecture is in line with the teachings of the Holy Qur'an, in hindsight [8, 9].

A multi-sensory approach was used as the tool to read the language of space in the Salman Mosque. This approach includes a balanced coordination of multiple human senses; using the sight, hearing, smell, taste, touch, skeleton, and muscles that function as sensors for visual, audio, tactile, proportions and space enclosure. Juhani Pallasmaa an architect who applied numerous bodily experiences as a way to comprehend architecture in greater depth, stated that architecture cannot merely be regarded as a form for aesthetic enjoyment, but also as means of experiencing space so that additional comprehension may be found in the form of human-to-architecture interaction [10, 11]. This is in line with the geographer Seamon's views, whose attention is directed at uncovering human sensitivity vis-a-vis the landscape and its element that prioritizes body-subject aspect or body movement gesture in daily routines within a space [12]. Steven Holl, who is also an architect, is a follower of bodily experience as an important part of producing meaning [13]. Moreover, the architect Kenneth Frampton thinks that the body has the ability to sense the environment so that the poetic element of an architectural construction can be approached tectonically (an element of architecture that can be dissected structurally) [14]. Unconsciously, we experience the structure of a building through our skeletal system. The focus is on the spatial reading of three parts of the mosque building: the foyer; outer and inner circulation lanes; and the main hall.

The qualitative research method has been used in this study. In order to determine how many people could decipher the spatial language of Salman Mosque (in the beginning of the study) we asked a number of users which aspect of Salman Mosque is interesting to them. 21% of the users stated that they were interested in the physical-spatial aspect of the building, while the rest were interested in other aspects [fig 1.a]. From these 21% users, 60% were able to experience the spatial aspect and convey their interpretation verbally [fig 1.b]; and so they were considered as our sample. What they experienced inside the mosque's area was then converted into a structured text and analyzed using the content analysis method.

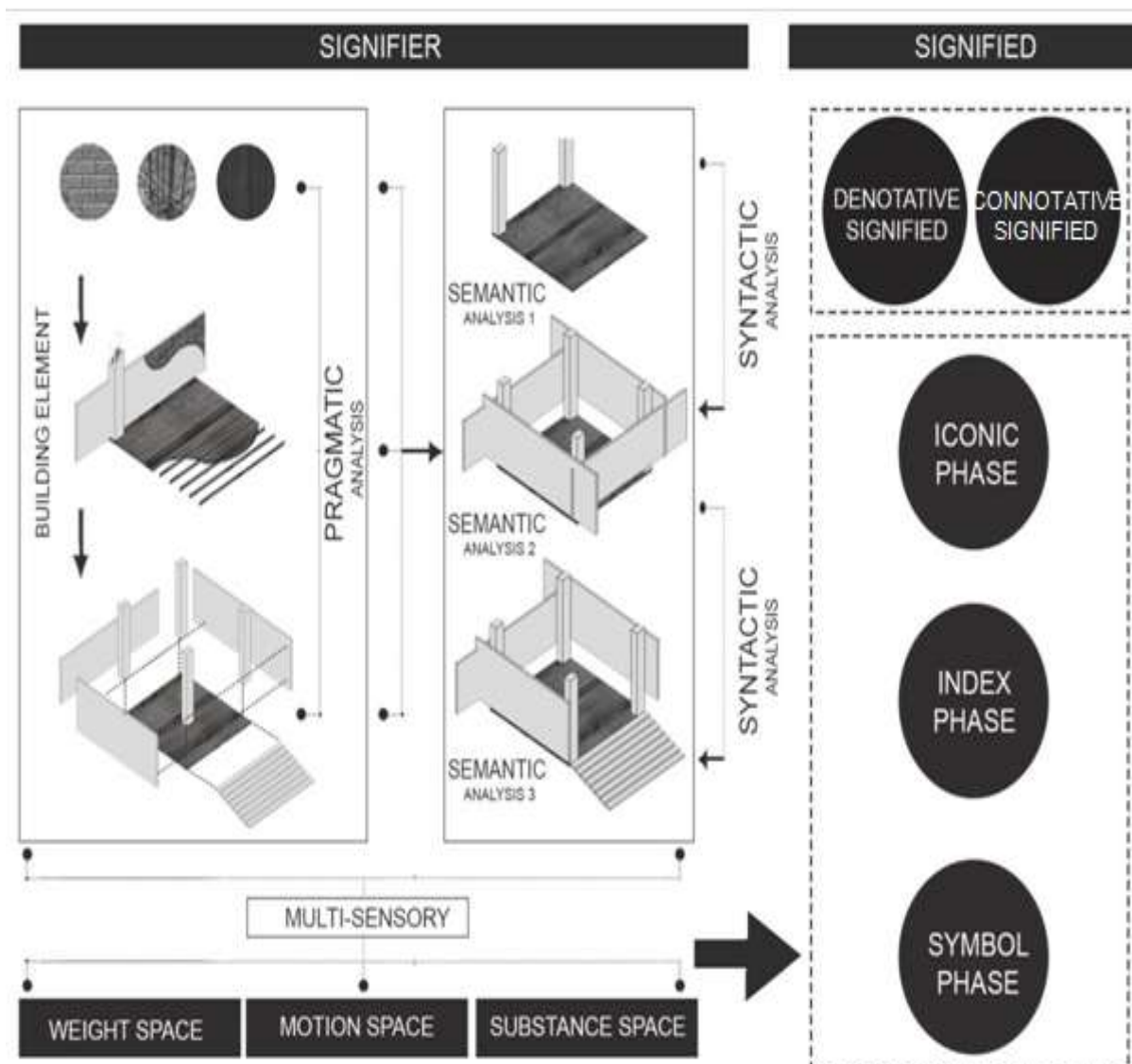


**Fig. 1:** a) Interesting factors of The Salman Mosque for users;  
b) Users' ability to understand the spatial language



The translation of the spatial language of the Salman Mosque is traced via the media of verbal language that is composed into a textual language that possesses the three elements of semantic, syntactic, and pragmatic aspects [15]. The semantics explains the signs and meaning of each building's element and the building as a whole; the syntactics covers the order and consistency between rooms; while the pragmatics refers to the interpretation of users to the detail and process of the building's elements [16]. To uncover the semantic aspect of a building, the existence of signifier and signified is needed.

The signifier is seen as an element of a building, while the signified is seen as the meaning of that element revealed through concept, functions, and/or values which can be denotative and/or connotative [17]. The signifier and signified can be read in signage as an iconic phase, indexical phase and/or symbol phase [18]. The iconic phase is a sign that bears similarity with an object. The indexical phase is a sign that shows a natural causal relationship with the signified or a sign that directly refers to reality. The symbolic phase is a sign whose existence is acknowledged based on mutual agreement. The syntactic aspect of a building consists of sequential relations and spatial relations. The sequential relation refers to the spatial order in a building while the spatial relation refers to the spatial experience with the enclosure. Last, the pragmatic aspect of a building deals with the way a message is conveyed physically based on size, material, technique, construction, accessibility, safety, ergonomics, and the eye's physical capacity. The above explanation is summarized in figure 2.



**Fig. 2:** Elaboration of the thinking process

### III. RESULTS AND DISCUSSION

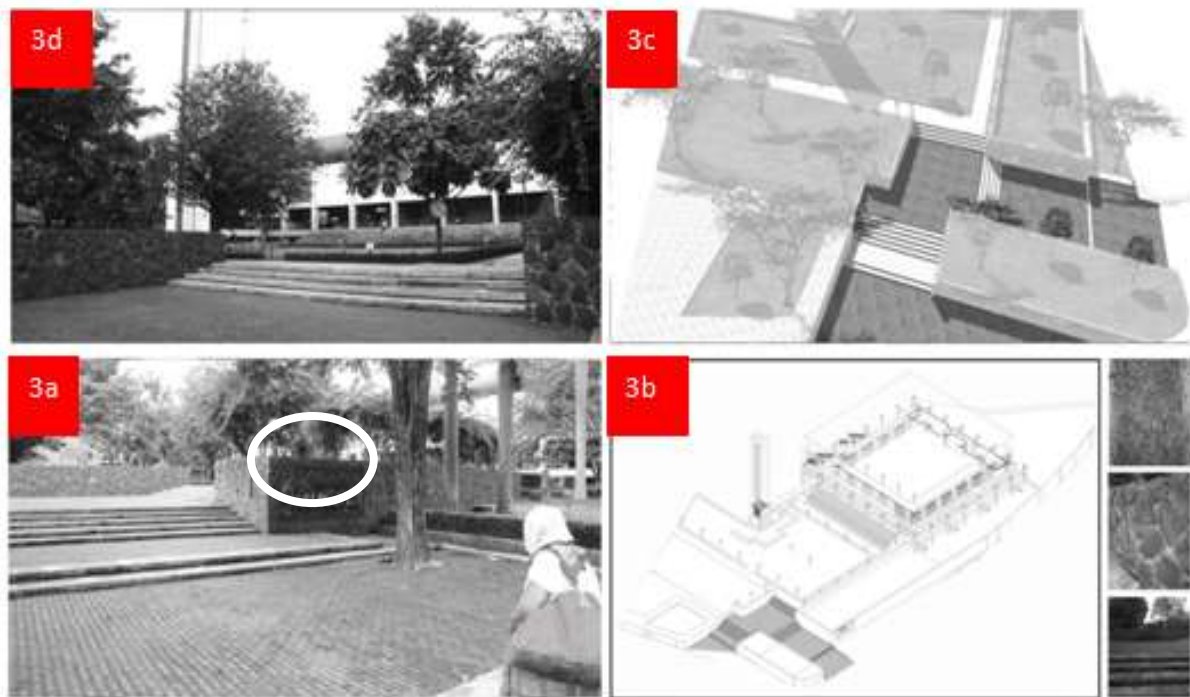
#### 3.1. Foyer of the Salman Mosque

The foyer is understood as the entrance to welcome visitors. This room also functions as a transition area from the outer part of the mosque to the area inside. Associated with the semantic aspect, the spatial elements found are as follow:

##### 3.1.a. Iconic phase: not found

3.1.b. Indexical phase: discerned from the presence of a stone wall in the front and trees in the back (fig. 3b, 3d). These elements function to border the outer part from the mosque's welcoming area. The indexical phase was also seen in moss that grows out of the grass and paving blocks that signify that users usually do not walk in that area, which contrasts with the "bare" paving block. Indexical phase was also shown by a signage from the stairs which affirms spatial hierarchy, and enclosures that direct the users' view and directional movement. In architecture we know that the movement from one room to another is a part of a hierarchical process that can be marked in various ways, for example through signs, stairs, material variations, dimensional differences, the light-dark contrast, and so on. The Salman Mosque utilizes different levels to indicate the functional change from public to semi-public. The choice of level differences is a one that helps differentiate between profane to sacred space.

3.1.c. The symbolic phase: was shown by the word "Salman" that is written on the wall facing the foyer (fig. 3a). Before the sign was placed, many users did not know that the building functions as a mosque. Mutual agreement caused the sign to function as a symbol.



**Fig. 3:** Spatial reading of the foyer. a) The "Salman Mosque" sign written on the wall in the foyer area; b) The position of main plaza in the mosque (in grey), and the material used for walls and floors (on the right side); c. the foyer viewed from above showing floor height differences; d) the foyer is facing the main hall which is positioned higher up.

The three indexes of semantic element of this space show the sign association concept carrying a denotative meaning. It is used throughout the foyer space because every sign is understood as a functional element. Meanwhile, no connotative meaning was found. From the text analysis, users read the space according to the following pattern (table 1).

**Table 1:** Themes that were perceived by users in the foyer based on their multi-sensory approach experience

EYES	EARS	SKIN	SKELETON	MUSCLES
Direction and position	Quality	Texture	Proportion	Height
Verticality	Type	Depth	Dimension	Distance
Contrast	Material used			
Detail	Detail			
Colours and light				

The pragmatic aspect of the space was read through the message found in the physical element of the room such as:

1) Substrate type: natural stone that is assembled into a plane as high as 1 meter with tall plants as a background. Some plants are shady and function as buffers while other plants are categorized as fruit plants that can be consumed. The floor element is composed of grass, paving blocks as well as a cement floor.

2) The design aspect: the concept of acceptance is shown through the space that is designed to be wide which then becomes narrower on the right side so as to give direction for circulation. Within this space, users are given the chance to decide which direction to go: go directly to the mosque's inner part or to other supporting rooms. This layout is made clearer with the presence of ascending stairs.

3) The technical aspect: Stone construction was made by assembling and stacking stones which were then cemented. The floor was paved using sand so that water can be absorbed by the soil below. Paving blocks are made of porous material that still enable water to be absorbed by the soil, while the sand beneath the paving blocks accelerates the water absorption to the soil (compared to paving blocks with cement construction).

### 3.2. Circulation lanes

From the semantic aspect, circulation lanes are understood by users to be divided into two options: to go inside the mosque or to go to supporting facilities first (figure 4a, b). The characteristics of circulation lanes also give it a very distinct appearance compared to the grassy yard. This lane leads users to stairs that consist of nine staircases directly connected to the front and side porch which provides connection to the main hall. The stair cases are translated as spatial hierarchy from the outer to the inner part of the mosque. The elements of space that were found are as follows:

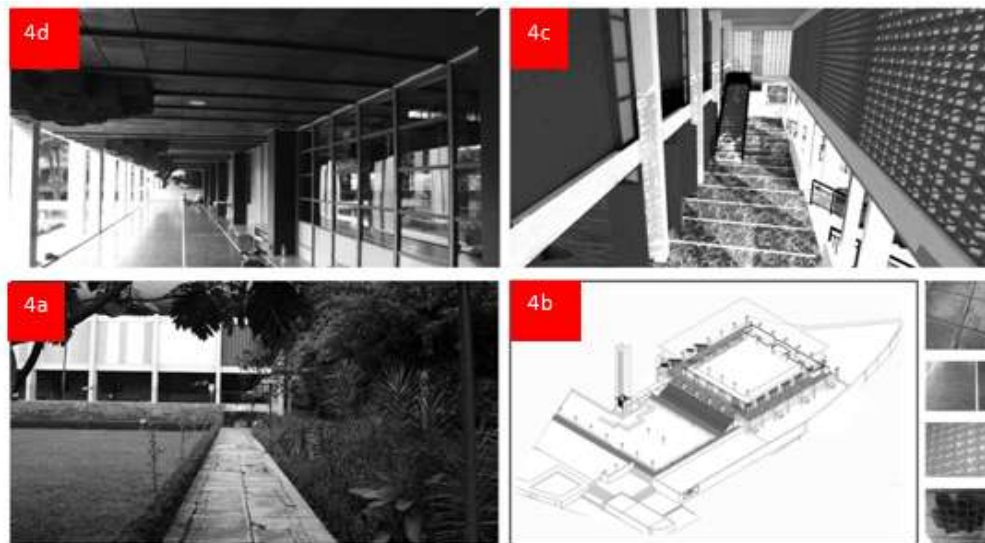
3.2.a. The iconic phase: *minaret* presented by the presence of a tower that signifies its height and verticality as a distinctive element rising from the main architecture.

3.2.b. The indexical phase: this can be seen from the presence of a "prohibited to smoke" sign and signs of plant names. The indexical phase can also be seen from the different circulation pattern activity: outdoor circulation shows active circulation where people pass by while the porch shows circulation combined with other activities. The indexical phase is also shown through a line of street lamps painted green that signifies a straight path. The pillars help to emphasize the directional character formed by the pedestrian lane.

Trees and bushes as high as 15 cm also strengthen the distinction of the circulation lane with other elements. In the inner part, the indexical phase is shown through a line of columns and roosters (fig 4c, d)

3.2.c. The symbolic phase: can also be seen from the presence of a tower because it signifies the existence of the mosque.

These results showed that from the semantic point of view, space in the circulation lane used the concept of association of signs with a denotative meaning because of its functionality. It could also be translated with connotative meaning because the verticality of the tower that stands on the ground with its end pointing to the sky could also be understood as reflecting the relationship of man in a low place and God in the most elevated one. In addition, staircases could be interpreted as the gradual steps users take to condition their hearts before entering the sacred room.



**Fig. 4:** Spatial reading of the circulation lanes. a) path/lane that directs the users towards the main hall of the mosque; b) circulation lanes in the mosque area (in grey), also show the material used: hardscapes, soft scapes, rooster and lamp position; c) the side porch viewed from above, circulation lanes bordered by rooster, glass wall, and folding doors that can open wide; d) front porch connecting directly to the front yard. This space is composed of column rows and glass plane with a wooden ceiling.

From the textual analysis, users read the space according to the following pattern (table 2).

**Table 2:** Themes perceived by users in the circulation lanes based on their multi-sensory experience

EYES	EARS	SKIN	SKELETON	MUSCLES
Flow	Quality	Texture	Proportion	Height
Verticality	Type	Depth	Dimension	Distance
Distance		Material used	Speed	Hierarchy
Detail				

The pragmatic aspect of the space is read through the message found in the physical element of the room, such as:

1) The substrate type: the floor of the outer space is made out of cement arranged in a square pattern. Some parts were found to be broken, which indicates old age. The circulation lane with this hard material is combined with bushes as high as 15 cm that provides a clear distinction between the circulation lane and the grassy yard. The porch area is made out of ceramic material and lines that show positions for praying. The ceiling is made out of wood that is arranged horizontally. It is equipped with wood compositions that look similar to stalactites in a cave functioning as lamps. Within the stalactite patterns there are lamps, as if the lamps were hidden, and only the light is radiating. This effect gives a poetic effect in a form of a flickering light that comes out of the stalactite-type element. The outer circulation lane is bordered by natural plants, while the inner circulation lane is bordered by perforated walls that allow light and air to enter.

2) Design aspects: a line of trees on each side of the outer circulation lane makes its direction clear for users. The circulation lane on the front porch is flanked by a plane made out of a combination of glass and wood on one side and rows of columns on the other side. The front porch space shows how it multi-functions to accommodate the activities organized in the room. Besides functioning as a circulation and social space, this space is also used for worship while the main room is full. The side porch is flanked by wooden folding doors on one side and a lattice (perforated walls) on the outer side. The holes in the wall allow light to enter, creating a beautiful silhouette.

3) Technical aspects: Installations of concrete flooring gives the impression of efficiency because it is easy to install and inexpensive, plants provide shade and cool the temperature while the lattice provide a way for air and light to enter and circulate. Wood appears with its natural color, brown, and the lattice made of clay maintains the terracotta color. All these elements are displayed in their natural colors so as to give a warm impression



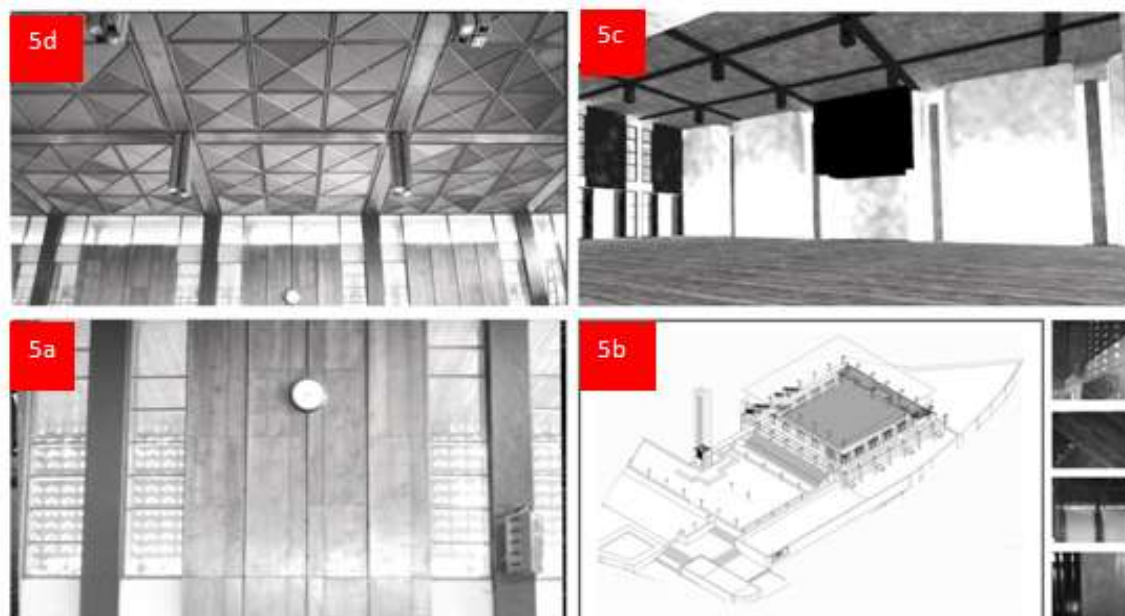
### 3.3. Main Hall

The main hall is understood by users as the primary destination, functioning as a space for worship. The hall also has the flexibility to function as a social space apart from the worship time. This room is a vast one, serene, and cool with a simple appearance. The elements of space that are found here are as follows:

3.3.a. The iconic phase: not found.

3.3.b. The indexical Phase: this vast room is a function index that shows the main function of the space. This space being an index structure for its spatial concept without column (fig 5c) shows that the building is designed using a wide span structure. The existence of the big folding doors shows flexibility of the space usage as the large doors are opened they unite the separated interior and exterior rooms as one big space. The big folding doors are an indexical sign.

3.3.c The symbolic phase: is shown by the presence of a mihrab on the wall at the front part of the main hall (fig. 5c), indicating the direction that Muslims should face when praying. It is a semicircular niche regarded by the Muslim society as the spot where the imam (priest) stands. Thus, mihrab can be categorized as a symbol. While the wide spread space unhindered by columns is perceived as a symbol of togetherness of the Muslim congregational worshipping together without barriers. The semantic reading of this space shows that this space uses the concept of sign association with its denotative and connotative meanings; denotative due to its functionality; and connotative as some elements in the room often create a certain association with the presence of light entering the room. The projection of light on the interior of the room forms shadows that look like pictures or patterns in portions of the wall and the floor. This shadow pattern is the one commonly associated by observers in different images.



**Fig. 5:** Spatial reading of the main hall. a) wall composition in the main hall that is designed with the combination of wood and glass; b) the main hall (area in grey) viewed from above. This hall is composed of lattice, wooden floor, and walls with air holes at the front part; c) main hall that is free of columns and with *mihrab* in front; d) wooden ceiling in the main hall designed using a geometrical pattern.

From the textual analysis, users read the space with the following pattern (table 3).

**Table 3:** Themes that were perceived by users in the main hall based on their multi-sensory approach experience

EYES	EARS	SKIN	SKELETON	MUSCLES
Verticality	Quality	Texture	Dimension	Height
Detail	Type	Depth	Proportion	
Colour and light		Material used		
		Linearity		

Pragmatic aspect:

a) Substrate used: flooring, doors, and the ceiling are made out of wood and each has a different composition (Fig. 5a, c). Wood is present to provide balance of softness because the outer part of the building is composed of hard elements (concrete and stone). The ceiling is also equipped with wood work that functions as the place for the chandelier. Glass is used to give the impression of room transparency and functions as a way for light to enter.

b) Design aspects: the room is made without columns (fig. 5c), which tells us that this room has various functions, not only for worship. Room doors can also be completely opened and closed. This strengthens the impression of flexibility and openness. In addition, the high ceiling that stretches out wide without being supported by scantling gives the impression of the vastness of the sky that houses the mosque. The column-less room gives the impression of vastness due to unimpeded vision. This impression of vastness is also strengthened by the high ceiling that gives the impression of being two and a half storeys tall. This seemingly vast room is also enhanced by the use of glass for the windows and the folding doors, so that the inner and the outer room can be joined seamlessly when the doors are folded. The one in nature concept is applied by using large transparent areas, and employing large glass windows. The design of this vast room emphasizes the relatively diminutive size of human beings within it.

c) Technical aspects: the detail geometric pattern on the wooden ceiling (fig. 5d). The detailed geometric patterns in Islamic architecture are used to visualize natural symbols, replacing living patterns (like animals and humans). The use of wood gives a natural impression due to its association with trees. Wood is used in elements of the ceiling, floor, and portions of the wall. Portions of the wall also utilize ventilation blocks in their upper sections. These ventilation blocks help air circulation and proper lighting for the purpose of user comfort even when the room is filled with the congregation.

### ***3.4. The Mosque building as a whole (syntactic aspect):***

The syntactic translation received from users about the spacing sequence as a whole (fig 6) in the Salman Mosque's exterior or interior is as follows:

3.4.a. Eyes: the spatial work from the foyer to the main hall shows order and consistency. They appear in rhythmical iteration which is performed by the vertical element, tone work (difference between low and high), as well as the presence of balance between hard and soft texture. Due to the emphasis of using a framework structure and its emphasis on volume, the columns of the Salman Mosque look as if they are separating themselves from the wall and the main shape of the building, hence column geometry is clearly shown. The omission of columns in the middle of the prayer room is based on the function of having the value of togetherness between people not hampered by columns that block the view. Thanks to the use of the cutting-edge technology available in that era, the pre-stressed concrete enables the vast structure. It can be observed in the outer concrete columns and the concrete column by the use of glass/wood at every joint. This reflects the "honesty" of the structure. This image of "honesty" is also reflected on the beams and the walls that display the image of "honesty" in every joint detail. This "honesty" principle can also be seen in material usage. The use of material is adapted to the characteristics of the material itself and it is allowed to be seen clearly without fabrication.

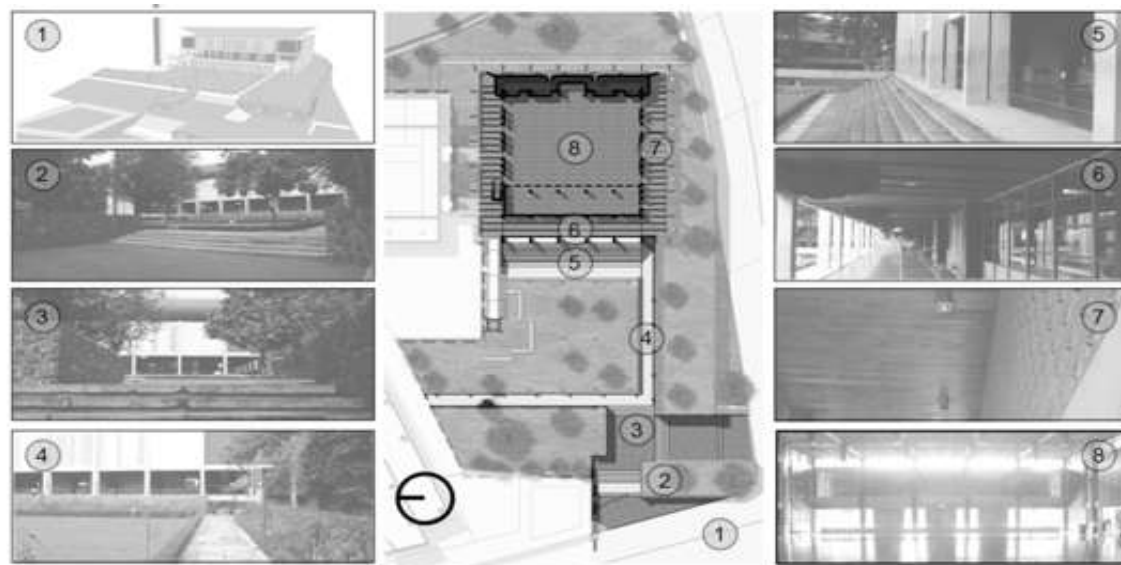
3.4.b. Ears: The quality and different sounds can also be heard by users. In the foyer and in the circulation lanes, the sounds of objects and animals dominate the space. Meanwhile, the sound in the main hall is dominated by faint human sounds. This reveals that each space presents different kinds of sounds.

3.4.c. Skin: The sensation of rough and smooth can be experienced by touching the wall and the floor material felt during touch or contact with the soles of the feet. This applies to the round smooth natural stone and rough natural stone, the smoothly stuccoed wall, smooth textured wood and ceramic flooring. Hot-warm-cold can be felt after the materials are exposed to sunlight or rainfall, hence the sensation of hot or cold when touched. A light breeze through the ventilation blocks or the open doors can be felt on the skin and may move hair and clothes, in addition to the warm wood, cold ceramic tiles and hot stone. Smooth-wavy patterns can be felt on the wall and the floor materials that are smooth and wavy, soft grass with wavy paving blocks. The empty-filled contrast can certainly be felt when entering the building from the outside to the inside, whereas the impression of vastness is limited with the building boundary field.

3.4.d. Skeleton: the feeling experience of high-low, proportional-disproportional is felt in each room. The height of the tower and the exterior of the mosque building are keenly felt when compared to the proportion to human height. There is an impression of the near-far, large-small contrasts when looking at the exterior of the building. While sitting on the floor at the main hall, the vast and tall interior and unimpeded vision makes humans feel small inside the room. Echoes aid the nuance of this sense of "smallness" inside.

3.4.e. Muscles: the feeling of far-near, wide-narrow is experienced by the users. The number of steps taken walking through the rooms will make us feel how extensive the circulation is toward the main plaza, that

is to say the distance of the main plaza to other rooms. The muscular movement will stimulate the feeling of distance-space, while the outstretching of the arms will generate the feeling of the wide-narrow contrast.



**Fig. 6:** Spatial reading of the whole space. 1) front view of the Mosque area; 2) the main hall viewed from the foyer; 3) stairs on the foyer; 4) the circulation lane was made distinct with the help of vegetation; 5) the stairs leading to the front porch; 6) the front porch; 7) the ceiling; 8) the main hall as the final destination of users

From the users' multi-sensory space experience that was translated into written knowledge, we can say that in the spaces within the Salman Mosque, there are:

1) Repeating themes: these often appear in the three spaces discussed: verticality, detail, color and brightness, type and quality, texture, depth, materiality, proportion, dimension, height, as well as distance (highlighted in grey in table 4).

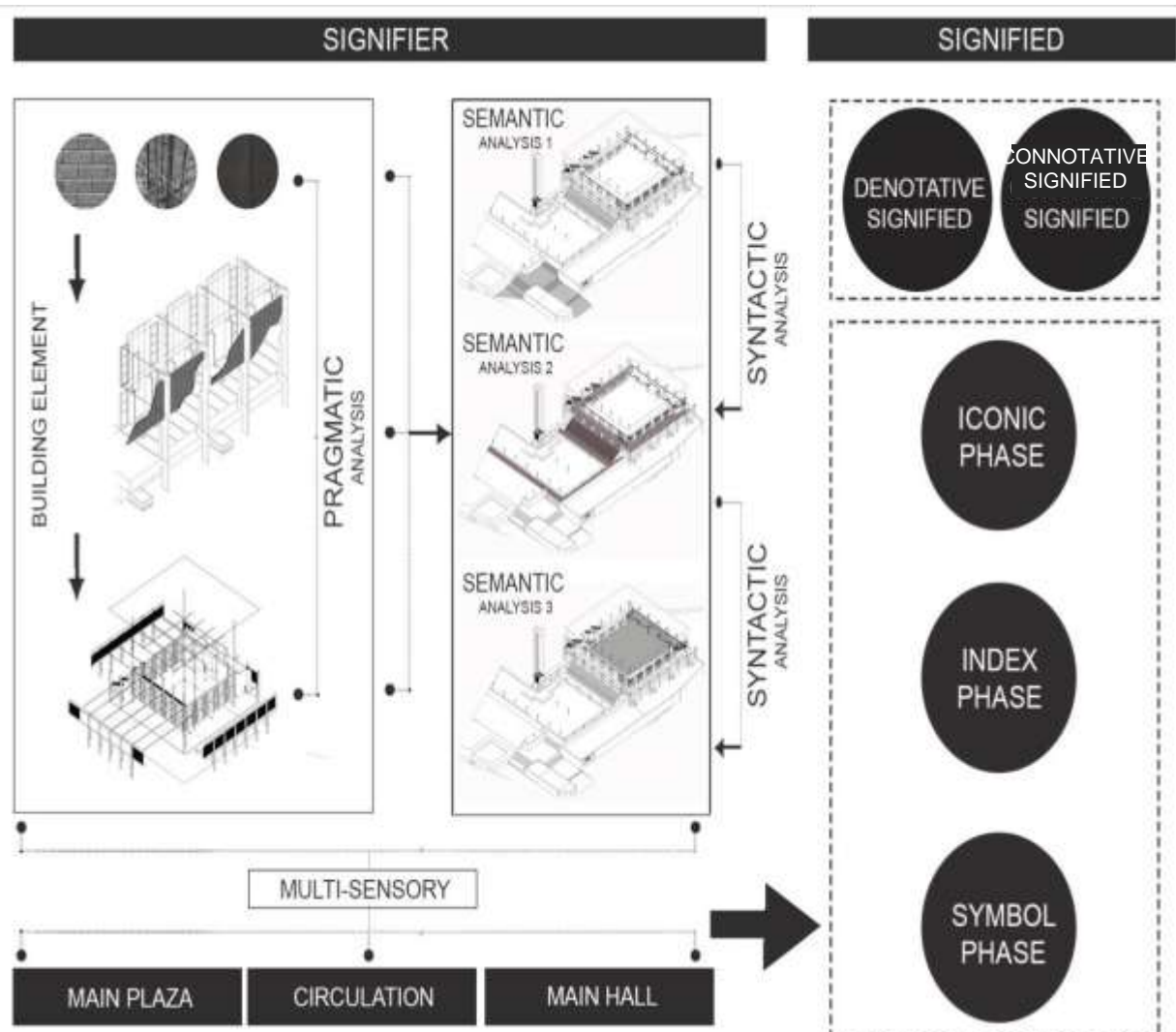
2) Unique themes: these only appear in one space. In the foyer: direction and position, contrast as well as details. In the circulation lane: flow, distance and speed appeared to be the strongest elements (most conspicuous). In the main hall, linear elements become the main keyfocus (without highlight in table 4).

These results highlight the presence of unique spatial experience as illustrated in Fig 7.

**Table 4:** Recuering and unique themes in each space

EYES	EARS	SKIN	SKELETON	MUSCLES
<b>PLAZA</b>				
Direction and position	Type	Texture	Proportion	Height
Verticality	Quality	Depth	Dimension	Distance
Contrast		Materiality		
Detail		Detail		
Colors and light				
<b>CIRCULATION</b>				
Flow	Type	Texture	Proportion	Height
Verticality	Quality	Depth	Dimension	Distance
Distance		Materiality	Speed	Hierarchy
Detail				
<b>Main Hall</b>				
Verticality	Type	Texture	Dimension	Height
Detail	Quality	Depth	Proportion	
Colors and light		Materiality		
		Linearity		





**Fig. 7: Application of reading in architectural context**

These findings reinforce the fact that by using a multi-sensory approach, these results are found:

1) Semantically, visual senses play a dominant role in translating the language of space at the Salman Mosque.

2) Pragmatically, eyes and skin play a dominant role in translating the language of space at the Salman Mosque

3) Syntactically, all senses were involved in translating the language of space at the Salman Mosque, Although still visually observed, muscle movement and proportion created by the skeleton dominate the overall experience by involving all the senses possessed we will generate a more profound spatial experience-induced sensation.

4) Experiencing space using the multi-sensory method that combines all the senses also generates a sense of: romanticism, affection, pride, convenience, and inconvenience as well as the association with objects and figures (for example, when they were inside the mosque, the atmosphere reminded the users of their beloved parents or of the late activist of Salman who strengthen their spiritual growth). Experiencing a room requires a stronger will and closer attention in observing an object, so that the relationship between observer and object can emerge. When someone tries to bring about the awareness of existing “relationship”, the past experience aspect will undoubtedly come to the fore. The presence of space, time, position, activity, and people involved at that point will remind us of the relation we were having in the same location. Therefore, conjuring up romance from the past requires creating sensitivity for the current situation. The feeling of romance built developed in that way will be able to bring back memories of our home just by sitting and enjoying the view of the garden in the main yard, or to feel the presence of a mother figure just by leaning down and enjoying the situation, as well

as smelling the food aroma from the cafeteria in the mosque area. Affection appears when we try to pay closer attention to objects. Building affection is important for the presence in order to move the emotional aspect and attention to objects or comprehension of current situation. The pride to be part of a space and understanding space will be awakened. One of the emotions that can build emotion is revealed when someone possesses pride. Without pride, someone will be reluctant to develop one's emotional relationship. The feeling of comfort will make someone feel the urge to develop a relationship with an object, be willing to linger, enjoy and appreciate it. On the other hand, the feeling of discomfort (no matter how unpleasant) will be able to stimulate certain memories that can trigger someone's emotion. For example, certain smells that can create discomfort, foul smells, or even pleasant smells that are relative for different people (for example, some people find the smell of gasoline offensive but others don't or the smell of perfume that may smell good to some but nauseating for others. Comfort is relatively objective for everyone, but discomfort is somewhat subjective.

In addition, by using this approach, users are able to create memories and fully engage in their imagination process.

#### **IV. CONCLUSIONS**

Based on our analysis, it may be concluded that:

1) The Salman Mosque, built with modern architectural concepts can be read using the integration of all human senses. Simplicity in the Salman Mosque can be communicated into functional language. Even with its simple design, all elements of the space worked well to make users feel that they are indeed inside a mosque and enable them to do what they need to do at a mosque.

2) In order to perceive the spatial language, the five human senses should support the sensory process. In a certain process, one or two senses could play the dominant role while in other processes all senses must work in balance with each other.

The translation of spatial language through the use of all senses is able to solve an interior and exterior lack of value problems. Spatial language can be understood for generations as long as an architectural product conceives a lasting creativity, and users wish to understand the process of experiencing the space. This study is important to measure the accomplishment of the Salman Mosque as an architectural product to evoke one's mental, physical and spiritual readiness to truly appreciate the space and decipher the spatial language.

#### **REFERENCES**

- [1]. Pallasmaa, Juhani. *The Geometry of Feeling: A Look at the Phenomenology of Architecture*. In Nesbitt, Kate. (Ed.). *Theorizing a New Agenda for Architecture: An Anthology of Architectural Theory 1965—1995*. NY: Princeton Architectural Press, 1996, pp. 450-453.
- [2]. Rasmussen, Steen Eiler. *Experiencing Architecture*, 2nd ed., the MIT Press, Cambridge. 1964. p 33.
- [3]. Pallasmaa, Juhani. *The Eyes of the Skin, Architecture and the Senses*. John Wiley & Sons Ltd., England, 2005, Pp 40-46.
- [4]. Baird, George. *La Dimension Amoureuse' in Architecture*. In Hays, Michael K. (Ed.). *Architecture Theory Since 1968*. Cambridge: MIT Press, 1969. p.54
- [5]. Bachelard, Gaston. *The Poetics of Space*. Beacon Press, Boston, 1969. pp. 25-26.
- [6]. Setia Budi, Bambang. *Masjid Salman ITB, Tonggak Arsitektur Masjid Kontemporer di Indonesia*. Kompas, 5 Januari 200 3.
- [7]. Ekomadyo, Agus S. *Architectural Representation of Islamic Modernism and Neo-Modernism in Indonesia: between Internationalism and Regionalism*. Case Study: Architecture of Achmad Noe'man, 2007.
- [8]. Utami. *Integrasi Konsep Islami dan Konsep Arsitektur Modern pada Perancangan Arsitektur Modern pada Perancangan Arsitektur Masjid (Studi Kasus pada Karya Arsitektur Masjid Achmad Noe'man)*. portalgaruda.org/download\_article.php. 2013.
- [9]. Al Qu'ran. Surat Al-Baqarah, ayat 170.
- [10]. Pallasmaa, Juhani. *The Embodied Image: Imagination and Imagery in Architecture*. John Wiley & Sons, 2009.
- [11]. Pallasmaa, Juhani. *The Thinking Hand: Existential and Embodied Wisdom in Architecture*. John Wiley & Sons, 2009.
- [12]. Seamon, David. *Lived Bodies, Place, and Phenomenology: Implications for Human Rights and Environmental Justice*. *Journal of Human Rights and the Environment*, Volume 4 no.2, September 2013, pp. 143-166.
- [13]. Holl, Steven; Pallasmaa, Juhani; Gomez, Alberto Perez. *Questions of Perception: Phenomenology of Architecture*. A+U Architecture and Urbanism, 1994.

- [14]. Frampton, Kenneth. *Studies in Tectonic Culture - The Poetics of Construction in Nineteenth and Twentieth Century*. MIT Press, Cambridge Massachusetts, 1995.
- [15]. Chandler, Daniel. *Semiotics for Beginners*. <http://www.aber.ac.uk/media/Documents/S4B/semiotic.html>. August. 8<sup>th</sup> 2014, pp 7-68.
- [16]. Morris, Charles W. 1903-1979. *Signs, Language and Behavior*. New York: Prentice-Hall, 1946.
- [17]. Peirce, Charles Sanders. 1931-58: *Collected Writings* (8 Vols.). in *Stanford Encyclopedia of Philosophy*. [www. plato.stanford.edu/entries/peirce-semiotics/](http://www.plato.stanford.edu/entries/peirce-semiotics/). February 2<sup>nd</sup>. 2014.
- [18]. Saussure, Ferdinand de. *A course in general linguistics* (W. Baskin, Trans.). New York: McGraw- Hill in *Semiotic Analysis* – Sage. [www.uk.sagepub.com/upm.../5171\\_Berger\\_Final\\_Pages\\_Chapter\\_1.pdf](http://www.uk.sagepub.com/upm.../5171_Berger_Final_Pages_Chapter_1.pdf), September 18<sup>th</sup>. 2014.