CHAPTER V

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1.0 SUMMARY

Residential lighting is of great significance due to the impact good lighting can have on general well-being. In homes where variety of visual tasks are performed, provision of good seeing conditions and a comfortable visual environment is of paramount importance. The visual environment should be such that essential task details are easy to see and adverse factors which may cause visual discomfort are excluded or appropriately controlled.

The concepts like work-efficiency, visual comfort, human health and safety through lighting have drawn attention of researchers both in the past and in recent years; but the focus has been targeted towards industrial and commercial sectors. There has been minimum concern about lighting in the domestic units. Kitchen is one of the most essential functional space of the home which absorbs nearly one-third of the waking hours in pursuing a variety of visual tasks. Literature survey revealed that the data available on kitchen lighting were scanty. Though, a few studies were undertaken on assessing the existing lighting conditions in homes, little research has so far been devoted to explore the effects of varying illuminances on the visual performances and visual comfort of the housewives while performing kitchen related tasks.

This study was designed to assess the existing status of artificial and natural lighting in residential kitchens, and factors that

affected the existing ambient illuminance under artificial lighting. It also aimed to measure visual performance and visual comfort of subjects on standard visual acuity test against selected brightness contrasts and illuminances, and brownness discrimination test under selected illuminances in a simulated kitchen with the focus on assessing the impact of the independent variables on the performance of the subjects in laboratory experimentation.

Assessment of existing status of artificial lighting was carried out in terms of general ambient illuminance; illuminances available at the three work areas, namely, cooking area, pre-preparation area and sink area; illuminance uniformity and illuminance ratio between work area and surrounding area. Some of the other parameters estimated include the room ratio (K), per cent ceiling cavity reflectances (p_{CC}), per cent floor cavity performance (p_{FC}), maintenance factor (MF) and utilisation factor (UF). The status of natural lighting in kitchens was ascertained in terms of general ambient illuminance, illuminances at three selected work areas as well as the daylight factor. Measurement of visual performance and visual comfort of the subjects were carried out through laboratory experimentations in a simulated kitchen, wherein the effects of different brightness contrasts between the test objects and its background under selected illuminances were assessed using a standard visual acuity test and brownness discrimination test that was specially designed for the study.

1.1 Objectivesof the Study

The specific objectives drawn to give proper direction to the investigation were to :

(1) Study the existing status of residential kitchens with reference to artificial lighting and natural lighting.

(2) Develop a scale to measure appropriately values of housewives with reference to artificial lighting in kitchen.

(3) Develop a scale to appropriately assess the knowledge of housewives and their spouses in relation to artificial lighting.

(4) Ascertain interrelationship between existing general ambient illuminance in residential kitchens under artificial lighting and selected situational, personal and family variables.

(5) To assess the visual performance and perceived visual comfort of selected subjects in a simulated kitchen through laboratory experimentation.

(6) To ascertain the effect of selected independent variables (illuminance, brightness contrast and age of subject) on the level of visual performance and perceived level of visual comfort of the subjects in simulated kitchen.

(7) To compare the economics of different lighting systems and to recommend lighting installations for selected size of kitchen to ensure lighting for effective task performance

1.2 Method of Procedure

An artificial lighting value scale (ALVS) was developed primarily to measure the relative prominence of six selected values namely, aesthetics, comfort, economy, modernism, safety and work-efficiency with regard to artificial lighting in the kitchen. An artificial lighting knowledge test (ALKT) was also devised. The instruments were validated prior to their use in the pilot study. After the pilot study the reliability of these instruments were established. Both the instruments had commendable degree of reliability. The ALVS thus prepared comprised of forty-five items that were chosen after item analysis. ALKT had twenty-five items which were selected on the basis of the reliability data of item analysis as well as on item difficulty index and item validity index. An illumination survey form (ISF) was developed by making modifications in the official IES foot candle survey form (1963) for recording data pertaining to artificial lighting. Data on illuminance under natural lighting in kitchens were recorded on a daylight survey sheet (DSS).

The sample of the study comprised of purposively selected kitchens of residential units. The housewives were the primary respondents of the study on whom the entire questionnaire was administered, while their spouses responded to the ALKT only. Data pertaining to artificial lighting were gathered from 208 residential kitchens while measurements on daylighting were carried out in a sub sample of 148 kitchens. In addition to furnishing baseline data, the housewives reported on the involvement of family in planning lighting system in kitchen, sources of information on lighting products, their kitchen lighting-related goals, discomfort experienced while working under artificial lighting in kitchen, preferences on lighting system and colour scheme in the kitchen.

The laboratory experimentations were carried out in a simulated kitchen that was designed on the basis of the mean area of field kitchens in the inter range lying between the first and the third quartiles. The average general illuminance and average illuminance on the work areas in the best lit (102 lx for average general illuminance and 166 lx and 72 lx at work areas) and worst lit (28 lx for average general illuminance and 17 lx at work area) kitchens in the inter quartile range, were created in the simulated kitchen in addition to creating illuminances of 500 lx, 300 lx and 100 lx at work areas in the ratio of 5:3 between task lighting and general lighting of the surroundings. A repeated measures experimental design was adopted for the present study. Two experimental tasks were used for laboratory estimations : (i) standard visual acuity test i.e., landolt's ring test with eight selected test objects subtending visual angles ranging between 11' 7" to 1' 8" against three different brightness contrasts. Based on the judgement of a panel of experts, the visual effort required to perceive the details of each of the selected test objects were equated with that required for the various kitchen - related activities. A brownness discrimination test constituting 14 samples of semolina roasted to varying degrees of brownness and a raw sample was administered on the subjects. The subjects of the experiment were 39 women with age ranging from 21 to 50 years.

The experimental schedule constituted three sessions which were carried out on three different days at three different times of the day. Each session constituted exposure to two illuminance conditions, the order of which was altered for each pair of subjects. The subjects of the experiment were used in pairs and both members of the pair experienced the illuminance conditions, simultaneously. After a short practice trial, under each illuminance condition, the subjects were administered the standard visual acuity test, for which

a time duration of 25 seconds was given to complete 32 rings in each size. The order in which different sizes of test objects on three selected brightness contrasts were administered to each subject was balanced in a latin square. The brownness discrimination test was administered thereafter. The subjects were then required to indicate their subjective assessment of lighting condition under which they performed the test, on a questionnaire. The same procedure was followed for each subject under laboratory experimentation under six selected illuminances.

1.3 Major Findings of the Field Study on Status of Artificial Lighting in Residential Kitchens

1.3.1 Baseline data

The mean age of the housewives was 45.5 years and that of husbands was 49.0 years. By and large husbands had relatively higher levels of education than housewives. Nearly three-fourth of the housewives were not gainfully employed. The mean monthly income of the sample was Rs. 14,426.00 of which Rs. 645.00 per month was spent on electricity bill while approximately Rs. 26.25 per month was spent on kitchen lighting. A little more than 90 percent of the families resided in their own houses. The mean age of house was 12.7 years.

1.3.2 Values, goals, preferences, knowledge and perceived level of discomfort

'Comfort', 'work efficiency' and 'economy' were identified as the most predominant values held by the housewives in relation to artificial lighting. Nearly one-half of the housewives quoted 'providing adequate illumination' and ' reduction in power consumption' as their lighting related goals for the kitchen. General lighting was preferred to functional cum general lighting by majority

of the housewives. The mean scores on knowledge test were 37.6 and 39.1 in case of housewives and their spouses respectively in a scale with a range of 25 to 50 scores. The mean score on perceived level of discomfort was 4.5 in a scale with a range of 0 to 24 scores. 'Strain in the eye', 'difficulty in locating items in the storage cabinets' and 'difficulty in cleaning utensils with intricate designs' were the most quoted problems in visual task performance under artificial lighting in the kitchen.

1.3.3 Kitchen and kitchen lighting

The mean floor area and height of small, medium and large size kitchens were 5.79 m^2 and 2.74 m, 8.82 m^2. and 2.85 m and 13.08 m^2 and 2.92 m respectively. An 'L'-shape layout of platform was observed in 67 per cent of the kitchens. A neutral colour scheme was found in a little less than 30 per cent of the kitchens while monochromatic colour scheme with predominant hues like yellow, red, orange and green was found in about 60 per cent of the kitchens. A little less than two-third of the kitchens were equipped with a bare fluorescent lamp providing general lighting while one-fourth of the kitchens were provided with a combination of a fluorescent lamp and an incandescent lamp. However, in 97 per cent of the kitchens, the routine tasks were carried out under a single source of light, generally using the fluorescent lamp. The mean mounting height of the lamp was 1.61 m and about 68 per cent of the lamps were found to be in a state of moderately maintained condition at the time of survey. The mean time for which artificial lights were used in the kitchen was 4.7 hours per day.

The mean value for room index was 0.98. The mean effective ceiling and floor cavity reflectances in the kitchens were 54.07 and 30.23 per cent respectively. The mean maintenance factor in the kitchens was 0.83 while the mean value of utilisation factor was 0.23.

1.3.4 Illuminance under artificial lighting

The mean general ambient illuminance under artificial lighting (IuAL) was 55.89 lx while the mean illuminance at cooking, pre-preparation and sink area were 50.63 lx, 47.16 lx and 47.66 lx respectively. The existing illuminances in the kitchens were far below the recommended values as per international standards (Philips Lighting Manual, 1993 ; ISI standards, 1966 and IES standards, Japan 1998). The mean value for uniformity ratio in the kitchen was 0.31. The illuminance ratios between the work area and surrounding area were extremely poor in all the kitchens.

1.3.5 Daylighting

The mean area of aperture in exterior walls of the kitchens was 2.27 m^2 while the mean aperture-floor ratio was 0.26, i.e., the aperture area was about one-fourth of the floor area. About two-third of the kitchens were identified with poor or undesirable orientation. The mean daylight factor in the kitchens was 2.27 per cent. The mean general ambient illuminance under natural lighting (IuNL) was 203.32 lx while the mean illuminances at the cooking, pre-preparation and sink area were 192.29 lx, 162.14 lx and 154.93 lx. The mean illuminance uniformity in the kitchens under natural lighting was 0.2.

1.3.6 Profiles of housewives with kitchens with high and low IuAL

A comparison of 56 kitchens with high IuAL with 56 kitchens with low IuAL revealed that housewives having kitchens with high IuAL were characterised by higher family income, lower age of house and

more number being owned houses. The kitchens with high IuAL had smaller floor area, lower mounting height of lamps, higher wattage rating and relatively slightly more burning hours, higher ρ_{CC}, ρ_{FC}, MF and UF, higher levels of illuminances at work areas, higher illuminance uniformity and higher ratio of illuminance at work areas to surrounding areas. On the other hand, kitchens with low IuAL had lower ρ_{CC}, ρ_{FC}, MF and UF, lower levels of illuminances at work areas and lower illuminance uniformity.

1.3.7 Profiles of housewives with kitchens with high and low IuNL

When 40 kitchens with high IuNL and 40 kitchens with low IuNL were compared, it was observed that kitchens with high IuNL were characterised by larger area of aperture in exterior wall(s), higher aperture-floor ratio, higher average daylight factor and average illuminance at work areas, lower illuminance uniformity and fewer numbers of them had poor or undesirable orientation. The age of house where kitchens had high IuNL was relatively low and these kitchens had larger floor area. It appeared that the kitchens of newer houses had higher aperture-floor ratio, which probably contributed to higher daylight illuminance in the kitchens.

1.3.8 IuAL in relation to the variables under study

IuAL was negatively correlated with age of house ($r = -0.2068^{**}$), floor area of kitchen ($r = -0.1459^{*}$) and perceived level of discomfort ($r = -0.4653^{**}$) ; it was positively correlated to UF ($r = -0.3184^{**}$) and knowledge level of housewives ($r = -0.1484^{**}$). Apparently, as age of house, floor area of kitchen and perceived level of discomfort increased, IuAL decreased. However, the higher the UF and knowledge level of housewives, higher the IuAL. The IuAL in the owned houses was higher as compared to that in the rented houses. The kitchens of housewives with moderate scores on

comfort value showed higher IuAL than that of those with more or less scores on comfort value.

1.4 The Major Findings in Relation to Laboratory Experimentation under selected Illuminances in Simulated Kitchen

The illuminance on the work areas in the best (166 lx and 72 lx) and worst (17 lx) lit kitchens identified from amongst the field kitchens in the interquartile range by area were created in the simulated kitchen in addition to creating illuminance of 500 lx, 300 lx and 100 lx on the work areas. The visual performance of the subjects on standard visual acuity test and brownness discrimination test, and their perceived level of visual comfort were assessed under these selected illuminances.

1.4.1 Accuracy factor in relation to performance of subjects on visual acuity test under varying illuminances in the simulated kitchen

The accuracy factor (AF) on large test objects ('A', 'B' and 'c') on different brightness contrasts for subjects in young and middle age group ranged from 0.93 to 0.98 under higher illuminances (500 lx, 300 lx and 166 lx) and 0.81 to 0.98 under lower illuminances (100 lx, 72 lx and 17 lx). However, the differences in AF on large test objects for old subjects were remarkably low as compared to the two younger age groups. In general the AF on large test objects was higher against high brightness contrast (BC.1) as compared to those against medium (BC.2) and low (BC.3) brightness contrasts.

The AF on medium test objects ('D' and 'E') against different brightness contrast was comparable within and between the two younger age groups, ranging between 0.88 to 0.95 under higher

illuminances and 0.73 to 0.93 under lower under illuminances. The AF on medium test objects for old subjects ranged between 0.77 to 0.90 and 0.51 to 0.80 under higher and lower illuminances respectively. The AF on medium test object 'E' against BC.2 and BC.3 for old subjects under the illuminance of 17 lx was as low as 0.28. The AF of subjects on medium test objects was relatively higher against BC.3 as compared to that against BC.2.

The mean AF on medium-small test object ('F') declined successively with decrease in illuminance from 500 lx through to 17 lx and brightness contrasts from BC.1 through to BC.3. The AF were comparable within and between the two younger age groups under illuminance of 500 lx and 300 lx, the mean value ranging between 0.85 to 0.90. However sharp variations in AF were observed under illuminance of 166 lx and thereafter between subjects in young and middle age groups, these differences being more pronounced when tests were performed under illuminance of 72 lx and 17 lx against BC.2 and BC.3. The mean AF on medium-small test object against BC.1 for old subjects under illuminance of 500 lx was 0.77 which tumbled down to 0.25 under illuminance of 17 lx. The fall in their AF was still more acute against BC.2 and BC.3.

With regard to the AF on small test objects ('G' and 'H'), distinct differences were found amongst the three age groups across the three brightness contrasts and under each of the six selected illuminances. The mean AF on test object G and H against BC.1 for subjects in young, middle and old age groups under illuminance of 500 lx were 0.85 and 0.66, 0.81 and 0.55, and 0.55 and 0.29 respectively. These

values experienced sharp fall against BC.2 and BC.3 and under lower illuminances.

1.4.2 Visual performance of subjects on brownness discrimination test under varying illuminances in the simulated kitchen

The mean scores on visual performance among the subjects in all the three age groups on brownness discrimination test ranged between 25.6 to 27.0 under the illuminances of 500 lx through to 166 lx. The range in mean values declined to 24.0 to 25.2 for the subjects in two younger age groups under illuminance of 72 lx and for the old subjects under illuminance of 100 lx and 72 lx. The mean scores under illuminance of 17 lx for subjects in young, middle and old age groups were 22.92, 21.85 and 21.54 respectively.

1.4.3 Perceived level of visual comfort (PLoVC) of subjects under varying illuminances in the simulated kitchen

The median value indicated a decline in PLoVC of subjects with each successive decrease in illuminance from 500 lx to 17 lx, the decline in PLoVC being sharp under illuminance of 100 lx, 72 lx and 17 lx. An age-wise comparison revealed that the decline in median scores of subjects in young and middle age groups on PLoVC across the illuminances of 300 lx to 17 lx ranged between 8 to 50 per cent in contrast to their scores on PLoVC under 500 lx. On the other hand, the relative drop in median scores on PLoVC of old subjects ranged between 10 to 40 per cent.

1.4.4 Level of visual performance and perceived level of visual comfort in relation to the variables under study

The computed 'repeated measures MANOVA' revealed significant differences in the mean overall LoP I and mean LoP I on

each of the four selected test objects against different brightness contrasts under varying illuminances by their age. Comparison of mean scores indicated that the subjects in old age group were significantly different (.01 level) than those in each of the two younger age groups in their LoP I, implying that the combined effect of varying illuminances and brightness contrasts was the most influential on the LoP I of the old subjects as compared to those in young and middle age groups. The defects in the eye caused by aging factor and relative decline in speed in discriminating small details with advancing age could be the factors contributing to low mean LoP I of subjects in older age group.

The mean overall LoP I and mean LoP I on test objects with four selected visual sizes against different brightness contrasts under illuminance of 500 lx was significantly different from those under illuminance of 100 lx and 72 lx. The mean overall LoP I and LoP I on medium-small and small test objects against different brightness contrasts under illuminance of 500 lx differed significantly (.01 level) from that under illuminance of 166 lx as well. The finding implied that the subjects had performed equally well under illuminance of 500 lx and 300 lx with respect to test objects of all visual sizes while the performances were also comparable under 166 lx on test objects subtending visual angle more than 4' 31". The LoP I of the subjects was adversely affected under other lower illuminances.

The overall mean LoP I and mean LoP I on medium, medium-small and small test objects against high brightness contrast differed significantly (0.01 level) from those against medium and low brightness contrast. Significant differences were observed in the LoP I of subjects on large (0.01 level), medium (0.01 level) and small

(0.05 level) test objects, when their performances were compared between medium and low brightness contrast. Subjects were also found to be significantly different (0.01 level) in their LoP I on large test objects against high and medium brightness contrasts. The analysis of data proved beyond doubt that the effect of brightness contrast of the highest order was extremely favourable in the performance of the subjects on test objects of all visual sizes, as compared to those of medium and low brightness contrasts.

The level of performance of subjects of brownness discrimination test (LoP II) under 500 lx differed significantly at 0.01 level from that under illuminance of 100 lx, 72 lx and 17 lx. Thus it was found that illuminances upto 166 lx permits accuracy in identification of brownness as that achieved under 500 lx. However the difference in LoP II amongst the subjects in three age groups was not significant.

Significant difference (0.01 level) in ratings on perceived level of discomfort under six selected illuminances was revealed through Friedman two way analysis of variance. A successive decline in the mean ranks on perceived level of discomfort of the subjects was observed with decreasing illuminances.

2.0 CONCLUSION

Housewives held varied kitchen lighting related goals. Though goals like 'providing adequate illumination' and 'reduction in power consumption' commonly reported by the housewives were in line with the values like comfort, work-efficiency and economy that they held, in practice these were not observed to be followed. The housewives and their spouses had little knowledge on aspects like desired levels

of illuminance, luminance distribution, need for task lighting, use of energy saving lamps like CFL, interpretation of information given on the lamps on colour temperature and colour of light. Their lack of knowledge was reflected in the existing lighting system in their kitchens as well as in their preferences of lighting system for a kitchen, wherein the idea of good quality light for clear visibility, safety and health was absolutely missing. Mass media seemed to play a lesser role as a motivating factor in influencing the choices of respondents for lighting products, though they were important source of information.

The existing general ambient illuminance and illuminance at the work areas under artificial lighting were assessed to be extremely poor as compared to the recommended values. Also the illuminance uniformity and illuminance ratio between the work area and surrounding were not appropriate. Illuminance level under natural lighting across the selected kitchens revealed extreme variations. In general majority of the kitchens had relatively higher levels of illuminance under natural lighting as compared to that under artificial lighting.

Tenure of housing affected the IuAL. Kitchen in owned houses had high IuAL as compared to those in rented accommodation. A sense of ownership might have attributed to better maintenance of room surfaces and lamps / luminaires in the owned houses leading to relatively higher illuminances. The age of house was inversely related to IuAL. As age of house increased, the IuAL in kitchens decreased. Kitchens in old houses had low p_{FC} and MF as compared to kitchens in new houses. The interplay of p_{FC} and MF with the age of house might be responsible for low illuminances in older houses.

IuAL and floor area of kitchen were in inverse relations with each other. There was a progressive decline in the IuAL in kitchens with increasing ranges in size. The lamp lumen distribution per unit square area decreased with increase in floor area of the kitchen. The lumen output of lamp(s) installed in kitchens were not appropriate with regard to their floor areas. The average illuminance was far below the recommended values due to installation of lamps with low lumen output.

As the UF of light emitted from the lamp(s) installed in the kitchens increased, the IuAL increased. This relationship is in line with the natural relationship between the two concepts. The UF was higher in kitchens with high K and p_{FC}. The observations imply that with an increase in K and p_{FC}, there was an increase in UF with accompanying increase in illuminance.

Housewife's level of knowledge regarding artificial lighting was directly related to the IuAL though husband's level of knowledge showed no definite association with IuAL. The housewives with higher level of knowledge regarding concepts in electricity and lighting, principles of good lighting and lighting products in the market could comprehend the importance and need for good lighting and probably were a little more conscious in planning lighting their kitchens than those with lower knowledge level. However, in general the illuminances in kitchen were far below the recommended values. In spite of relatively higher knowledge level, there might have been some impediments in the selection of appropriate lamps and luminaires, which could be traced to low priority and lack of willingness to spend money for this purpose.

Among the values held by housewives with regard to artificial lighting in kitchens, comfort value was positively correlated with IuAL. None of the other five selected values were significantly correlated with IuAL. Although there was not much difference in the type and wattage of lamps installed across the selected kitchens, the housewives who prioritised comfort as their value might have made a conscious effort to select appropriate colours and finishes for the room surfaces and to maintain the same, which might have contributed to relatively higher IuAL in their kitchens.

Perceived level of discomfort of housewives while working under artificial lighting in the kitchen was inversely related to IuAL. The housewives experienced high discomfort in kitchens with low IuAL. However, most of the housewives had become accustomed and habituated to work under low illuminances and had accepted it as a way of life and were even satisfied with the same.

A hierarchical order in the variables studied in relation to IuAL was found to exist. Perceived level of discomfort, floor area of kitchen, p_{FC}, age of house, UF and MF emerged out as the factors associated with IuAL in order of importance.

In the light of the laboratory experimentation, it can be concluded that age of the subjects was a significant factor contributing to differences in the level of visual performance on visual acuity test (LoP I) against different brightness contrasts under varying illuminances. There was a drastic fall in the LoP I of subjects in old age group (41-50 years) as compared to those in young (21-30 years) and middle (31-40 years) age groups. The drop in LoP I was more pronounced in test objects subtending visual angle

less than 3' of arc. However age did not prove to be a significant source of individual differences on brownness discrimination test.

An illuminance of 166 lx was found adequate to perform activities that do not have minute details (i.e. those substending visual angle 4'31" of arc or more). However, when it comes to fine tasks where high visual acuity is required (i.e. those subtending visual angle less than 2'15" of arc) a minimum illuminance of 300 lx would be adequate. Considering the visual performance of the subjects, the results obtained do not offer strong support for recommended illuminance of 500 lx. The laboratory experimentation has revealed that the performance level even under illuminance of 300 lx were comparable to those under recommended value of 500 lx in reference to all sizes of tasks. The ability to discriminate different degrees of brownness was also adversely affected under lower illuminances. An illuminance upto 166 lx permitted accuracy in identification of varying degress of brownness as that achieved under illuminance of 500 lx .

The brightness contrast between the work object and its background was identified as an important factor contributing to significant differences in the visual performance of the subjects under varying illuminances. The subjects performed their best on test objects against brightness contrast of the highest order i.e. 0.89, while the subject's performance was adversely affected on test objects against the other two brightness contrasts i.e. test objects against backgrounds with brightness contrasts of 0.61 and 0.57 respectively. The effect of brightness contrasts was magnified on test objects with fine detail under lower illuminances and in case of old subjects.

The perceived level of visual comfort of the subjects consistently declined with decreasing illuminances. However, the illuminance of 500 lx was described as glaring and too bright by some subjects in old age group. The fact that the subjective assessment of subjects regarding adequacy and brightness of illuminance, pleasantness and comfort features of lighting varied with change in illuminance, stresses upon the fact that lighting for working interiors should be based on visual performance as well as visual comfort parameters.

3.0 IMPLICATIONS OF THE STUDY

The findings from this study can be seen in relation to its implications for conceptualisation of strategies for designing future residential lighting related research studies. Directly these findings can be of use in chalking out action programmes and policies that would lead to efficiency in visual task performance in a sustainable manner.

3.1 Future Research

A value scale was developed in the present study to assess the relative predominance of selected values held by the housewives with regard to artificial lighting in the kitchen. The same instrument might be adapted to study the values held by the housewives and even by the husbands with regard to artificial lighting of other parts of the house like entrance hall, stair case, living room, bedroom and bathroom. Comparative studies could be conducted to gain insight into the relative predominance of values amongst housewives/husbands (i) staying in rented and owned accommodation (ii) having different family income and (iii) belonging to different age groups.

Additional field measurements can be carried out like illuminance in the storage cabinets, shadowed illuminance, measurement of illuminance before and after cleaning of lamp(s), carrying out simultaneous measurement of outdoor illuminance for each reading taken for indoor illuminance to estimate daylight factor at each point of measurement as well as between average illuminances. Similar study can be undertaken to assess existing illuminances in hostels, old homes, orphanages and other community residences.

Detailed task analysis of various kitchen activities can be carried out in terms of the distance maintained between the work object and the worker, size of the work object and background against which the tasks are usually performed. Based on the exact details of kitchen tasks standardised tests can be devised with appropriate sizes of test objects and brightness contrasts which would be more relevant and representative for kitchen tasks. Also suitable tests can be developed to assess the ability of the worker to discern colours accurately. The brownness discrimination test could be devised against varying backgrounds such that varying degrees of brightness contrasts in a definite pattern are created and the visual performance of the subjects under varying illuminances are assessed. Alternatively, the actual task of roasting can be carried out by giving samples of roasted semolina against which the degree of doneness to be reached in the performance test of "roasting semolina" can be undertaken under varying illuminances. Similarly, other test samples for practical visual task performance test could be identified and standard practical tests developed.

Similar laboratory experimentations can be carried out taking the best and worst lit kitchens from the inter quartile range based on the existing illuminances. Also measurement of speed of the subjects in performing the test can be done by recording time taken to accomplish a given quantum of task. Experimental work can also be conducted on actual kitchen tasks as well as visual tasks pursued in other rooms in the family residences.

3.2 Action Programme

The filed measurements carried out in the study showed that the illuminance existing in kitchens were much less than the recommended values of 500 lx at the working place. The laboratory experimentations revealed that level of performance of subjects under an illuminance of 300 lx at the working place are comparable to that under 500 lx with reference to all sizes of tasks subtending visual angle ranging between 11'17" to 1'8" of arc while tasks with details subtending a visual angle of more than 4'31" can be performed equally well even under illuminance of 166 lx. In the light of the above findings, it becomes essential to consider the implications of the complete pattern of results for the lighting standards recommended for kitchen. The results obtained in the present study do not offer strong support for a recommended illuminance of 500 lx, and thus suggests a need to reconsider the standards that have been set up at National and International levels. Literature reveals that standards applying to illuminance have undergone considerable change since they were first established. Progress in the range of technology available has made higher level of artificial lighting easily obtainable and the recommended levels have risen accordingly. But in view of the energy crisis faced all over the world and the rising energy costs, it is essential to re-

evaluate these standards with the understanding that other factors may be more important than the simple intensity of light.

The obvious discrepancy between the recommended illuminance and that provided in most of the homes is a crucial matter of concern. On the one hand, issues like lighting and human health and safety, and lighting for aging population are being researched and discussed about, while on the other hand it is found that almost universally the illuminances observed in homes, even at points where accurate vision is essential, are extremely low. Bad lighting can be the one of many contributory factors to the domestic accidents which occur because people fail to see what they need to see. It is suggested that the public must be educated to create awareness of the advantages of having higher illuminances for visual performance, visual comfort and visual ambience. Public must also be made aware of use of appropriate technology to be able to achieve economy without sacrificing the quality of light. Appropriate steps to reach potential target group through maximum exploitation of mass media to generate public awareness on energy saving lamps need attention of policy makers. Concrete efforts need to be made by government organisations, lighting research organisations, manufacturing units, lighting engineers and educationists in promoting the benefits of energy efficient and quality lighting for the homes.

There should also be a greater awareness on the need for better residential lighting amongst those who are responsible for providing housing i.e. the builder, architects and housing associations.

Promotion of energy saving lamps should be supported by making these lamps available at subsidised rates. Domestic energy audit should be made mandatory and fiscal benefits (soft loans and tax benefits) may be provided to families to enable them to switch over from energy intensive deficient lighting systems to sustainable artificial lighting systems of adequate quantity and quality.