CHAPTER III
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This chapter contains information on the various aspects of the plan of investigation. The problem, the research design, the variables, and the model showing the hypothesised relation among the variables in the study are explained. Operational definitions and the procedure followed for the development of the instrument for gathering relevant data are presented. The procedure for the collection of data and the plans for statistical analyses are also described under separate sections.

One of the major focuses of the study was to gain insight of the existing artificial lighting in the kitchens of residential buildings and to measure the illuminances in general as well as the work areas in the kitchen, namely, sink area, cooking area and pre-preparation or mixing area. Another equally important focus of the present investigation was to assess the visual performance of the subjects under differential levels of illumination and to measure differential levels of performance of the subjects on standard tests for visual acuity and, visual comfort through laboratory experimentation in simulated kitchen model created (set up) for the same in one of the rooms of the Home Management Residence, Department of Home Management of the M.S.University of Baroda. Research questions were mainly concerned with relationships between the selected dependent and independent variables that were studied through descriptive and experimental research designs respectively. The variables identified for the survey research design were classified into situational, personal and family variables whereas those of experimental design were classified into environmental, task and subject variables. The

situational variables included in the field survey part of the study were tenure and age of house, floor area of kitchen, room index, per cent effective ceiling and floor cavity reflectances, utilisation factor and maintenance factor. Personal variables studied were values held by the homemakers, knowledge level of homemakers and their spouses, and discomfort experienced by homemakers. Family income was the family variable that was identified for the present study. Further, illuminance conditions, brightness contrasts and age of subject were identified as environmental, task and subject variables, respectively in the laboratory experimentation part of the study.

1.0 A MODEL SHOWING HYPOTHESISED RELATION AMONG THE VARIABLES IN THE STUDY OF ARTIFICIAL LIGHTING IN KITCHEN

The proposed model on existing artificial illuminance condition in residential kitchen, and visual performance and visual comfort in the simulated kitchen is illustrated (Plate 1). The existing lighting condition in residential kitchens referred to the average ambient illuminance in the kitchen under artificial lighting. In other words, it means the pool of light under which a worker in the kitchen performs any given task. Kitchen provides the setting for various life supporting activities that are pursued day after day by the family. Families create certain illuminance in the kitchen to facilitate efficient task performance. The illuminance if inadequate, might put constraint on task performance.

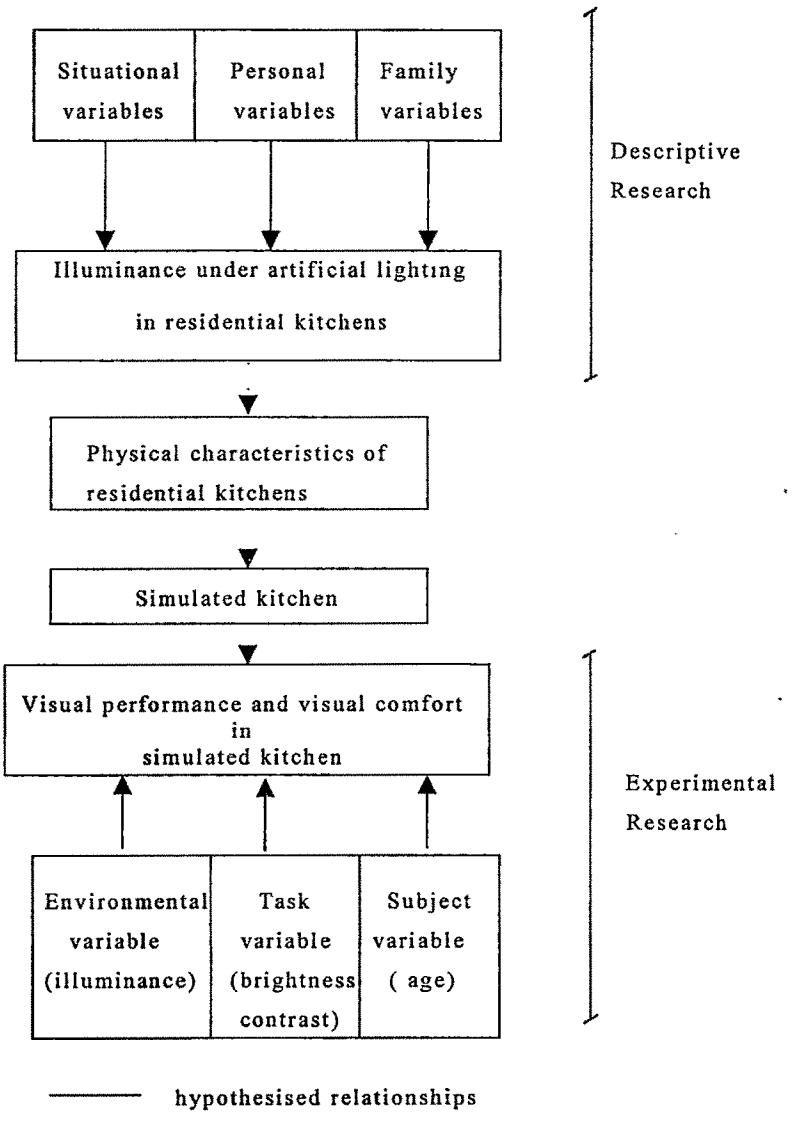
The present study was based on the premise that workers of varying ages perform tasks in the kitchen under artificial lighting. The artificial ambient illuminance available is influenced by situational, personal and family variable, like tenure and age of house, floor area

of kitchen, room index, per cent effective ceiling and floor cavity reflectances, utilisation factor, maintenance factor, values held of homemakers, knowledge level of homemakers and their spouses, discomfort experienced by homemakers and family income. In the model there are two distinct parts, one pertaining to field study and the other pertaining to laboratory experimentation. Through the field study, necessary database was built to design and develop simulated kitchen and this essentially provides the link between field survey part and experimental part of the present investigation. The upper half depicts the influence of situational, personal and family variables on the existing artificial illuminance condition in residential kitchen. On the other hand the lower half of the model exhibits the cause-effect relationship between environmental, task and subject variables and the visual performance and visual comfort in simulated kitchen.

As mentioned earlier the field survey apart from providing a measure of selected dependent and independent variables related to the study, provided the necessary data to design simulated kitchen. Thus simulated kitchen model was set up based on the field data on physical characteristics of the kitchens. Differential levels of illuminances were created in the simulated kitchen wherein subject performed two tests–one, a standard visual acuity test (landolt's ring test) and a second one specifically designed and developed for the present study, brownness discrimination test, to measure visual performance and visual comfort through laboratory experimentation. The laboratory experimentation was based on the premise that the impact of illuminance can be ascertained from differential levels of performance of the subjects on given tasks against different brightness contrasts and their perceived visual comfort in doing the tests. In other words, subjects' performance is influenced by illuminance conditions, brightness contrasts and age of the subjects. Once the impact of the

illuminance on the performance of subjects is established, it would facilitate recommendations to create adequate illuminance to attain the best performance in the most efficient manner.

Plate 1 : Model showing the hypothesised relation among the variables in the study of artificial lighting in kitchens.



In the model, the continuous lines represent the hypothesised relationships while the broken lines reveal an interception of the two

halves of the model indicating that the data pertaining to existing physical features of the residential kitchens provided a basis for creating the simulated kitchen. The application of data in this manner was resorted to, so that the results, conclusions and generalisations drawn through experimentation in simulated kitchen become more relevant to apply in the field.

2.0 OPERATIONAL DEFINITIONS

2.1 *Value* is a conception, explicit or implicit, distinctive of an individual or characteristic of a group, of the desirable which influences the selection from available modes, means and ends of action (Kluckholm, 1951).

2.1.1 *Aesthetics* in lighting pertains to sensuous perception experienced by the worker in lighting environment, i.e. perception of beauty of components of lighting set up from stand point of form, grace, elegance, symmetry or fitness to the totality - total interior decor of kitchen.

2.1.2 *Safety* through lighting is indicative of lighting condition that protects the worker from or guards the worker against all potential hazards and accidents. In other words, it refers to a lighting condition that provides freedom from hurt and injury.

2.1.3 *Modernism* in lighting pertains to use of latest, up-to-date and innovative state-of-art in lighting technology, i.e. use of contemporary styles of lighting systems that are expressive of present times.

2.1.4 *Comfort* with reference to lighting refers to state of contentment of the worker in a lighting environment that induces ample convenience and visual well-being in terms of being free from any kind of discomfort and strain while performing visual tasks.

2.1.5 *Economy* in the realm of lighting implies frugality, thrift and judicious handling of different aspects of lighting to avoid wastage of material resources or to avoid extravagance.

2.1.6 *Work Efficiency* in a given lighting environment implies a state of lighting which assures accomplishment of work with minimum expenditure of time and effort.

2.2 *Lighting or Illumination* is the application of light to a scene, objects or their surroundings so that they may be seen (Philips Lighting Manual, 1993).

2.2.1 *General Lighting* is lighting designed to illuminate the whole of an area without provision for special local requirements (IES, 1973). General lighting provides for substantially uniform lighting of an area without provision for special local requirements (Philips Lighting Manual, 1993).

2.2.2 *Local Lighting* is lighting designed to illuminate a particular small area which usually does not extend outside the visual task (IES, 1973). Local lighting refers to lighting for a specific visual task, additional to and controlled separately from the general lighting (Philips Lighting Manual, 1993).

2.2.3 *Localised Lighting* is lighting designed to illuminate an interior and at the same time to provide higher illuminance over a particular part or parts of the area (IES, 1973). Localised lighting is lighting designed to illuminate an area with higher illuminance at certain specified positions, for instance those at which work is carried out. (Phillips Lighting Manual, 1993).

2.2.4 *Diffused Lighting* refers to lighting in which the flux comes from many directions none of which predominates (IES,1973). Diffused lighting occurs when the light on the working plane or on an object is not incident predominantly from a particular direction (Philips Lighting Manual, 1993).

2.2.5 *Direct Lighting* refers to lighting in which the greater part of the flux from the luminaire reaches a surface (usually the working plane) directly, i.e., without reflection from surrounding surfaces (IES, 1973). Direct lighting refers to lighting by means of luminaires with a light distribution such that 90 to 100 per cent of the emitted flux reaches the working plane directly, assuring that this plane is unbounded (Philips Lighting Manual, 1993).

2.2.6 *Indirect Lighting* refers to lighting in which the greater part of the flux reaches a surface (usually the working plane) only after reflection at other surfaces and particularly at the roof or ceiling (IES, 1973). Indirect lighting occurs when lighting by means of luminaires with a light distribution such that not more than 10 per cent of the emitted luminous flux reaches the working plane directly, assuring that this plane is unbounded (Philips Lighting Manual, 1993).

2.3 *Luminous Environment* refers to lighting in a given environment considered in relation to its physiological and psychological effects (Philips Lighting Manual, 1993).

2.4 *Work or Working Plane* is the reference surface defined as the plane at which work is usually done (Philips Lighting Manual,1993).

2.5 *Mounting Height* is the distance between the reference plane and the plane of the luminaire (Philips Lighting Manual,1993).

2.6 *Room Index* is an index related to the dimensions of a room

Room index = $lw/h_m (L+W)$

Where l is the length of the room, w the width and h_m the mounting height of the luminaire above the working plane (IES, 1973).

2.7 *Illuminance* refers to the luminous flux density at a surface, i.e., the luminous flux incident per unit area. This quantity was formerly known as the illumination value or illumination level (IES, 1973).

2.8 *Average Illuminance* refers to Illuminance averaged over a specified surface (Philips Lighting Manual, 1993).

2.9 *Uniformity Ratio of Illuminance* is a measure of the variation of illuminance over the plane expressed as either :

1) the ratio of the minimum to the maximum illuminance.
2) the ratio of the minimum to the average illuminance (Philips Lighting Manual, 1993).

2.10 *Utilisation Factor* is the ratio of the utilised flux to the luminous flux emitted by the lamps (Philips Lighting Manual, 1993).

2.11 *Utilised Flux* is luminous flux received on the reference surface under consideration (Philips Lighting Manual, 1993)

2.12 *Reflectance* of a surface is the ratio of the flux reflected from a surface to the flux incident on it (IES, 1973).

2.13 *Ceiling or Floor Cavity Reflectance* refers to equivalent reflectance of the room volume above the plane of the luminaires, or of the room volume below the working plane (IES, 1973).

2.14 *Glare* refers to a condition of vision in which there is discomfort or a reduction in the ability to see significant objects, or both, due to an unsuitable distribution or range of luminance or due to extreme contrast in space or time (Philips Lighting Manual, 1993).

2.15 *Lighting System* refers to the lighting scheme of a room in terms of lighting method (General / Local); type, number, wattage and position of the lamp(s) / luminaire (s); and distribution of light.

2.16 *Illuminance under Artificial Lighting* in kitchen refers to the ambient horizontal illuminance provided by the existing electric source(s) of light in the given kitchen interiors.

2.17 *Average Daylight Factor* is the ratio of average ambient daylight illuminance indoors to ambient daylight illuminance outdoors during a stipulated period of time.

2.18 *Visual Acuity* refers to the sharpness of vision. In qualitative terms it is the capacity for seeing distinctly objects very close together, while quantitatively it is the reciprocal of the value (generally in minutes of arc) of the angular separation of two neighbouring objects (points or lines) which the eye can just perceive as being separate (Philips Lighting Manual, 1993).

2.19 *Visual Capacity* implies for the clinical condition of the eye of a person with reference to his / her eye sight and colour vision. In other words it is physiological range of visual sensitivity (Weston, 1949).

2.20 *Visual Performance* refers to the quantitative assessment of the visual system in the performance of a visual task in terms of accuracy (Philips Lighting Manual, 1993). Visual performance was assessed under differential levels of illuminances (500 lx, 300 lx, 166 lx, 100 lx, 72 lx and 17 lx) using visual acuity test against different brightness contrasts (0.89, 0.61 and 0.57) and brownness discrimination test. The visual acuity test comprised of identifying correct gap orientation of landolt's rings with details subtending visual angles of 11' 17 " (test object 'A'), 9' 1" (test object 'B') and 6 ' 46 " (test object 'C') falling in the category of large size ; 4' 3 " (test object 'D') and 3' 23 " (test object 'E') falling in the category of medium size ; 2' 15 " (test object 'F') falling in the category of medium-small size and ; 1' 29" (test object 'G') and 1' 8 " (test object 'H') falling in the category of small size. Brownness discrimination test

comprised of identifying the degrees of brownness of 14 samples of semolina roasted to varying degrees of brownness and one sample of raw item. The visual acuity test against selected brightness contrasts and brownness discrimination test were administered on the subjects under each of the selected illuminances created in the simulated kitchen.

2.21 *Accuracy factor* refers to the number of landolt's rings correctly marked expressed as a fraction of the total number which should have been marked. The visual performance data on each of the rings was used to compute accuracy factor.

2.22 *Level of visual performance* on visual acuity test (LoP I) refers to the extent to which the gap orientation of landolt's rings of large size (test object 'A'), medium size (test object 'D'), medium-small size (test object 'F') and small size (test object 'G') were correctly identified. A sum of the correct responses on test object A, D, F and G reflected overall LoP I (OLoP I).

OLoP $I_{L.BC}$ represents the sum of OLoP I against all three the brightness contrasts under all the selected six illuminances. In other words, it reveals the combined effect of brightness contrasts and illuminaces on OLoP I.

LoP $I_{L.BC\text{-}L}$ refers to the sum of LoP I on large size of landolt's rings (test object 'A') against all the three brightness contrasts under all the selected six illuminances. It depicts the combined effect of brightness contrasts and illuminances on large size landolt's rings.

LoP $I_{L.BC\text{-}M}$ refers to the sum of LoP I on medium size of landolt's rings (test object 'D') against all the three brightness contrasts under all the selected six illuminances. It depicts the

combined effect of brightness contrasts and illuminances on medium size landolt's rings.

LoP $I_{L.BC\text{-}MS}$ refers to the sum of LoP I on medium-small size of landolt's rings (test object 'F') against all the three brightness contrasts under all the selected six illuminances. It depicts the combined effect of brightness contrasts and illuminances on medium-small size landolt's rings.

LoP $I_{L.BC\text{-}S}$ refers to the sum of LoP I on small size of landolt's rings (test object 'G') against all the three brightness contrasts under all the selected six illuminances. It depicts the combined effect of brightness contrasts and illuminances on small size landolt's rings.

OLoP I_{BC} represents the sum of OLoP I against all the three brightness contrasts under each of the selected illuminances. In other words, it reveals to the main effect of illuminaces on OLoP I.

LoP $I_{BC\text{-}L}$ refers to the sum of LoP I on large size of landolt's rings (test object 'A') against all the three brightness contrasts under each of the selected six illuminances. It indicates the main effect of illuminances on LoP I on large size landolt's rings.

LoP $I_{BC\text{-}M}$ refers to the sum of LoP I on medium size of landolt's rings (test object 'D') against all the three brightness contrasts under each of the selected six illuminances. It indicates the main effect of illuminances on LoP I on medium size landolt's rings.

LoP $I_{BC\text{-}MS}$ refers to the sum of LoP I on medium-small size of landolt's rings (test object 'F') against all the three brightness contrasts under each of the selected six illuminances. It indicates the main effect of illuminances on LoP I on medium-small size landolt's rings.

LoP $I_{BC\text{-}S}$ refers to the sum of LoP I on small size of landolt's rings (test object 'G') against all the three brightness contrasts under each of the selected six illuminances. It indicates the main effect of illuminances on LoP I on small size landolt's rings.

OLoP I_L represents the sum of OLoP I against each of the selected brightness contrasts under all the selected six illuminances. In other words, it projects the main effect of brightness contrasts on OLoP I.

LoP $I_{L\text{-}L}$ represents the sum of LoP I on large size of landolt's rings (test object 'A') against each of the selected brightness contrast under all the selected six illuminances. It depicts the main effect of brightness contrasts on LoP I on large size landolt's rings.

LoP $I_{L\text{-}M}$ represents the sum of LoP I on medium size of landolt's rings (test object 'D') against each of the selected brightness contrast under all the selected six illuminances. It depicts the main effect of brightness contrasts on LoP I on medium size landolt's rings.

LoP $I_{L\text{-}MS}$ represents the sum of LoP I on medium-small size of landolt's rings (test object 'F') against each of the selected brightness contrast under all the selected six illuminances. It depicts the main effect of brightness contrasts on LoP I on medium-small size landolt's rings.

LoP $I_{L\text{-}S}$ represents the sum of LoP I on small size of landolt's rings (test object 'G') against each of the selected brightness contrast under all the selected six illuminances. It depicts the main effect of brightness contrasts on LoP I on small size landolt's rings.

2.23 *Visual Comfort* refers to the degree of visual satisfaction produced by the visual environment (Philips Lighting Manual, 1993).

2.24 *Visual Skill* is a skill which is the outcome of purposive and selective use of the physiological range of visual sensitivity (Weston,1949), e.g., observation power, rate of visual perception.

2.25 *Landolt's Ring* is a two dimensional ring with a gap, the width of the gap and the thickness of the ring each being equal to 1/5 of the outer diameter of the ring (Philips Lighting Manual, 1993).

2.26 *Brightness Contrast* can be expressed in terms of the reflection factors of the objects concerned, provided these objects are equally illuminated. Numerical index of the degree of contrast is the ratio of the difference between the reflection factors of the contrasted surfaces to the higher value of the pair (Weston, 1949).

Index of degree of contrast = $r_x - r_y / r_x$

r_x - reflection factor of surface x

r_y - reflection factor of surface y

For the present study brightness contrast was between the work object (Landolt's rings) and the background against which the object was seen.

3.0 SECTION I : ASSESSMENT OF ARTIFICIAL LIGHTING IN RESIDENTIAL KITCHENS

One of the major objectives of the study was to throw light on the existing natural and artificial lighting conditions in residential kitchens and to probe into the personal, family and situational factors affecting the existing artificial lighting conditions.

Further, in order to create the simulated kitchen it was imperative to assess the physical features of the existing kitchens, as well. Descriptive research design, wherein survey method was an integral part, was thought to be the most appropriate for the field study in the present investigation. In the ensuing paragraphs, the details of the survey in terms of the development of tools for data collection, sample selection, survey procedure and analysis of the data are presented.

3.1 Tools for Data Collection

Questionnaire Cum Observation Schedule was resorted to build up the data for the present investigation. The main reasons for adopting the questionnaire method were based on the following merits of its use, as pointed out by Rao, 1993 :

(1) It is less expensive to administer.

(2) It avoids bias of the investigator.

(3) It is effective because the respondents are able to express their reactions clearly with greater openness as there is less fear when there is no immediate listener.

(4) It places less pressure on the respondents for immediate responses.

The observation schedule served as an objective recording device which made possible accurate entry of data and it aided to concentrate on the circumscribed elements essential to the analysis.

The objectives drawn for the study guided the development of an appropriate questionnaire cum observation schedule, having four distinct sections. The first section of the schedule dealt with questions related to the background information of the sample and information pertaining to kitchen lighting. The second section comprised of an Artificial Lighting Value Scale (ALVS) and queries regarding discomfort experienced by the worker, herein, the home maker, while working under the existing artificial lighting conditions in the kitchen. The third section of the schedule was meant to elicit information on preferences of the homemaker for lighting system and colour scheme in the kitchen. It also constituted an Artificial Lighting Knowledge Test (ALKT) for homemakers and their spouses. The artificial lighting illumination survey was facilitated with the help of an observation schedule titled Illumination Survey Form (ISF), which occupied the last section of the questionnaire cum observation schedule. The ISF dealt with the detailed description of the kitchen interior and lighting provisions, and measurement of ambient illuminance and illuminances at three selected task areas. In addition, a Daylight Survey Sheet (DSS) was also included to determine the amount of daylight available in the kitchen.

3.1.1 Development of instrument to measure values

The assessment of values related to artificial lighting required a standardised scale. The value scale developed by Allport, Vernon and Lindzey (1960) served as an useful aid in constructing the tool for assessing values in the present study. Six values, namely, aesthetics, comfort, economy, modernism, safety and work-efficiency were

identified as relevant values in the context of artificial lighting in kitchen. The ALVS was designed primarily to measure the relative importance of the selected six values in the homemaker's scheme for artificial lighting in the kitchen. The ALVS was designed in two parts. Part-I of the scale was designed to elicit information regarding the relative predominance of the six selected values through paired comparison technique, while a rating scale was adopted for Part-II of the ALVS.

3.1.1.1 Item collection

The content of the scale comprised of statements called items. Each item comprised of two alternatives in Part-I and four alternatives in Part-II of the ALVS. The most important factor considered in framing the item was that each of its alternatives should exclusively reflect any one of the six selected values. The items were constructed on the basis of literature surveyed and original ideas of the investigator. These were then edited in the process of discussions with the guide. The following criteria were borne in mind while editing the statements :

(1) The statements should be brief, clear and straight forward.
(2) The statements should be as simple as possible.
(3) No statement should have double negatives or other confusing expressions.
(4) Double barrelled statements should be avoided.
(5) The statements should be such that persons with different views and ideas, as far as a particular value is concerned, can endorse or reject it in accordance with their agreement or disagreement with the value.

The Part-I of the ALVS initially had forty-two items while Part - II had twenty-one items.

3.1.1.2 Content validity of the scale

The carefully edited items were then submitted to a panel of fifteen judges for content validation. The judges were experts from the Department of Architecture, Psychology, Human Development and Family Studies and Home Management , the M.S. University of Baroda. The judges were requested to indicate the clarity of each statement listed in the scale and to place it in one of the six categories where it fitted the best. The six categories were : (1) aesthetics, (2) comfort, (3) economy, (4) modernism, (5) safety and (6) work-efficiency. The operational definition of each of the values was also furnished to the judges.

(1) Any statement reported as clear by seventy-five per cent or more of the judges was included in the ALVS.
(2) The statements on which seventy-five per cent or more of the judges showed agreement with regard to the category where it fitted the best were included in the ALVS.

Wherever sixty-seven per cent or more of the judges showed agreement necessary modifications were made in the statement and were then included in the ALVS to provide for equal number of statements for each value under consideration.

Thus out of the original set of sixty-three items, fifty-one items, with thirty-three and eighteen items in Part-I and Part-II respectively, satisfied both the criteria and were included in the ALVS for pilot study (Appendix I.1).

3.1.2 Development of instrument to measure knowledge

A standardised Artificial Lighting Knowledge Test (ALKT) was used to measure the knowledge of the homemakers and their spouses in this regard. The ALKT comprised of items related to basic concepts of lighting like current, power, illuminance, lumen output, colour temperature and colour of light; quality of light; types of lamps, its uses and availability in the market and principles or guidelines for planning kitchen lighting. It also included selected items pertaining to electricity like current and power.

3.1.2.1 Item Collection

Items relevant to the various aspects to be covered in the knowledge scale were gathered through extensive and intensive survey of available literature. The knowledge scale thus developed initially had thirty-eight statements (Appendix I.2).

3.2 Pilot Study

A sample of forty residential units, comparable to the final sample, were identified for the purpose of pilot study. The entire set of data except the observations on existing artificial lighting in kitchen were gathered through questionnaire method. The homemakers drawn from the forty residential units were the primary respondents of the study on whom the entire questionnaire was administered, while their spouses responded to the ALKT only. The knowledge scale was administered simultaneously but independently to both the homemakers and their spouses in the presence of the investigator. However, in ten cases the spouses were not available due to circumstances beyond the control of the investigator.

Data pertinent to existing artificial lighting in kitchen were gathered by the investigator through field measurements using an ISF.

Minor changes and additions were made in the questionnaire and ISF wherever necessary on the basis of the pilot study.

The responses on the ALVS and ALKT were scored, coded and subjected to statistical verification for establishing the reliability of the instruments and for constructing the final scales.

3.2.1 Reliability of the value scale

The complete scale was divided into six parts, each part constituting statements affiliated to a particular value and reliability co-efficient was computed for each of the six sub scales.

Split half technique was used to establish the reliability of the sub scales. In this method each sub scale was further subdivided into two halves using odd numbered statements for one half and even numbered statements for the other half. Each of the two sets of statements was treated as separate scales. The respondents who scored high on odd numbered statements should score high on even numbered statements as well, if empirical errors have been kept to a minimum and the same applies in the case of low scores as well. The coefficient of correlation computed using Pearson Product Moment formula served as a measure of reliability. From the self correlation of the half tests, the reliability coefficients of each of the six sub scales were estimated using Spearman Brown Prophecy formula which states

$$r_{rel} = 2.r \,/\, 1 + r$$

where r_{rel} is the reliability coefficient and r is the correlation coefficient.

The correlation coefficient and reliability coefficient of each sub scale was as given below :

Values	r	r_{rel}
Aesthetics	0.72	0.84
Comfort	0.54	0.70
Economy	0.68	0.81
Modernism	0.87	0.93
Safety	0.67	0.80
Work Efficiency	0.64	0.78

The mean reliability coefficient, using Z transformation was 0.82. Item analysis was then carried out to ascertain whether the items were differentiating and the scores were properly assigned. All the correlation coefficients were positive. Based on the reliability data from item analysis, thirty items were selected from Part I and fifteen items from Part II for inclusion in the final scale (Appendix II).

3.2.2 Reliability of knowledge test

Split half technique was employed in estimating the reliability of the knowledge test. The correlation coefficients worked out to be 0.58 and 0.73 in case of tests administered to homemakers and their husbands respectively. The reliability coefficients computed by Spearman Brown Prophecy formula were 0.73 and 0.84 respectively.

3.2.3 Item analysis of the knowledge test

The two indices that were computed under the item analysis were the index of difficulty value and the index of validity value. Index of difficulty determines the degree of difficulty of an item while index of validity indicates how well an item measures or discriminates

in agreement with the rest of the test. The extent to which an item discriminates the well informed from the poorly informed respondents is judged from the item validity index or the index of discrimination.

To gather data for item analysis of 38 items during the pilot study, the scale was administered to 40 homemakers and 30 husbands. The total scores earned by the homemakers and husbands on the ALKT were individually entered in descending order and were further categorised into three groups, namely, high scorers, moderate scorers and low scorers.

3.2.3.1 Item difficulty index

The index of difficulty of an item was computed by averaging the proportions of correct response in the upper 27 per cent and the lower 27 per cent of the total respondents. The items with item difficulty value ranging from .20 to .80 were considered for inclusion in the final knowledge test.

3.2.3.2 Item validity index

The validity index of an item, i.e., its discriminative power, was determined by biserial correlation, which gave the correlation of an item with the total score on the test. The validity indices were found by interpolation in the table of normalised biserial coefficient of correlation (Flanagan, 1955). Items with validity indices of 20 were regarded as satisfactory and were included in the final knowledge test. The final test thus developed had twenty five statements (Appendix II).

3.3 Data Collection Procedure and Scoring of the Instruments

In order to carry out the illumination survey under the present study, visits to the families of selected residential units were made during late evening and night hours i.e., between 7:00 p.m. to 10:00 p.m., so that artificial lighting could be measured under its normal condition of use. During the pilot study, investigator encountered difficulty in getting cooperation from unknown families due to the peculiar nature of the present study. Hence the sample of the study comprised of purposively chosen residential units of 208 families of students undergoing B.Sc. Programme of study in the Faculty of Home Science.

The familiarity with the families through the students facilitated the collection of data. Thus the questionnaires were distributed to 208 families, questionnaire was returned by only 191 respondents where the homemaker was at least a graduate and could read, write and express fluently in English language. The homemaker formed the primary respondent and reported on personal as well as general data. The ALKT was administered on both the homemakers and their spouses separately. The terms 'homemakers' and 'housewives' are used interchangeably through out the text.

For the purpose of collection of data, the investigator took assistance of four field enumerators who were adequately trained prior to field data generation. Once the enumerators became well versed with the process of eliciting data, the final data collection began.

The enumerators were equipped with letters of introduction to the respondents. They made appointment with the respondents prior to visiting their homes. At the outset itself they intimated the respondents the purpose of the study and importance of their cooperation for the successful completion of the study.

The enumerators reported the progress of work every day. They followed the time frame for data collection that was prepared by the investigator. Random checking of the field enumerators was a regular feature to ensure authentic data generation, the frequency of the same being more in the initial phase of data generation.

3.3.1 Soliciting data pertinent to baseline characteristics and related aspects

First of all, detailed information regarding background characteristics of the sample, tenure of housing, involvement of family members and professionals in planning of lighting system in the kitchen, sources of information regarding lighting products, and willingness to incur expenditure to make alterations in existing lighting provisions were gathered. Information was collected regarding power consumption during a period of six months in terms of the amount paid and units of power consumed from the record of bills that were maintained. Respondents were further asked to reflect upon their objectives regarding artificial lighting in kitchen.

3.3.2 Values underlying artificial lighting in kitchen

The questionnaire comprised of a standardised scale to measure the values held by the respondents regarding artificial lighting. Paired comparison technique and rank order technique were adopted for the measurement of values in Part I and Part II of ALVS respectively. Part-I of the ALVS consisted of thirty items, each having two alternative answers. The respondents were required to indicate their relative preference for the two alternatives by giving them scores in a manner that the sum of the score of the two alternatives would always be three. In other words, the distribution of the scores for the two alternatives could be, 3 and 0 or 0 and 3 or 2 and 1 or 1 and 2 with the

higher score being indicative of higher preference. Part II of the ALVS comprised of fifteen items, each of which was provided with four possible value options for rank ordering. The respondents were required to rank order preference for the given alternatives by allotting a score of 4,3,2 and 1 in descending order of preference.

In case the respondents omitted any item due to inability to make a choice, a score of 1 1/2 was assigned to each of the two alternatives to make the sum of the score equal to 3 on such items in Part I. While in Part II, a score of 2 1/2 was assigned to each of the four value alternatives to make the sum of the scores on such items equal to 10.

The total of the scores received on the twenty options from 10 items pertaining to a particular value was the score for that value. Thus scores for each of the six values were obtained. The score for each value ranged between 10-70 and was indicative of its relative importance among the other values in the homemaker's scheme for artificial lighting in kitchen.

3.3.3 Knowledge regarding artificial lighting

A knowledge test was constructed and standardised to assess the knowledge level of the homemakers and their spouses regarding artificial lighting. The ALKT constituted of 25 items and was administered personally to the homemakers and their husbands individually. Each of the responses was checked for its correctness and a score of 2 was assigned to each correct answer with a score of 1 assigned to an incorrect item. The scores were interpreted such that the higher the score, the better the knowledge level. The range of scores was from 25 to 50.

3.3.4 Discomfort experienced under artificial lighting in kitchen

The discomfort experienced by homemakers while working under existing artificial lighting in kitchens was assessed in relation to physical, mental and functional discomfort. The data were gathered by means of a check list constituting 24 statements. A score of '1' was assigned if the respondent revealed discomfort and '0' if no discomfort was indicated. The range of score was from 0 to 24, higher score indicating higher discomfort.

3.3.5 Preferences for lighting system and colour scheme in kitchen

Preference of the homemaker for lighting system in kitchen was ascertained in terms of lighting method (general lighting / a combination of general and task lighting), type, number, wattage rating and position of lamp (s) and use of shade. The respondents were required to mark their preferences on perspective drawing of a kitchen provided to them. The respondents were asked to indicate the most preferred hue on a four point value scale with white or very light, light, medium and dark for the walls, ceiling, floor, and work surface in the kitchen.

3.3.6 Illumination survey

The existing lighting conditions in the kitchens were assessed with regard to artificial and natural lighting. The illumination survey procedure is described in the ensuing paragraphs.

3.3.6.1 Illumination survey procedure for artificial lighting

The data on artificial lighting were gathered from kitchens of 208 residential units of the sample covered. Along the lines of I.E.S. footcandle survey form (1954), an Illumination Survey Form (ISF) was developed to record data pertaining to room dimensions and layout of

the work platforms, characteristics of room surfaces, existing lighting system, quality of lighting in terms of shadow and glare and ambient illuminance and illuminance at cooking area, sink area, and pre-preparation (mixing) area.

Criteria developed by the IES (1954 and 1973) for making photometric measurements were followed in the present study. Prior to recording the data pertinent to artificial lighting, the concepts of light source seasoning period and warm-up period were taken into consideration in the following manner :

(a) The light source seasoning period in the case of discharge source system, particularly the fluorescent type, was fulfilled for the recording of illuminance if it had been operated for a total of atleast 100 hours at the time of measurement. In case of incandescent lamps the seasoning period was 6 hours of operation at labelled volts. This was done to achieve stabilisation of light output.

(b) The warming up period for the discharge source system was its continuous operation for atleast half an hour prior to taking the reading for illuminance.

Precautions with reference to the use of the photometer included the following:

(1) The photocell of the photometer was kept exposed to light for about five minutes before taking the first reading.
(2) Care was taken not to cast a shadow on the photocell while readings were taken.
(3) The surface of the photocell was kept clean prior to its use every time.

3.3.6.1.1 Procedure for the measurement of illuminance under artificial lighting

Illuminance measurements for artificial lighting in the residential kitchens were taken after dark, between 7.00 hours and 10.00 hours. Measurement of Illuminance was done using a digital photometer (lutron LX-101) having a cosine-corrected and colour-corrected photocell.

3.3.6.1.2 Measurements of ambient illuminance under artificial lighting

The floor area of each kitchen was divided into a regular grid of modular sections, each section being nearly a square. The illuminance at the centre of each square was measured by placing the photometer in a horizontal plane at a height of 81 cm above the floor. A portable wooden stand was used to support the instrument at the correct height and in horizontal position. For the present survey, the number of measurement points were more than double the number of points given by IES (1973) to get higher accuracy in measurements. Ambient illuminance was obtained by computing the mean value of all the measured readings (Plate 2).

3.3.6.1.3 Measurement of task area illuminance under artificial lighting

For assessing the illuminance at specific task points, three work areas, namely, the cooking area, pre-preparation area and sink area, were distinctly identified in each kitchen.

Cooking Area included the gas burner with a maximum work space of one foot on either sides.

PLATE 2 : FIELD ENUMERATOR TAKING READING FOR GENERAL AMBIENT ILLUMINANCE

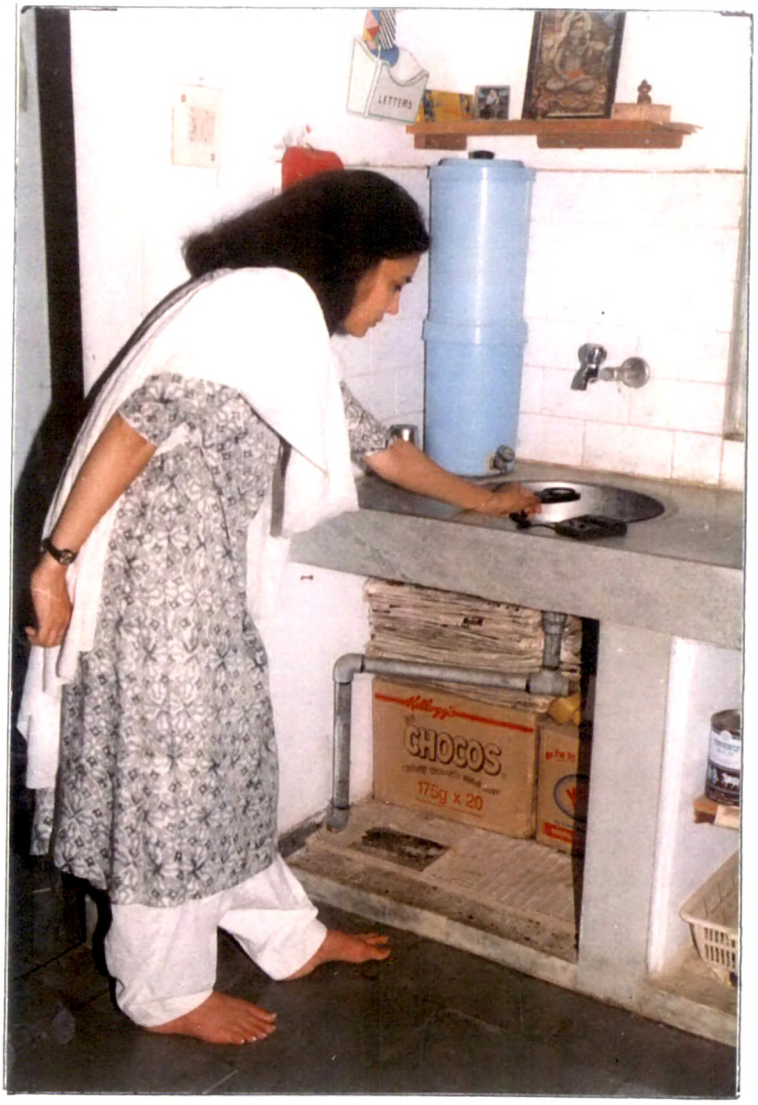


PLATE 3 : FIELD ENUMERATOR TAKING ILLUMINANCE READING AT SINK AREA

Sink Area included the sink bowl with a maximum work space of one foot either sides.

Pre-preparation Area included the maximum work space of 3 feet where the homemaker performed the pre-preparation activities like cutting, chopping, mixing and kneading.

Each of the three work areas were divided into small square areas of approximately 20cm x 20 cm and illuminance was measured at the centre of each area by placing the photometer on the work surface. Average Illuminance for each of the work area was computed from the measured values at the respective area (Plate 3).

3.3.6.2 Daylight survey procedure

The purpose of daylight survey was to determine the average ambient illuminance and average illuminance at the three work areas under natural lighting. Data pertaining to daylight illuminance was recorded in a Daylight Survey Sheet (DSS). Observations regarding solar orientation, and window and door apertures provided on the exterior walls of the kitchen, window treatment(s), measurement of daylight illuminance in the kitchen and measurement of outdoor illuminance. The survey to build up data on daylight was carried out during 11.00 hours to 13.00 hours with reference to all residential units.

3.3.6.2.1 Measurement of daylight illuminance in the kitchen

Measurement of daylight illuminance was carried out using a photometer and the procedure followed was similar to the one adopted for measurement of illuminance under artificial lighting. However, the number of points of measurements were decided as per the guidelines given by IES (1973) based on the room index.

3.3.6.2.2 Measurement of daylight illuminance available outdoors

It was mandatory to measure exterior illuminance for the purpose of calculation of average daylight factor. Outdoor illuminance under daylight was measured along with the indoor illuminances. The measurement of outdoor illuminance was restricted to one reading.

3.3.7 Lighting calculations

Room index (K), per cent effective ceiling cavity reflectance (p_{CC}), effective floor cavity reflectance (p_{FC}), maintenance factor (MF) and utilisation factor (UF) and the daylight factor (DF) were computed using the data gathered through the ISF and DSS by standard procedures for calculation (Hopkinson, 1963 ; IES, 1973 ; Philips Lighting Course ; Philips Lighting Manual, 1993).

3.4 Analysis of Data

3.4.1 Categorisation of the sample for the purpose of analysis

The following variables were categorised by taking the mean scores of the entire sample and the standard deviations into consideration. Thus mean plus standard deviation or more ($\bar{X} + \sigma$ or more) formed the group - high, mean minus standard deviation or less ($\bar{X} - \sigma$ or less) formed the group - low, and mean minus standard deviation to mean plus standard deviation ($\bar{X} - \sigma$ to $\bar{X} + \sigma$) formed the group - moderate, as the case might be

(1)	Family income	(i) Low	< Rs. 5405.01
		(ii) Moderate	Rs.5405.01 to Rs.23446.51
		(iii) High	> Rs. 23446.51
(2)	Age of house	(i) New	< Rs. 2.46 years
		(ii) Moderate	2.46 to 22.96 years
		(iii) Old	> 22.96 years

3.0	Values			
3.1	Aesthetics	(i)	Low	< 25.95
		(ii)	Moderate	25.95 to 39.97
		(iii)	High	> 39.97
3.2	Comfort	(i)	Low	< 39.09
		(ii)	Moderate	39.09 to 49.73
		(iii)	High	> 49.73
3.3	Economy	(i)	Low	< 36.37
		(ii)	Moderate	36.31 to 48.97
		(iii)	High	> 48.97
3.4	Modernism	(i)	Low	< 31.20
		(ii)	Moderate	31.20 to 43.58
		(iii)	High	> 43.58
3.5	Safety	(i)	Low	< 33.67
		(ii)	Moderate	33.67 to 45.41
		(iii)	High	> 45.41
3.6	Work efficiency	(i)	Low	< 37.44
		(ii)	Moderate	37.44 to 48.58
		(iii)	High	> 48.58
(4)	Knowledge of husband	(i)	Low	< 35.01
		(ii)	Moderate	35.01 to 43.29
		(iii)	High	> 43.29
(5)	Knowledge of homemakers	(i)	Low	< 33.42
		(ii)	Moderate	33.42 to 41.84
		(iii)	High	> 41.84
(6)	Discomfort experienced	(i)	Low	< 0.89
		(ii)	Medium	0.89 to 8.03
		(iii)	High	> 8.03
(7)	Floor area of the kitchen	(i)	Small	< 6.24 m^2
		(ii)	Medium	6.24 to 12.02 m^2
		(iii)	Large	> 12.02 m^2

(8)	Room index	(i)	Small	< 0.58
		(ii)	Medium	0.58 to 1.38
		(iii)	Large	> 1.38
(9)	Effective ceiling	(i)	Low	< 43.03 per cent
	cavity reflectance	(ii)	Medium	43.03 to 65.11 per cent
		(iii)	High	65.11 per cent
(10)	Effective ceiling	(i)	Low	< 18.25 per cent
	cavity reflectance	(ii)	Medium	18.25 to 42.21 per cent
		(iii)	High	> 42.21 per cent
(11)	Maintenance factor	(i)	Low	< 0.76
		(ii)	Medium	0.76 to 0.92
		(iii)	High	> 0.92
(12)	Utilisation factor	(i)	Low	< 0.14
		(ii)	Medium	0.14 to 0.42
		(iii)	High	> 0.42
(13)	Illuminance under	(i)	Low	< 34.82 lx
	artificial lighting	(ii)	Moderate	34.82 to 76.96 lx
		(iii)	high	> 76.96 lx

Tenure of housing was categorised as (i) rented and (ii) owned for the purpose of analysis.

3.4.2 Statistical analysis of data

Out of 208 residential lighting survey questionnaires distributed, seventeen were not returned. Hence the stastical analysis was based on data gathered from 191 housewives and 184 husbands (seven female respondents were widows). On the other hand, data on 208 residential kitchens gathered through illumination survey form were utilised in regard to illuminance related aspects.

Frequencies and percentages were computed in relation to baseline data, viz. age and education of the homemakers and husbands; occupation and employment status of the homemakers, family type; tenure of housing; involvement of family members and professional in planning lighting in kitchen; sources of information regarding lighting products; objectives held by respondent pertaining to lighting in kitchen ; existing lighting system and colour scheme in kitchens; and the respondents' preference for these items respectively, maintenance condition of room surfaces and lamps / lighting fittings; total power consumption; solar – orientation of window and door apertures on the exterior wall, their placement with regard to the three work areas, window treatments and exterior obstruction to apertures.

Further, descriptive statistics like frequency, percentage, mean and standard deviation were computed for data on knowledge of homemakers and husbands; values held by homemakers; family income; age of house; area and height of existing kitchens; height of work surfaces; size of apertures on exterior walls; effective ceiling and floor reflectances; maintenance factor; utilisation factor; ambient illuminance, illuminance at the work centres, and illuminance uniformity with regard to artificial lighting; day light illuminance and day light factor.

Correlation coefficients were computed using data from all the respondents for all continuous variables under study. Analysis of variance were computed for existing illuminance levels under artificial lighting in the kitchen, and each of the variables under study. Where significant 'F' values were found, 't' tests were carried out. In the case of discrete variables χ^2 and 't' test were carried out.

The level of significance required for judging the association between the variables under study was 0.5 level of probability.

4.0 SECTION II - LABORATORY ESTIMATIONS IN A SIMULATED KITCHEN

The second broad objective of the present study was to measure the visual performance and visual comfort of a sample of female subjects on selected tests under varying illuminances in a simulated kitchen, with the focus on determining the relationship that existed amongst these variables. Experimental research design was adopted to achieve the stated objective. An experimental environment (a simulated kitchen), that had a close resemblance to the domestic kitchens existing in the field, was set up to generate the necessary data. The experiments were conducted only under artificial lighting. The setting, lighting conditions, tasks, experimental design, subjects and experimental procedure are described below.

4.1 Experimental Setting

4.1.1 Setting for laboratory experimentation

The most popular kitchen shape and the mean area of the 50 per cent field kitchens between the first and the third quartile were identified along with the mean area of the platform. Thus an L - shaped simulated kitchen was designed with an area of 8.825 m^2 (Plate 4). The simulated kitchen model of hardboard and plywood was set up in one of the rooms of the Residence - a laboratory under the Department of Home Management. The laboratory experimentation were to be carried out during the period when the Residence was not in use by the department. The particular room was chosen as it had two exterior walls - one facing east and the other north, a preferred orientation for kitchen. Moreover, it was chosen so since this

room was sparingly used by the students and hence could be available to the investigator to generate data in case the experimentation were not over prior to the student's stay began in the new academic year. The simulated kitchen was smaller in size than the selected room. Hence two walls of make shift type were made of hardboard fitted in wooden frame. The ceiling height of 2.85 m. as observed in the field kitchens was also created by false ceiling of hardboard. The false ceiling provided the surface against which the light fittings (lamps and luminaires) for general lighting were fixed. The 'L' shape platform in the kitchen was created with hardboard. So also the top cabinets and base cabinets were created. A refrigerator was placed adjacent to the shorter arm of 'L' and a kitchen sink in hardboard was placed below the window on the shorter arm of 'L' shape platform to create a simulated kitchen environment.

4.1.2 Solar orientation

The orientation of the simulated kitchen was planned in accordance with recommendations cited by Deshpande (1985) and Tarkhedkar (1996). The exterior walls of the existing room served as the exterior walls for simulated kitchen as well. The simulated kitchen thus had two exterior walls - one facing the east and other facing the north direction.

4.1.3 Position of doors and windows

The two doors in the simulated kitchen were positioned facing each other - one each on the two opposite walls. One of the two doors was positioned on the exterior wall facing the east direction. Alongside of the door, was the window. The area of window and door was a little more than 1/3 of the total floor area while the window area was a little less than 1/6 of the floor area. These apertures were

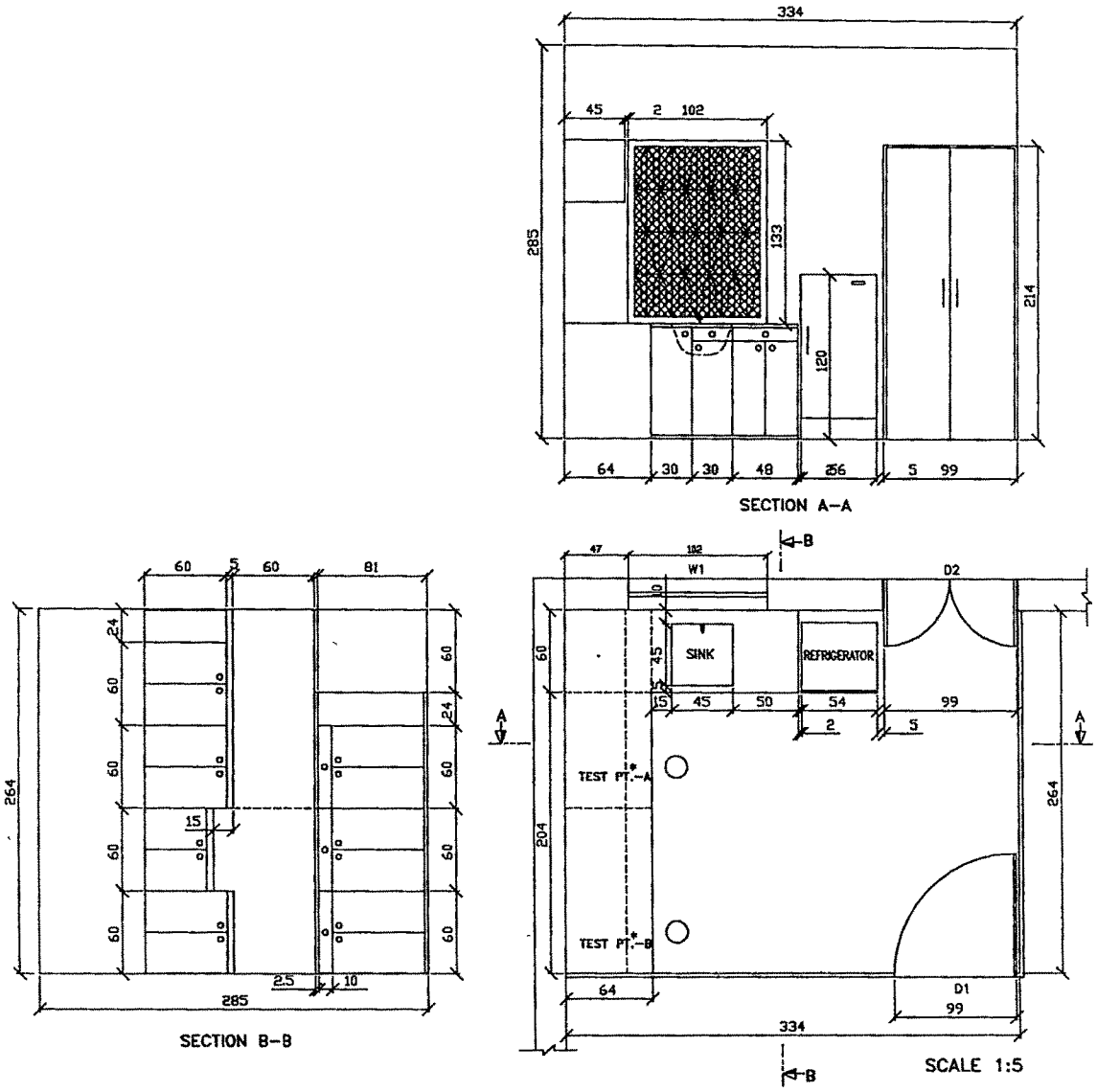


PLATE 4 : FLOOR PLAN AND ELEVATIONS OF THE SIMULATED KITCHEN WITH THE TEST POINTS (DIMENSIONS IN cm.)

properly sealed from outside with black paper to simulate after – dark conditions. The inside area of the window was covered with thermocol board in white.

4.1.4 Arrangement of work centers

The "work center" approach was followed in planning the arrangement of work centers from right to left in the sequence of,

refrigerator to work surface to sink to work surface to cooking range and to work surface. The works of Rutt, 1949; Pickett, 1960; Steidl and Bratton, 1968; Ehrenkranz and Inman, 1973; Peet, Picket and Arnold, 1975; Clarke, 1987; Real Estate Recorder, 1993 and Vijayan, 1997 were useful in planing the sequence of work centers in the simulated kitchen. A counter length of 0.6 m was provided to the left of cooking range, which then merged with the pre-preparation area that was distinguished by 0.8 m long length of uninterrupted counter. Approximately 0.5 and 0.8 m counter areas were provided at the right and left of the sink respectively.

4.1.5 Colour and reflectance of the surfaces

The most commonly found colours on ceiling and walls, and floor and platform in the field kitchens were applied on the corresponding surfaces in the simulated kitchen namely, white and grey respectively. Reflectances of the various surfaces are given in Table 1, Appendix III.

4.2 Lighting Conditions

Six distinct illuminance conditions as shown below were created in the simulated kitchen to gain insight into the non-linearity in the relationship between illuminance and visual performance.

Of these 17, 72 and 166 lx were identified from the worst and best lit kitchens from amongst those lying between the first and third quartile sizes of kitchens covered under the study. An illuminance of 500 lx for task with 300 lx for general lighting as per recommended values for kitchen (Philips Lighting Manual, 1993) were created. In addition 300 lx and 100 lx for task lighting with proportionate general lighting were created to assess level of performance of subjects under these illuminances.

The six conditions of illuminance created in the simulated kitchen are given below :-

	At test points	General	
L_1	500 lx	300 lx	
L_2	300 lx	180 lx	
L_3	166 lx	102 lx	Best lit
L_4	72 lx	102 lx	field kitchen
L_5	100 lx	60 lx	
L_6	17 lx	28 lx ←	Worst lit field kitchen

The selected illuminances, were created through three evenly spaced luminaires equipped with fluorescent lamps and acrylic diffusers that produced uniform and diffused lighting in the kitchen. In addition six incandescent lamps with translucent glass shades were also installed on the ceiling. The task lighting was provided through four fluorescent lamps installed beneath the top cabinets, along the front edge. The lamps were concealed with an overhang directing the light downwards on the work surface. Two spot lights were mounted above the sink, to provide for local lighting at the sink area (Plate 5). Plate 6 projects the layout of lamps/illuminaire in the simulated kitchen while Table 2, Appendix III provides the description of the lamps/luminaries installed in the simulated kitchen. Plate 2 through to 6, Appendix III show the placement of lamps/luminaries to provide for six different levels of illuminances on the horizontal boundary surfaces, namely work surface and horizontal plane at 81 cm height above the floor. The selected illuminances, were achieved by altering the use of lamps and/or controlling the lamp voltage by means of variac (Plate 7, Appendix III). Each of the illuminances were provided at two separate positions corresponding to the locations of the two test points where the two subjects who were required to perform the tests simultaneously in the kitchen.

PLATE 5 : SIMULATED KITCHEN WITH LIGHTING INSTALLATIONS

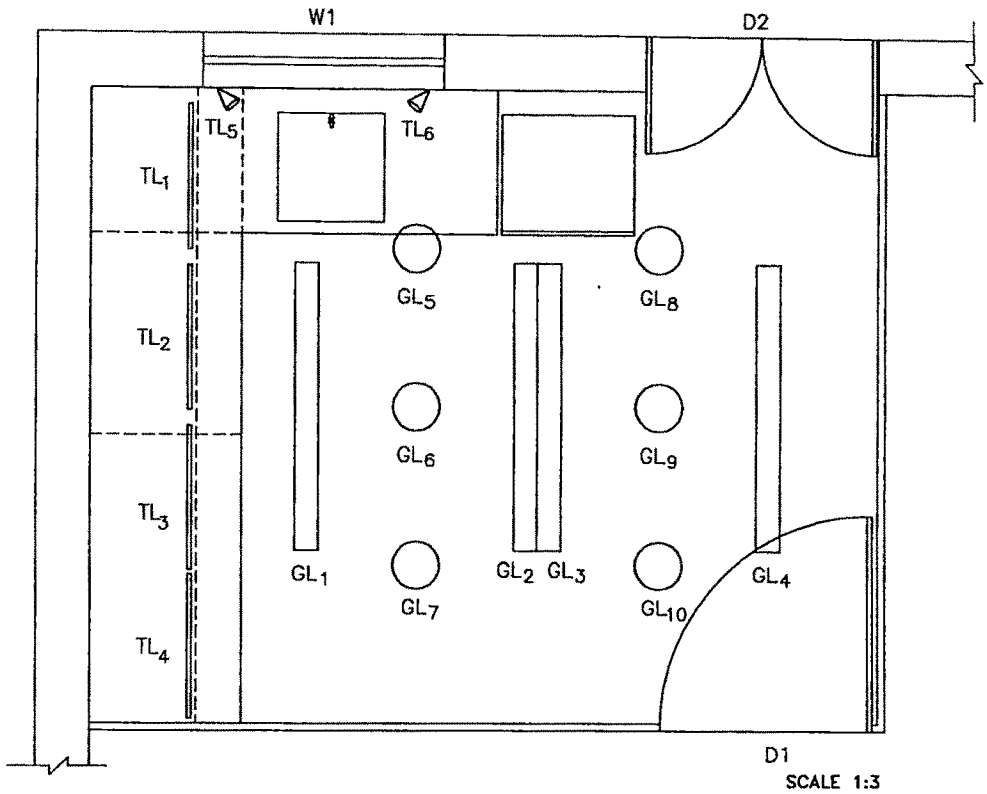


PLATE 6 : LAYOUT OF LAMPS/LUMINAIRES IN THE SIMULATED KITCHEN

KEY, $GL_1 - GL_4$: 36W FLUORESCENT LAMPS (With acrylic diffuser)
$GL_5 - GL_{10}$: 100w INCANDESCENT LAMPS (With transluscent shade)
$TL_1 - TL_4$:18W FLUORESCENT LAMPS
$TL_5 - TL_{10}$: 60W INCANDESCENT REFLECTOR LAMPS

4.3 Experimental Design

A repeated measures experimental design was adopted for the present study. In this design all the subjects of the experiment were required perform the tests under each of the six selected illuminances. This type of design is referred to as a "subject as own control" design or a within subject design (Johnson and Solso, 1978) The latter designation is derived on the basis of the fact that comparisons between treatments are made within the same subject. The within subjects experimental design is a very powerful technique for eliminating any bias due to subject characteristic.

In addition, it has the advantages as pointed out by Singh (1986):

1. There is the advantage of economy of subjects because each subject serves in all conditions. Thus within subjects design uses fewer subjects than other techniques like between subjects design.
2. The within - subjects design is typically more powerful or more sensitive because the possibility of error resulting from subject variability is reduced relative to that in other designs. This increases the correlation among measures which in turn, reduces the error variance.

3. For experiments where preparation for the experiment requires a fair amount of time and patience, the within - subjects design is preferred because the same group of subjects with all its initial preparation can be more easily tested under different conditions of the experiment.

Thus in the light of the above mentioned merits, the within – subjects design was found to be a suitable design and was chosen for the present investigation.

The laboratory experimentation schedule was prepared bearing in mind the fact that the subject's practice effect and fatigue effect should be kept at the minimum and the schedule should be convenient to the subjects who were homemakers (employed or unemployed) and students. Cooperation of the subjects from the beginning till the completion of all the test conditions planned was of utmost importance for generating data. Hence, the schedule of laboratory experimentation was planned as given in Table 3, Appendix III as per the scheme evolved by the investigator in consultation with guide. The subjects

were formed in pairs and the members of each pair were exposed to a given illuminance simultaneously. In one session of Day 1, each pair was administered all the tests under two illuminances. The pair competed performance of all the tests under two illuminances each in three sessions that were in the morning, mid noon and evening hours of the day on three different days respectively. There was a gap of three days in between the three experimental sessions to minimise the fatigue effect, practice effect and diurnal rhythm effect. During each session the order in which the two illuminances were used was altered for each pair of subjects. The given schedule was strictly followed in practice except in case of eleven subjects who were unable to comply to the given schedule for one session due to unavoidable circumstances. The sessions missed by these subjects were then readjusted into a supplementary schedule. Along with these subjects, each of the three experimental sessions were also carried out for three extra subjects.

4.4 Experimental Tasks

One of the objectives of the present study was to assess the visual performance of the subjects on standard tests under selected illuminances in a simulated kitchen. Two approaches have been identified and followed by the investigators in the past to determine the relationship between illuminance and performance. First dealt with specific practical tasks to be carried out in typical work situations (Ferree and Rand, 1927, 1928 and 1931; and Hess and Harrison, 1923; Luckiesh, 1924; Ives, 1924; Luckiesh and Moss, 1938; Joint IES – ASME, 1949; Simonson and Brosek, 1948) while the second involved conducting laboratory investigations of the basic factors which influence visual performance (Luckiesh and Moss, 1937; Weston, 1935 and 1945; Blackwell, 1952 and 1955). The latter approach was adopted for the present study. Thus laboratory

experiments were carried out using standard tests as well as a test designed specifically for the purpose.

A standard test, comprising of landolt's ring, one of the most widely used test object, was utilised for testing the visual acuity. Further, since colour is an important element in culinary art contributing to appearance, taste and aroma of a cooked or processed dish / recipie, it was thought appropriate to study the impact of illuminance on the efficiency of the subjects in discriminating varying degrees of brownness. A thorough search was made to identify a standard test for the purpose. Since the investigator was unable to procure any such test, a test entitled as brownness discrimination test was designed specifically for the present study which is described under relevant subtitle in this section. The tests used for the laboratory experimentation are referred to as experimental tasks hence forth. The selected tasks were such that their performance demanded the use of visual faculty of an individual.

Laboratory experimentation using landolt's ring test and brownness discrimination test were adopted not only because it would ensure objectivity and reliability but also because it would provide the kind of information that could be applied more generally. To enhance the application of the laboratory experimentation to kitchen related tasks in the field, it was imperative to analyse the kitchen related tasks from the perspective of their being considered as visual tasks. Hence, task analysis was carried out in terms of content and its details, and the manner in which it is performed. This exercise led to the following conclusions :

1. Most of the kitchen - related activities can be categorized as mesoramic, since the objects of visual attention are neither at

very long nor at very short range, but lie intermediately i.e., less than 6', but not less than 10" from the eye.

2. There can be fine or coarse visual work performed in the kitchen depending on the details within a task. While "kneading dough" is an example of coarse task, "cleaning of cumin seeds, mustard seeds and sesame seeds" provides example of fine task. In other words the various tasks lend themselves to be classified in large, medium, medium - small and small categories.

3. Kitchen related tasks involve colour discrimination.

4. These tasks are frequently carried out under varying conditions of brightness contrast.

Further, the various kitchen – related activities were classified by the visual acuity associated with each of them. For this purpose an inventory of activities performed in the residential kitchens was prepared, based on the documented data and interactions and discussions with married colleagues in the faculty. The inventory thus prepared was given to 5 to 6 housewives for further suggestions. The final inventory along with illustrations of eight sizes of landolt's rings (Appendix IV.1) were then distributed to a panel of 32 judges who were experts from Department of Foods and Nutrition and Home Management, and homemakers who were well versed with the contents of the kitchen tasks and their details. Each kitchen – related activity was categorised by visual acuity based on how well it matched, as a visual task, with any one of the given size of landolt's ring.

All those activities that were categorised by 60 per cent or more of the judges as a visual task, matching the detail of identification of

orientation of the gap of a particular size of landolt's ring were grouped together as one category. Landolt's rings represented various categories of sizes depending on the visual angle subtended by the details : as large (> 6 minutes of an arc), medium (> 3 minutes of an arc), medium small (> 1.5 minutes of an arc), small (> 50 seconds of an arc) and minute (< 50 seconds of an arc). On the strength of the judge's valued data the various kithcen related activities were classified as large, medium small and small (Appendix IV.2). There were no meal related task that matched with the minute size of landolt's ring.

4.4.1 Test for visual acuity

Landolt's broken rings in eight different sizes served as test objects. The visual angle subtended by the eight test objects ranged between 1' 8" to 11' 17" minute of an arc (Plate 8, Appendix IV).

4.4.1.1 Composition of test

The selected sizes of landolt's rings were printed in black against three neutral backgrounds. The brightness contrasts between landolt's ring and the backgrounds were 0.89, 0.61 and 0.57 respectively. There were 32 rings arranged in two separate square blocks of 16 rings each placed parallel to each other for each of the selected sizes. The square blocks with their specified order of arrangement of rings were randomly picked up from the available standardised landolt's ring test (Weston,1962).

The blocks of rings representing four different sizes were presented on one sheet. Thus two sheets of landolt's rings comprising of four sizes each completed the test sheets for one brightness contrast. In this manner three sets were prepared for the three brightness contrasts. The set comprising of two sheets of eight sizes

of ring against each background was treated as independent tests. Thus three experimental tasks were administered on the subjects.

4.4.1.2 Administration of the test

(1) The subjects were required to identity and mark the position of the gap by drawing a 'dash' against it in each ring presented against white, light grey and dark grey backgrounds (e.g. C-).

(2) The distance of 12" was kept between the eye of the subject and the test object. The subjects were helped to position their head the specified distance with the help of a foot ruler. The subjects were continuously monitored while the test was in progress to maintain this distance.

(3) The subjects who were habituated to using spectacles were instructed to conduct the test with spectacles.

(4) A time duration of 25 seconds was given to complete 32 rings in each size.

(5) The order in which each subject was administered the different sizes of rings on the three selected backgrounds was balanced in a Latin Square. This was done to counter balance the effect of practice and fatigue.

4.4.2 Brownness discrimination test

Roasting and frying are popular cooking methods. The degree to which the food item is to be roasted or fried depends on the type of 'dish' prepared and is often judged by the colour (degree of brownness) of the item in question. To assess the impact of illuminance on the accuracy of judging the degree of brownness, a test was designed specifically for the present study.

"Semolina" was selected as the test object due to its granular character of fairly uniform size and its potential objectivity while

conducting the test and also for being roasted uniformly to varying degrees of brownness. The test consitituted of 15 semolina samples, of which one was raw sample and remaining fourteen were roasted to different increasing degrees of brownness. Different gradations of brownness were obtained by roasting weighed quantities of samples of semolina through progressively increasing the roasting time with constant heat input. The 15 samples of semolina used in the brownness discrimination test as in Appendix IV, Plate 9, were randomly presented to the subject. The subjects were required to visually examine and then rank order the semolina samples by their degree of brownness. The subjects were instructed to identify the samples only through visual inspection without handling the test object.

4.5 Scoring of the Tests

4.5.1 Scoring of visual performance

Measurement of performance was based on the accuracy of the subject in attempting the experimental tasks. For the visual acuity test i.e., landolt's ring test, each correctly marked orientation of the gap was given a score of one and incorrectly marked orientation was given no score. Thus each subject acquired 8 x 3 sets of scores, each ranging between 0 - 32, for each of the selected lighting conditions. The accuracy factor was computed using the performance on each and every test ring. For statistical analysis purpose the classification of landolt's rings under large (A, B and C), medium (D and E), medium small (F) and small (G and H) by the degree of detail in each ring was adopted. A subsample of landolt's rings was selected by identifying a representative ring from each of the four categories. Thus landolt's rings A, D, F and G were selected for the purpose of statistical analysis. An overall performance score was arrived at by computing the sum of individual scores on each of the four selected landolt's

rings. For "colour discrimination" test a score of 2 was assigned to every correct identification and 1 for every incorrect identification. Thus the score ranged between 15 to 30.

4.5.2 Scoring of visual comfort

In addition to the measurement of performance, the subjects assessment about the lighting was ascertained. After conducting the tests under each lighting condition, each subject was required to indicate her judgement regarding the lighting condition in terms of adequacy and brightness of light, comfort feature, pleasantness in the room, and presence of glare and shadow. The subjects were required to rate each of these aspects on a five point rating scales (Appendix IV.3). The cummulative scores of all these aspects gave the measure of visual comfort and the range of score for visual comfort stretched between 6 to 30.

4.6 Subjects

The subjects of the experiment were 39 women with age ranging from 21 to 50 years. There were three age categories : 21 to 30 years, 31 to 40 years and 41 to 50 years and each category constituted 13 subjects. Most of the subjects in the former age group were students undergoing graduate / post graduate / doctoral programme of education, while the latter two age groups contained homemakers, both employed and unemployed.

4.6.1 Selection of subjects

An exhaustive procedure was followed to select the subjects for the experiment in order to eliminate all possible sources of bias occurring due to subject characteristics. Subjects with comparable visual capabilities and skills were identified through a battery of tests, namely, clinical examination of the eye for acuteness of near and distant vision, Ishiara test for colour vision, tests to examine the level of observation power and rate of visual perception (Appendix IV.4 and Plates 10 and 11), to keep sources of bias due to subject characteristics at the minimum. A total of 52 subjects were initially examined for their visual capabilities and skills and among them 39 subjects were selected on the basis of the following criteria :

(1) Subjects who had normal colour vision.
(2) Subjects who acquired a score of 5 or 6 on the observation test.
(3) Subjects who earned a score of 24 or more on the landolt's rings test for assessing the rate of visual perception test and could complete the test, within a time duration of 3 minutes.
(4) Subjects who had the willingness to participate in the experiment.

4.7 Experimental Procedure

A series of trial sessions were conducted before proceeding for the final data collection through laboratory experimentation to familiarise with the laboratory estimations. Once the investigator and enumerators became familiarised with the experimental tasks and procedures on repeated measures, the final data collection started.

The procedure adopted for each experimental session with a pair of subjects was as follows :

The pair of subjects was comfortably seated in a reception room on their arrival at the prescribed time and the experimental procedure was outlined to them. The initial visit of the subjects for the screening purpose helped in gaining quick familarity with the procedure of experiment and the tasks to be carried out. The oral temperature, pulse rate and blood pressure of each subject was recorded before proceeding for the experiment. Simultaneously, the temperature and humidity in the simulated kitchen were also noted. The subjects were then taken to the simulated kitchen with illuminance condition, L_1 and each member of the pair was made to sit at the given test points, which were equipped with the test sheets, pen, ruler and paper weight (plate 7). The subjects were encouraged to become familiar with the physical setting, their seats, the tests and the pen to be used. Further, the subjects were explained the sequence in which the eight sizes of landolt's broken rings in three different backgrounds were to be attempted. Prior to administering the test for final data collection, the subjects were given a practice trial on all the eight sizes of landolt's broken rings. It was found necessary to conduct the practice trial in order to acquaint the subjects with the test and to stabalise their speed in giving the test. Then the final experiment was carried out. A duration of 25 seconds were given to perform one set of 32 landolt's ring. The time was indicated by "start" and "stop" annoncement from the investigator using a stop watch. A time gap of about 15 to 30 seconds was given before proceeding for each subsequent set of rings (Plate 8). On completion of the landolt's broken ring test, the subjects were administered brownness discrimination test wherein they were (Plate 9) required to rank order the samples from the lowest to the highest degree of brownness. Once

PLATE 7 : LABORATORY EXPERIMENTATION IN PAIRS OF SUBJECTS

PLATE 8 : STANDARD LANDOLT'S RING TEST IN PROGRESS

PLATE 9 : BROWNNESS DISCRIMINATION TEST IN PROGRESS

the test was completed, the subjects were administered a questionnaire to indicate their subjective assessment for visual comfort experienced during the course of laboratory experimentation under each of the selected illuminances. The subjects were then required to leave the simulated kitchen and were taken to an adjacent bed room to relax. They were encouraged to lie down and close their eyes for 10 to 15 minutes. Then the subjects were served some soft drinks and were allowed to indulge in light conversation. Meanwhile the illuminance in the simulated kitchen was altered at L_2. The subjects returned to the simulated kitchen and were given a short warming up period to get accustomed to the new illuminance condition. The experiment was carried out in a similar fashion as the preceeding one, except that it did not involve any practice trial. The total procedure took about one hour.

The experimental procedure was repeated for the remaining two sessions, each constituting exposure to two illuminance conditions, on the prescribed days as per the experimental schedule.

4.8 Analysis of Data

4.8.1 Categorisation of the sample for the purpose of analysis

The following variables of the study were categorised as per the requirements of the present investigation.

9.1.1 Age of subjects	(i)	21 – 30 years
	(ii)	31 – 40 years
	(iii)	41 – 50 years
9.1.2 Brightness Contrast	(i)	Low brightness contrast : 0.57
	(ii)	Medium brightness contrast : 0.61
	(iii)	High brightness contrast : 0.89

9.1.3	Illuminance at test point	(i)	17 lx
		(ii)	72 lx
		(iii)	100 lx
		(iv)	166 lx
		(v)	300 lx
		(vi)	500 lx

4.8.2 Statistical analysis of data

Descriptive statistic like frequency, percentage, means and standard deviation were computed for pertaining to the mean performance of subjects on visual acuity test i.e., landolt's ring test against different brightness contrasts under varying illuminances.

MANOVA was computed using the data on visual performance on visual acuity test and brownness discrimination test and each of the selected variables. The main effect of the variables and their interaction effect with the age of subjects was assessed. Non-parametric tests like Friedman's test, and Mann Whitney test were carried out for data pertaining to visual comfort and the variables under study.

The level of significance required for judging the association between the variables under study was 0.5 level of probability.