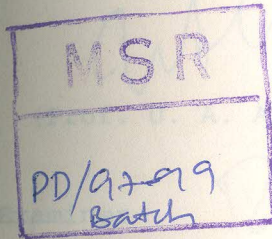


HOW ARCHITECTS THINK

Special Project

Guided by: Professor U.A. Athavankar



INCLUDES THE PAPER (OUTCOME OF THE PROJECT) TITLED "POTENTIAL OF MENTAL IMAGERY IN ARCH DESIGN PROCESS" presented and published in IDATER 99, Dept of Science & Techn, Univ of Loughborough, Loughborough. U.K.

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APPROVAL SHEET

The special project titled "How Architects Think." by Anshuman Singh is approved in partial fulfilment of the requirement for the Masters Degree in Industrial Design at IIT Bombay.

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The purpose of the experiment was to study the role and potential of mental imagery in the architectural design process. To study the use of only mental imagery as a feed back while designing, in absence of other media viz. sketching. This experiment is a continuation of experiments conducted on Industrial designers. The experiment was made to study architects. To ascertain the role of mental imagery which is different in scale and complexity than industrial design.

This was achieved by using an experienced architect and blindfolding him during the act of design. The results achieved clearly indicate that he was able to use mental imagery to assist him in the design.

KEY WORDS

- Protocol analysis
- Mental imagery
- How architects think
- Design process
- Visual thinking

PURPOSE AND HYPOTHESIS

The purpose of the experiment was to study the role and potential of mental imagery in the design process, to examine whether mental imagery can enrich the design process. Also to study the advantages and disadvantages of using, only mental imagery as a feed back while designing, in absence of other media viz. sketching.

The previous experiment ¹ conducted on product designers established the fact that mental imagery can be used to do complex modelling tasks and taking formal design decisions. In comparison to industrial design, architects deal with much larger volumes and spaces. These spaces cannot be worked from exteriors only. The study was designed to ascertain the role mental imagery plays while taking decisions on interior and exterior space simultaneously in absence of sketching (which is an important tool in architectural design)

EXPERIMENT AND PROCEDURE

The subject chosen for the experiment was an architect in his mid fifties. He has been practising architecture for the past 30 years. We shall refer to him as VS. He was given a problem of designing a motel on a highway for 18 rooms of mixed type with ancillary facilities (see Appendix 1). The problem was supplied in terms of textual material and drawing (details of introduction of problem given later). An architect, amongst the experimenters framed the problem.

The study was done to observe the role of mental imagery in the problem solving. The study uses protocol analysis technique with audio-visual recordings. The design problem and environment was recreated to match the needs of real life design situation as much as possible.

Mental imagery is a personal experience. There are no outward signs, which a camera can catch consistently. Measures were taken to access this imagery without being too intrusive in the problem solving process. The subject was made to rely on mental imagery by depriving him of sketching, which offers a visual and kinaesthetic feedback to the subject.

SEQUENCE AND STAGES OF THE EXPERIMENT

Stage 1

VS was asked to read the design brief supplied to him. The design brief contained textual description of the site, surroundings, topography and functional requirements (from 00:00:00 to 00:02:28*). VS was asked to repeat the requirements and details after memorising them, till he got the content right. The experimenter, (who was well acquainted with the problem), made clarifications and additions on the missing information. This part lasted from 00:02:29 to 00:09:23. He was then supplied with the scaled drawing depicting the site, topography and surroundings. VS had to memorise the drawing & describe the site. The experimenter added the missing information and details. This process was repeated till VS was able to recall all the details of the site. (This part of the stage 1 lasted from 00:09:40 to 00:13:20).

Stage 1 took 13 minutes 20 seconds in totality.

Stage 2

VS was asked to solve the problem blind folded. He had to speak aloud, as he proceeded with the problem solving. He had to retain the eye mask throughout this stage. VS had to rely on his mental imagery, as he could not sketch, to develop his ideas. This stage could be divided further into two sub units viz.

2a) General planning- allocation of spaces, site planning of the building. (00:14:02 - 00:21:50)

2b) Fine-tuning - Detailing of surface treatment, fixing dimensions, interiors etc. (00:22:00 - 01:02:36)

During the second stage he discovered some problems (detailed later in this paper) which he solved by altering the decisions taken in the first sub unit. Questions were asked by experimenter to help him details the attributes which he forgot to mention. Some of these details were visualised of but not mentioned and some questions appeared entirely new, which he did not think about.

The whole stage 2 lasted from 00:14:02 - 01:02:36.

* - All time stamps are from the play session unless mentioned otherwise.

Stage 3

The subject was asked to finally describe the idea before the eye-mask was removed. During this process he again made minor modifications. The process lasted from 01:03:07 - 01:10:25.

Stage 4

After VS was clear about the design, he was asked to sketch the solution rapidly. He was instructed to inform of any additions to the sketch made, besides what he visualised while sketching (he did not add any element besides what he visualised). The sketching & simultaneous discussion lasted from 01:11:35 to 01:24:26.

Stage 5

After the description he was shown the video recording of the session to comment on where ever he had instances of mental imagery. The process lasted for two hours precisely. (00:00:00 - 2:00:00 replay time)

* - All time stamps are from the play session unless mentioned otherwise.

ANALYSIS

The paper is based on analysis of the protocols. The experiment was analysed from the point VS had read the textual brief (00:09:23).

Entire session was video recorded which not only contained all the decisions that he took while developing his ideas, but also the final description of his solution, narrated before the eye mask was removed.

Results showed that the features and details he shows in his final sketches were decided during the stage he was wearing a mask. His final description as well as his think aloud referred to all the decision suggesting that VS had worked everything in his images. There are certain areas in planning, where his approach remained only at a conceptual level or alteration of specific spaces. (E.g. Service area and its overall appearance). He does not go into details of this area in his think aloud protocols nor in his final sketch. He probably treated this as 'routine' matter to be worked out in detail later, but never reached the stage. Thus some areas like kitchen, service yard, general toilet remained as space allocations only.

The experiment was designed in a fashion to ensure that the details are not added while sketching the solution at the end. The description of design solution was video recorded and the verbal record was used to cross check. To ensure that he did not miss any details while sketching the video record of his gestures and verbal description was recorded.

The entire process depicts the non-linearity and incremental nature of the design process. The process is analysed on the basis of the following factors.

Design as Incremental Process

The incremental nature of problem solving was evident throughout the process. Although he was unable to sketch, VS was able to retrieve images later and details, and move ahead. For example he was able to conceive the details about the room first then, moved ahead with other features, then come back to the room and added details.

00:20:20- I am not visualizing anything to go on g + 1 up (thinking about mass of the rooms)

00:22:41- Stone wall, Mangalore tile roofs, and lot of wood. I'd like to use glazing... (Visualizing general image of the rooms)

00:32:11- Vertical walls are stone and horizontal finished materials (Finalizing detail of finishes)

00:34:30- Each unit has a small lawn, sitting space, individual maybe shared for sufficient privacy. (Detailing out landscaping)

00:37:40- There is variation in height, I can have glazing on south side. (Resolving climatic issues)

00:49:34- Windows are same wood only, low sill wooden windows (detailing elevations)

Similarly he handles other spaces like dining hall, entrance lobby and parking.

Non Linearity

VS starts the design process by talking about lawn (00:15:13) which was triggered by the Banyan tree. From here he switches to service areas and kitchens (00:16:00) and allocation of spaces.

This is quite unlike of the usual hierarchy of planning spaces. He proceeds forward with the general image of the motel (00:22:17). After he is sure about the general image he proceeds to detail the rooms and its treatment (00:22:41). VS then details circulation requirements in the site (00:27:05 - 00:27:42). He comes back to the room to detail privacy and climatic issues (00:34:30 - 00:35:25) and landscapes. From here he switches back to the site level climatic control and details

high walls, trees etc (00:35:40 - 00:36:11). VS details the site again for circulation (00:43:46, 00:46:29) then switches back to interiors (00:49:39, 00:52:05, 00:54:29). These instances suggest the non-linearity in the design process relying on mental imagery.

Detailing And Aesthetic Issues

Mental imagery can prove a vital tool in dealing with aesthetics and detailing. The rapidness, flexibility and volatile nature helps to handle these issues with much ease than sketching does. Treatments and details can be imagined, modeled and changed at a very high pace. For example, immediately after allocation of spaces he proceeds to develop an image for the whole building. The image emerging in his mind stays the same till the end.

00:21:23 - I am visualizing sloping roofs and not flat surfaces...

00:22:12 - Stone wall, Mangalore tile roofs, and lot of wood. I'd like to use glazing...

After resolving the general image, which had fascination for stone and Mangalore tiles he tries to resolve the interiors. The first image of stone and tiles influence his details all the time. Even in the treatment of rooms (00:22:41) dining hall (00:47:40) the stone treatment finds place repeatedly (00:55:00).

Most of these issues are being planned at the grand level as space allocations. But in some parts he switches back and forth to view from the top (birds eye view) to resolve issues.

00:38:10 - Roof profile I am visualising is different. Smaller roof but sloping. There is a valley and then there is a corridor to collect rainwater. There is variation in height. I can allow light from the south....

00:57:48 - There are vertical links in corridor, where the changes (in level) will happen...

When inquired about the interiors of the dining VS responds by

00:47:40 - decorate it with hangings, crafts...

He later informed (in the replay) that these details about interiors were triggered by an image of high walls of a fort and banners, crafts etc.

It was interesting to watch the decisions being made on the colours and textures of pavement surfaces.

00:50:00 - General areas are red stone...Kota stone for services...would use the same orangish stone, as I've used in Prithvi (previous work) for flooring...

He was also to resolve privacy and related issues at various levels and was clear about the image, although details of placement were not clear many a times.

00:34:30 - Porch (actually a sit out on the backside of room) for sufficient privacy...lawn can be shared...but porch cannot.

00:36:11 - Add trees to cut the noise...

Here he had trees in mind looking from highway but not clear about how they will be seen from inside.

Changes In Shape And Form

Mental imagery was used as a potential tool to develop and change built forms with great ease and speed. VS used it as a part of exploratory moves and reflected upon them in imagery.

00:19:31- Its not necessary for me to go G+1, I can spread everything on the ground.

00:20:41- I am not going G+1

00:21:13- If some area is left it can go up... no, no I am visualising sloping roofs and not flat surfaces.

While detailing things he could change his initial imagery to suit his new requirements, like he changes from clusters to pair of rooms

00:26:10- Everything has to go inside the plot! My first image of Banyan tree as a part of the lawn has to change. The lawn has to shift more on left-hand side. The service entry will be on the extreme side. The volumes also changes with the enrichment of the design.

00:30:20- What is emerging is "T" and not a rectangle.

VS is also able to visualise sun which do not picture in the site immediately.

00:32:34- You'll get sun on the south side (He evaluated that he will get shadow in the courts, which was conflicting to his initial images)

In the final description he changes his design. While walking towards the building in his imagery he finds the gable of dining hall disturbing and changes the front elevation.

1:05:04- I am visualising an octagonal roof.

USE OF GESTURES

One would expect excessive usage of gestures as the subject was blindfolded. On the contrary the subject except for the initial part of site description refrains from usage of gestures. (Contrary to the experiments done on Industrial designers: Athvankar). The gestures are

usually limited to talking gestures and don't have spatial accuracy with them (00:02:50). In fact the subject refrains from using gestures and sits with the hands folded. Since only one architect was studied it cannot be generalised.

STEREOTYPE AND NOTIONS

The subject was biased on certain notions or had pre conceived notions, which affected his thought process. He assumes north to be closer to him (and south away, contrary to standard practice in drawing where north is away from the viewer). This was based on his knowledge of geography (Goa being south of Bombay). He corrects this after viewing the drawing.

He is continuously visualising for the initial part of the experiment that lobby is biggest and reception and dining are attached spaces.

This is contrary to the requirements, but goes with his image, which is derived from a five-star hotel (00:08:35)

00:19:50- while assumes setbacks to be of 10m, which is derived from the grid of 10m X 10m drawn on the drawing supplied.

SPECIAL FEATURES

Unpredictable elements in imagery:

00:47:40 - decorate it with hangings, crafts... (sketch 5)
He later informed (01:47:28 Replay Time) that these details about interiors were triggered by an image of high walls of a fort and banners, crafts etc.

The origin of this image was unexplained. It was assumed that stone walls or previous visits to forts could've triggered these. Another possible bearing for the use of stone walls could be his previous conservation works in hills where stone and wood are predominant building materials.

00:58:56- the dining is floating... (plinth is set inside, sketch 4)
VS added in the replay (01:48:00) that he had an image of a swimming pool in mind which was the basis of this decision.
He could not explain the basis for this imagery. Swimming pool wasn't a part of the design requirement.

Light as a factor: VS is continuously visualising his design in a sunny environment. He continuously refers to light coming in through the windows in the room, across the court and in the dining room.
01:19:33 replay time- It was a sunny day, the stone was already there, greenery...

Moves and reflections: Mental imagery was used as a potential tool to change forms with great ease and speed. VS used it to change his moves after reflecting upon it.

00:19:31- Its not necessary for me to go G+1, I can spread everything on the ground.

00:20:41- I am not going G+1

00:21:13- If some area is left it can go up... no, no I am visualising sloping roofs and not flat surfaces.

While detailing things he could change his initial imagery to suit his new requirements, like he changes from clusters to pair of rooms (00:39:30). He was also able to modify his decisions when countered with contradicting facts.

Image driven decisions: VS decided upon many attributes driven by imagery. He sees trees from the highway side but could not place them inside the plot.

00:36:11- my parking is there...plant the trees... to cut down noise. VS while reacting to this statement in the replay says...

01:09:11 replay time- high walls, large trees & car parked below. From outside I saw the trees. From inside I visualised clean parking without the trees.

He visualises octagonal roof on the dining because he does not like the triangular gable roof.

01:56:14 replay time- initially roof was simple (simple triangular pitched roof) then realised that there was a lawn in the front, so didn't want a triangular wall in the front.

Presence and Walk Through: Since VS was working with mental imagery he was able to walk though his building, switch viewpoints, move from inside to outside with great ease and take design decisions.

00:37:10 replay time- I am inside the room looking outside at the lawn.

01:09:11 replay time- From outside I saw the trees. From inside I visualised clean parking without the trees.

01:37:40 replay time- I was walking in the corridor & toilet was blocking the view.

01:46:30 replay time- the level differences I saw from top.

Reaction to the site: He responded to the Banyan tree by placing the lawn around it. Similarly he had images of service areas near the railway track.

00:35:40 - Since there is a highway, the trucks passing in the night will be an inconvenience. I'll have a high wall there...

00:36:42 - On the nala side there is no mans land...since my entry is inside I don't need a wall there...

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APPENDIX 1

Design of a motel

Site

Design a motel on the site located on the "Bombay Goa highway" in Chiplun village. The plot is approximately 3000 m². It is a rectangular site as shown in the attached sheet. The highway runs along the West Side of the plot. On the eastern side of the plot a railway track runs parallel to the plot. There are farmlands on the north side of the plot. On the south there is a fresh water nallah parallel to the plot. Across the nallah are farmlands. Across the highway on the West Side there is an industrial belt.

Constraints

1. Material should be locally available.
2. The height of the structure should not exceed g+1.

Climate

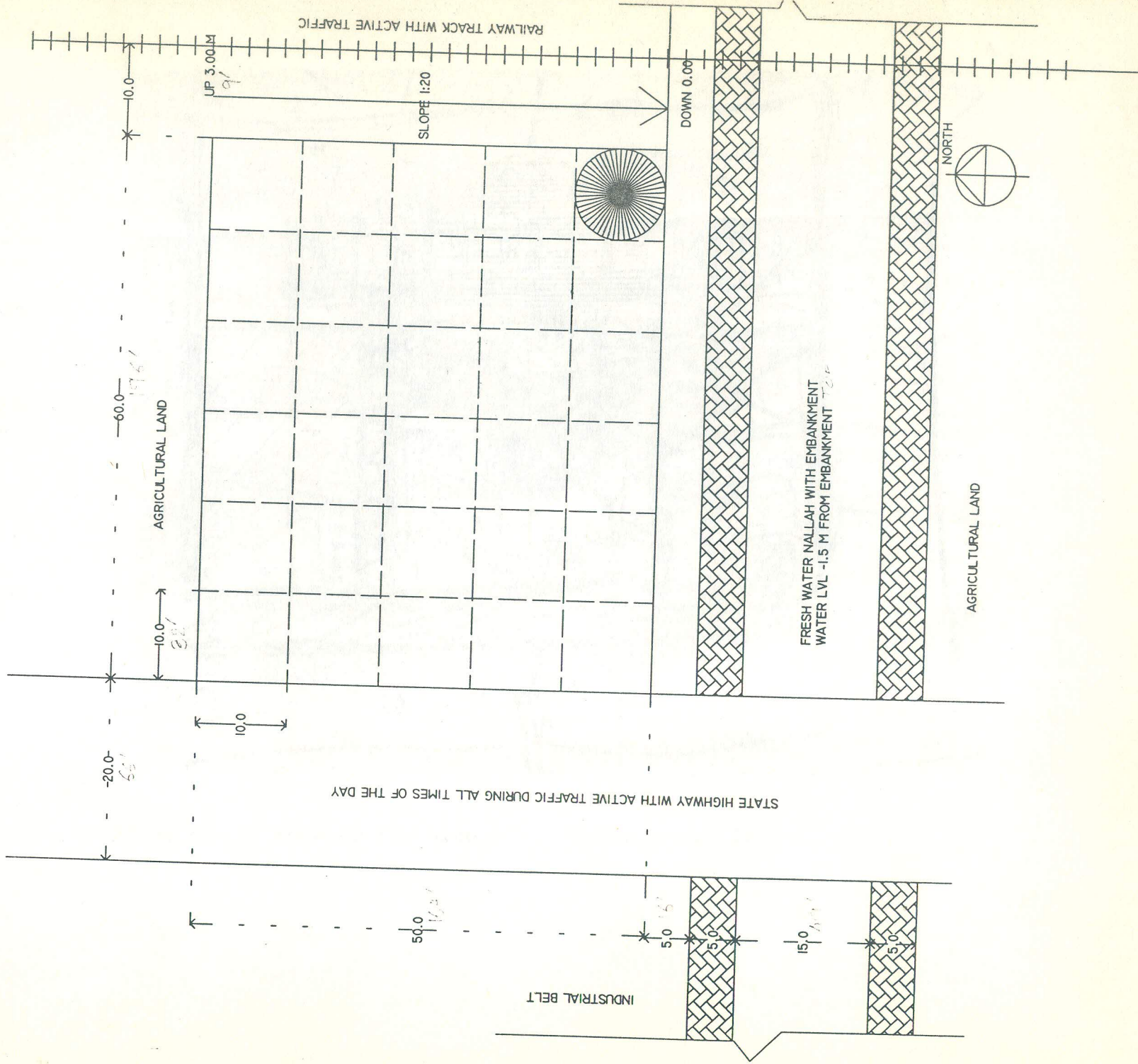
Hot humid. Heavy rains during monsoon.

Spatial requirements

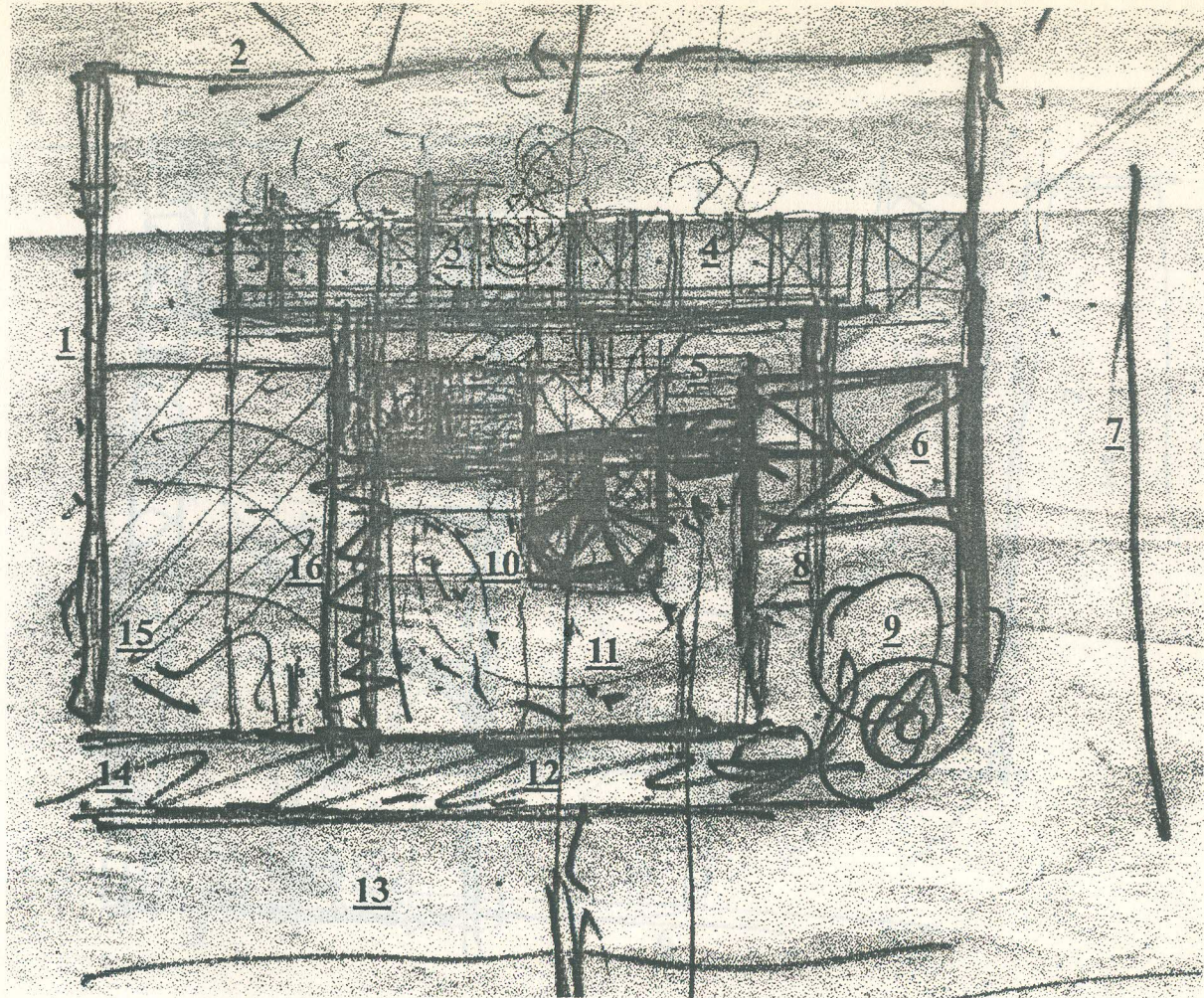
- | | | |
|---|--------|--------------|
| 1. Reception | | 15m2 approx. |
| 2. Lobby to convey the culture & essence of the region. | | 30m2 approx. |
| 3. Double-bedded ac rooms with balcony | 5 nos. | 25m2 approx. |
| 4. Single bedded ac rooms | 5 nos. | 15m2 approx. |
| 5. Double-bedded non-ac rooms | 8 nos. | 20m2 approx. |
| 6. Interaction spaces- lawn courts | | |

Services

- | | |
|--|---------------|
| 1. Kitchen with store | 20-m2 approx. |
| 2. Dining room with bar for all the guests | 100m2 approx. |
| 3. All rooms a have a toilet attached. | |
| 4. Parking lot for 20 cars 5 buses | |
| 5. Toilet facility for general visitors | 20m2 each. |



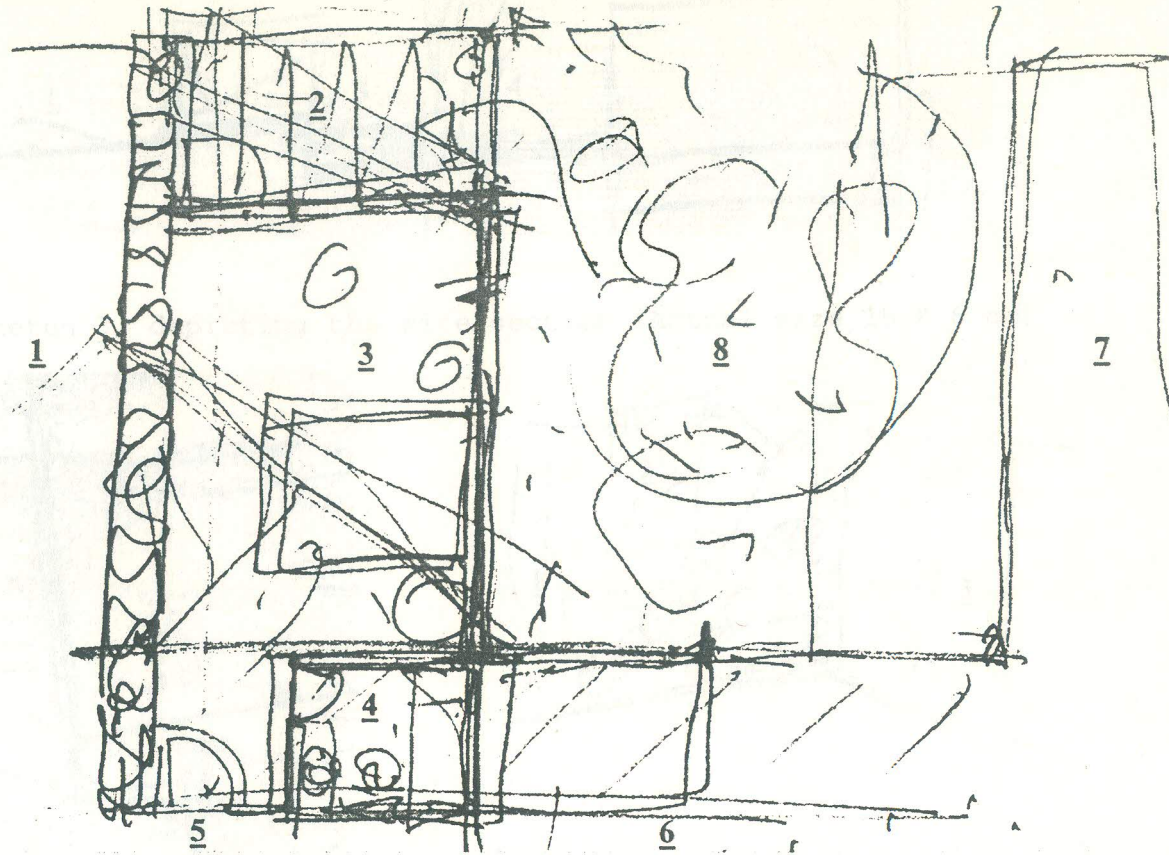
1. High wall on the highway side.
2. Perforated wall on farmland side
3. Pairs of room
4. Open space between rooms
5. Courtyards
6. Kitchen
7. Railroad
8. Service yard
9. Banyan tree
10. Dining room
11. Lawn
12. Service road
13. No mans land next to fresh water nala
14. Entry
15. Parking
16. Pathway



Sketch 2 depicting a typical room & surroundings (Actual size 24x35)

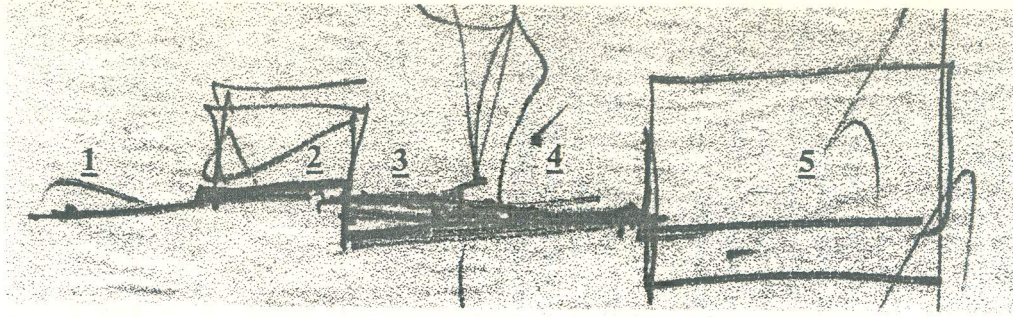
First sketch showing the Site Plan. (Actual size 14 x 12 cm)

1. Adjoining room
2. Sit out (referred as porch by VS)
3. Room
4. Toilet
5. Entrance door
6. Corridor
7. Room across the lawn
8. Lawn in between two rooms



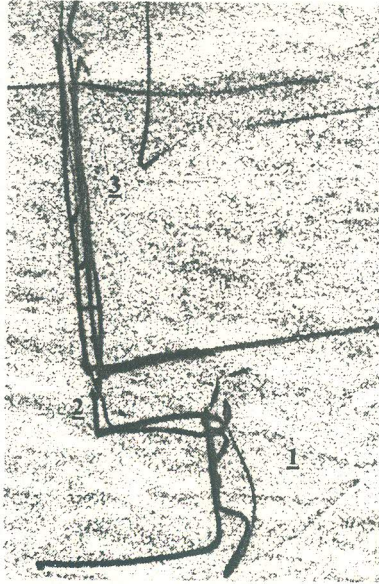
Sketch 2 depicting a typical room & surroundings (Actual size 28X25 cm)

1. Lawn behind the rooms
2. rooms
3. corridor
4. courtyard
5. dining

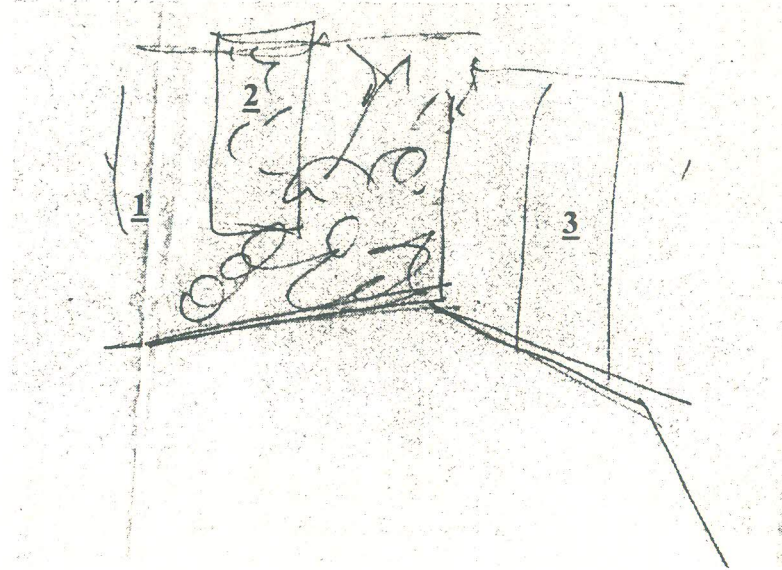


Sketch 3 depicting the site section (Actual size 15 X 6 cm)

1. Dining room plinth set inside.
2. Cantilevered floor for floating effect
3. Full height windows



Sketch 4 depicting the section of dining room wall
Actual size 10X6 cm



Sketch 5 depicting the inside view of dining showing stone wall (1), full height windows(2)& wall hangings(3)
Actual Size 27 X 21 cm

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ABSTRACT

The purpose of the experiment was to study the role and potential of mental imagery in the architectural design process and to study the use of mental imagery as a feed back while designing, in absence of other media viz. sketching. This experiment is a continuation of experiments conducted on Industrial designers. The experiments conducted on Industrial designers indicate that they were able to design well, blindfolded. This experiment studied an architect, to ascertain the role of mental imagery in the architectural design, which is different from industrial design in scale and complexity. This was performed by studying an experienced architect, blindfolded during the act of design. The results achieved clearly indicate that he was able to use mental imagery to assist him in the design process.

KEY WORDS

Protocol analysis
Mental imagery
Visual thinking
Architectural design

138 words

1. 0 INTRODUCTION

The paper deals with the analysis of protocols of an architect assigned with the task of designing blindfolded. This is a part of ongoing projects focussing on the role of mental imagery in design behaviour. These experiments were performed on design professionals like Architect, Industrial Designer (Athvankar, 1996), Musician & Advertising designer.

The experiment was designed to study the above factors in absence of other media to externalise the thought viz. sketching. To study whether imagery offers benefits as conventional media to serve as display to react and portrayal of content of design? The complexity, size of spaces, working both in interior and exterior spaces (which are beyond the human gestures) and scale were the unique factors studied. These factors were not so complex in other professions studied earlier.

Sketching is known to offer several advantages when designing. It offers a way of representing and thus recording decisions (Ullman, 1990). It also serves as a display for the designer to react to (Gabriela, 1992). By preventing the designer from sketching the experiment attempts to explore, if mental imagery can serve the role sketching does? It also explores the nature of imagery experiences.

The purpose of the experiment was to study the role and potential of mental imagery in the design process, to examine whether mental imagery can enrich the design process. Also to study the advantages and disadvantages of using, only mental imagery as a feed back while designing, in absence of other media viz. sketching.

In the previous experiment conducted on product designers (Athvankar, 1996) established the fact that mental imagery can be used to do complex modelling tasks and taking formal design decisions. In comparison to industrial design, architects deal with much larger volumes and spaces. These spaces cannot be worked from exteriors only. The study was designed to ascertain the role mental imagery plays while taking decisions on interior and exterior space simultaneously in absence of sketching (which is an important tool in architectural design)

2.0 EXPERIMENT AND PROCEDURE

The subject chosen was in mid fifties and has been practising architecture since 30 years (referred as V.S. in the paper). V.S. was trained in traditional ways to design, had been relying on sketching till he started using computers extensively during past 5-7 years. Subject with 30 yr. of experience was chosen because of his already developed style of design and method to tackle a problem. Years of experience help to develop individuals image bank, which was necessary in this experiment.

He was given a problem of designing a motel on a highway with 18 rooms of mixed type with ancillary facilities. The problem was presented as textual material and drawing (details of introduction of problem given in 2.1). An architect, amongst the experimenters framed the problem.

The study was done to observe the role of mental imagery in the problem solving. The study uses protocol analysis technique with audio-visual recordings. The design problem and environment was recreated to match the needs of real life design situation as much as possible. Since mental imagery is a personal experience, there are no outward signs which a camera can catch consistently. Measures were taken to access this imagery without being too intrusive in the problem solving process. The subject was made to rely on mental imagery by depriving him of sketching, which offers a visual and kinaesthetic feedback to the subject.

2.1 SEQUENCE AND STAGES OF THE EXPERIMENT

Stage 1: Reading the Design Brief.

V.S. was asked to read the design brief supplied to him. The design brief contained textual description of the site, surroundings, topography as well as functional requirements (from 00:00:00 to 00:02:28). V.S. was asked to repeat the requirements and details after memorising them, till he got the content right. The experimenter, (who was well acquainted with the problem), offered clarifications and added the missing information. This part lasted from 00:02:29 to 00:09:23. V.S. was then supplied with the scaled drawing depicting the site, topography and surroundings. V.S. had to memorise the drawing & describe the site again. The experimenter added the missing information and details. This process was repeated till VS was able to recall all the details of the site. (This part of the stage 1 lasted from 00:09:40 to 00:13:20). Stage 1 took 13 minutes 20 seconds in totality.

Stage 2: Blindfolded Problem Solving

V.S. was asked to wear an eye mask and solve the problem blindfolded. He was asked to speak aloud, as he proceeded with the problem solving. As he could not sketch, V.S. had to rely on his mental imagery to develop his ideas. This stage could be divided further into two sub units viz.

2a) General planning- allocation of spaces, site planning of the building.
(00:14:02 - 00:21:50)

During the second stage he discovered some problems (detailed later in this paper) which he solved by altering the decisions taken in the first sub unit. Questions were asked by experimenter to remind him to describe the attributes, which he forgot to mention. Some of these details were visualised of but were not mentioned. Some questions appeared entirely new, which him to look at these aspects.

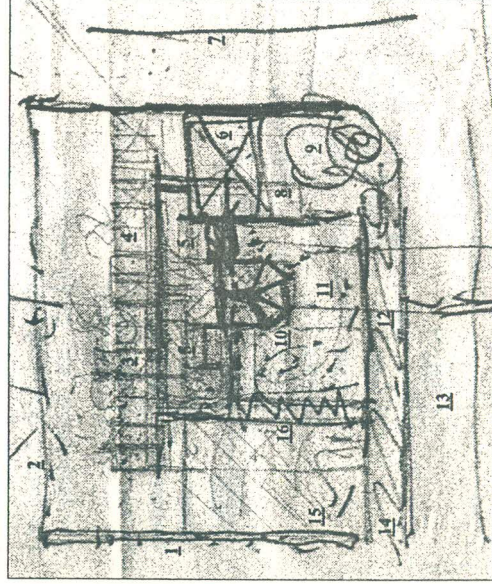
The whole stage 2 lasted from 00:14:02 - 01:02:36.

Stage 3: Description of the Final Design Proposal.

The subject was asked to finally describe the idea before the eye-mask was removed. During this process he again made minor modifications. The description was intended so that it could be compared to the sketches done in the stage three. The process lasted from 01:03:07 - 01:10:25.

Stage 4: Quick Sketching.

After V.S. was clear about the design the eye mask was removed and he was asked to sketch the solution rapidly. He was instructed to inform of any new features that he may have added during the act of sketching besides what he visualised (he did not add any element besides what he visualised). The sketching & simultaneous discussion lasted from 01:11:35 to 01:24:26.



1. High wall on the highway side.
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12. Service road
13. land next to fresh water nala
14. Entry
15. Parking
16. Pathway

Sketch 1: The Site Plan sketched by VS. (Actual size 14 x 12 cm)

Stage 5: Commentary on the replay

After the description he was shown the video recording of the session he was asked to comment on where ever he had instances of mental imagery. The process lasted for two hours precisely and was again video recorded. The experimenter also intervened to ask V.S. about his mental imagery experience. (Replay time (RT) 00:00:00 - RT-2:00:00)

2.2 ANALYSIS AND RESULTS

The experiment was designed in a fashion to ensure that the details were not added while sketching the solution at the end. The final description of design solution was video recorded in stage 3 and the verbal record was used to cross check. Results showed that all the ideas, plans, features and details he showed in his final sketches were decided during the stage he was wearing a mask. His final description as well as his verbal protocol referred to all the decision suggesting that VS had worked everything in his images.

There are certain areas in planning, where his approach remained only at a conceptual level or alteration of specific spaces. (E.g. Service area and its overall appearance). He does not go into details of this area in his think aloud protocols nor in his final sketch. He probably treated this as 'routine' matter to be worked out in detail later, but never reached the stage. Thus some areas like kitchen, service yard, general toilet remained as space allocations only.

One would expect excessive usage of gestures as the subject was blindfolded. On the contrary the subject except for the initial part of site description refrains from usage of gestures. (Contrary to the experiments done on Industrial designers: Athvankar, 1997). The gestures are usually limited to talking gestures and don't have spatial accuracy with them (00:02:50). In fact the subject refrains from using gestures and sits with the hands folded. Since only one architect was studied it cannot be generalised.

V.S. dealing with the problem started with the broad allocation of spaces over the site, to be detailed later in the due course of session. He continuously switched back and forth to resolve issues, in a non-linear fashion (discussed in detail further in the paper). The verbal record during the design process served as a cue to recall the nature and details of imagery during the play back session. For analysis this relationship was documented as following.

play session time stamp	verbal record	remark	replay session time stamp	Reaction by V.S.	remark
00:27:05	As you enter there are car parks... the lawn is there... there is service yard	Resolving planning issues and modelling of spaces	00:47:44	Here I had conflicting images service yard and lawn Will there be a wall?	Had imagery of trucks & tempo entering the yard.

Since the area of focus was role of mental imagery in the design process, the instances where V.S. had occurrence of mental imagery were recorded first. These were later correlated with the play sessions.

The above data format was later analysed for factors as discussed below.

3.0 CREATION OF VIRTUAL DESIGN STUDIO IN THE MIND

In the absence of any externalisation medium viz. sketching V.S. had to rely on mental imagery to serve as a portrayal of his design and as a display to react. The entire design process appeared as if the designer was conceiving a 3D building in his mind's eye and kept modifying and shaping it through out. It was almost like working in a virtual design studio. These factors are discussed as follows:

3.1 Modelling of Spaces and Planning:

Mental imagery was used as a potential tool to develop and change built forms with great ease and speed. VS used it as a part of exploratory moves and reflected upon them in imagery.

Between 00:19:31 and 00:31:13 he decides on the number of trees and the volume of the built form by analysing the space available to him. In the replay session he comments-

RT-00:31:08- Something came to my mind ...a roof like this with mezzanine floor, triangular, with glazing on top.

The modelling ideas are much more clear in the later stages of the design. In the final description he changes his design. While walking towards the building in his imagery he finds the gable of dining hall disturbing and thus changes the front elevation.

RT-1:56:14- I realised that there was a lawn in the front and I did not want a triangular wall coming in.

V.S. was able to allocate spaces and later change them in his mind as the design developed. When he was reminded of the fact that the service road is in the site he quickly remodelled it.

00:26:10- Everything has to go inside the plot!!! My first image of Banyan tree as a part of the lawn has to change. The lawn has to shift more on left-hand side. The service entry will be on the extreme side. RT-00:45:10- I visualised a road from the broader side of the site. It was outside the plot, but when he said inside, a gate came to my mind. Huge large gate of metal.

3.2 3rd Dimension & Detailing of elements:

These modifications were not only limited to space allocations, but also to the elements of the built form viz. walls, windows, and roofs and their details. The rapidness, flexibility and volatile nature of mental imagery helps to handle these issues with much ease than sketching does. Treatments and details can be imagined, modelled and changed at a very high pace. For example, immediately after allocation of spaces V.S. proceeds to develop an image for the whole building. The image emerging in his mind stays the same till the end.

00:22:12 - Stone wall, Mangalore tile roofs, and lot of wood. I'd like to use glazing...

RT-00:34:53- It was like countryside as in..., sloping roofs, stone walls.

After resolving the general image, which showed fascination for use of stone and Mangalore roof tiles he tries to resolve the interiors. The first image of stone and tiles influence his details all the time. Even in the treatment of bedrooms (00:22:41) dining hall (00:47:40) the stone treatment finds its place repeatedly.

3.3 Presence and walkthroughs:

Perhaps one of the most rich experiences mental imagery offered, which sketching cannot, were walk through in the design process. Since VS was working with mental imagery he was able to walk through his building, switch viewpoints, move from inside to outside with great ease and take design decisions.

RT-00:37:10 - I am inside the room looking outside at the lawn.

RT-01:09:11 - From outside I saw the trees. From inside I visualised clean parking without the trees.

RT-01:37:40 - I was walking in the corridor & toilet was blocking the view.

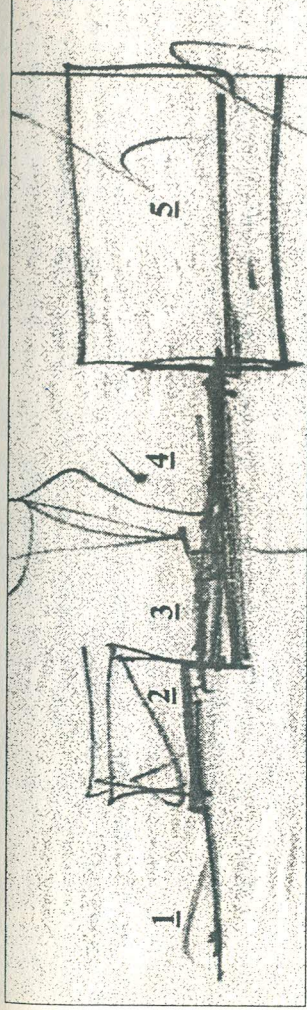
RT-01:46:30 - the level differences I saw from top.

He also assumed north to be closer to him (contrary to standard practice in drawing where north is away from the viewer). This was based on his knowledge of geography of the site (Goa being south of Bombay). He corrects this after viewing the drawing.

3.4 Visualisation of Spaces and their details:

The subject was at ease while visualising spaces with decoration and specific lighting conditions. VS was able to visualise and presence of light and noise while visualising the motel and site surroundings.

00:32:34- You'll get sun on the south side.



1. Lawn behind the rooms
2. Rooms
3. Corridor
4. Courtyard
5. Dining

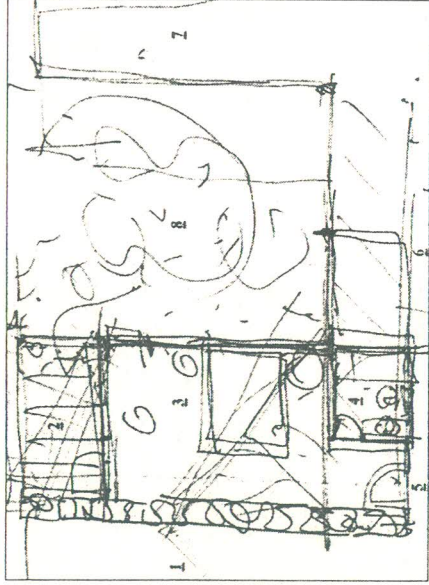
Sketch 2: Depicting the site section (Actual size 15 X 6 cm)

He evaluated in his mind that there will be shadow in the courts, which was conflicting to his initial images (RT-01:00:00). Also the noise from the railway tracks which prompted him to place a high wall on the railway track side (RT-01:11:24)

3.5 Conceive and view spaces with people:

V.S. was able to conceive spaces with people. Usually his imagery experience was in terms of built form but at 00:23:30, while detailing the room and adjoining spaces with privacy as the key factor, he was able to visualise people in the imagery. This presence of people was not reported anywhere else by him in the replay session.

RT-00:40:52- visualise people.. couple & child outside with a ball. The woman was wearing a sari.



1. Adjoining room
2. Sit out (referred as porch by VS)
3. Room
4. Toilet
5. Entrance door
6. Corridor
7. Room across the lawn
8. Lawn in between two rooms

Sketch 3: Depicting a typical room & surroundings (Actual size 28X25 cm)

4.0 Imagery and Image Bank

"Precedents" played a vital role in dealing with issues related to imagery. Image bank is a very personalised issue, which creates the distinct differences in solutions between individuals. While discussing the lobby he says:

00:47:40 - decorate it with hangings, crafts...

VS later informed (RT-01:47:28) that these details about interiors were triggered by an image of high walls of a fort and banners, crafts etc.

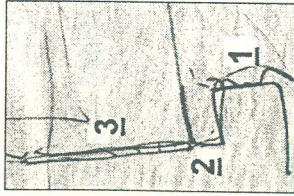
The origin of this image was unexplained. It was assumed that stone walls or previous visits to forts could've triggered these. Another possible bearing for the use of stone walls could be his previous conservation works in hills where stone and wood are predominant building materials. These imagery driven decisions also had bearing upon the strong notions he had about the site and the geography of the locale.

He is continuously visualising for the initial part of the experiment that lobby is biggest and reception and dining are attached spaces. This is contrary to the requirements, but goes with his image, which is derived from a five-star hotel (RT-00:11:41). At 00:19:50 he assumes setbacks of the site to be of 10m, which he admits (RT-00:16:00) to have taken from the 10m X 10m grid drawn on the drawing supplied.

There were instances where imagery prompted him to take design decisions viz. The Banyan tree prompting him to place a lawn around (RT-00:13:47) and the railway track to place the service block along with it (RT-00:24:10). Although there were other interesting imagery driven decision which could not be explained

00:58:56- the dining is floating...

VS added in the replay (RT-01:48:00) that he had an image of a swimming pool in mind, which was the basis of this decision. He could not explain the basis for this imagery. Swimming pool wasn't a part of the design requirement.



1. Dining room plinth set inside.
2. Cantilevered floor for floating effect
3. Full height windows

Sketch 4: depicting the section of dining room wall
Actual size 10X6 cm

VS was continuously visualising his design in a sunny environment. He continuously refers to light coming in through the windows in the room, across the court and in the dining room.

01:19:33 replay time- it was a sunny day, the stone was already there, greenery...

The subject later reported (apart from the experiment) that whenever he visualises a window, he starts by visualising a full size window with no wall. He focuses his attention on the light falling in and not on the window.

5.0 SIGNIFICANCE OF THE FINDINGS

The experiments point out the important role mental imagery plays in design thinking, at least when sketching is not used. The findings can be classified in to three parts.

Pedagogic Significance:

There are hardly any exercises imparted in the design training to develop or to use mental imagery as a creative tool. These findings suggest that mental imagery offers great speed and versatility while designing and has a pedagogic significance. However, it may not serve as a replacement to sketching, but act as a complimentary tool.

Most of the protocol analysis studies done on designers, especially architects were so focussed on sketching that the role of mental imagery was neither discussed in these findings nor was it studied. These studies focus more on to the visible behaviour of design and thus, these studies have left large part of the findings untouched. The results discussed here indicate the potential and versatility mental imagery offers to designers. Thus any serious study done on design behaviour should not neglect the role of mental imagery. Further, study of verbal protocols is not sufficient. There were instances of imagery like fort and banners which were reported only in the retrospective sessions (RT-01:47:28) in the experiment.

Significance for Computing and Artificial Intelligence:

In design sketching & imagery support many decisions. But the computing tools, existing CAD software and concept-sketching devices do not address these issues (Michael, 1988; Athvankar, 1990). It could be because mental imagery is a highly personalised experience. However there could be a facility developed with the current systems, which learns, grows and develops with the designers image bank.

Also the current research in AI on developing image banks, work on a system of logical thinking and deriving logical parallels between things. However the instances where the subject draws parallel from a fort wall (RT-01:47:28), in his mental imagery, to resolve aesthetic treatment to the motel lobby, which does not follow any logical reasoning.

6.0 UNRESOLVED ISSUES

Since only one subject was studied the findings cannot be generalised. There is a need to study more subjects in order to establish the results as a rule or a pattern. Thinking aloud may affect the natural flow of thought process or may not actually portray his mind. But this can be considered as the limitation of the experiment as there is no other way to access the image bank. There is need to find alternative ways of accessing mental imagery of the subject in a less obtrusive way.

Younger subjects, not studied here, may yield different results due to difference in image bank, experience and problem solving methodology.

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