ERGONOMIC INTERVENTION BY VENTILATION AND WINDOWS REMODELING INCREASES COMFORT OF OCCUPANTS OF HOUSES TYPE 36/120 IN NUANSA KORI HOUSING SADING MENGWI BADUNG

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ABSTRACT

Development of the housing sector has now spread to the suburban areas of Denpasar; even some rural areas in Bali have become targets of housing developers. Designing and arranging of houses through ergonomic intervention comprises one of several efforts for improving the houses' quality in terms of their natural comfort. The ergonomic intervention should meet such criteria as to be technically applicable, less costly, energy saving especially that of electricity, socio-culturally convenience, and environment friendly. This experimental study being reported applied a treatment by subject design, in which eight houses were selected as sample, located in the housing complex of Perumahan Nuansa Kori Sading Mengwi Badung. Of the eight sampled houses, each two houses faced north, south, east and west, respectively. Twenty six occupants of the eight sampled houses were interviewed using a questionnaire. All samples were selected by stratified random sampling. The ergonomic intervention comprised remodeling of ventilation and windows of all the sampled houses. Data collecting of objective comfort was carried out before and after intervention i.e. at 8 am, 10 am, 12 pm, 2 pm, 4 pm and 8 pm, by measuring temperature, humidity, light intensity, and airflow. Data of subjective comfort were collected by questionnaire, which had been tested earlier for its validity and reliability. The results showed that (1) before intervention the average of wet temperature was 23.66 ± 1.36 ºC, after intervention was 23.09 ± 1.20 ºC; (2) before intervention the average of dry temperature was 28.76 ± 1.07 ºC, after intervention was 27.88 ± 0.73 ºC; (3) relative humidity before intervention was 73.44 ± 4.37 %, after intervention was 72.63 ± 2.73 %; (4) natural light intensity before intervention was 134.94 ± 71.69 lux, after intervention was 229.69 ± 114.53 lux; and (5) the average of airflow before intervention was 0.10 ± 0.04 m/sc, after intervention was 0.31 ± 0.08 m/sc. The conclusions could be arawn are that ergonomic intervention by remodeling ventilation and windows of houses type 36/120 could improve objective comfort by 12.4% ($p<0.05$), along with increase of subjective comfort of the occupants of the houses facing all directions. This study suggests that ergonomic intervention should be applied since early in the construction of houses in order to make them cheaper, healthier, and more comfortable.

Key words: *Ergonomic intervention, house type 36/120, comfort, electricity saving.*

1. Introduction

The development of housing sector was initiated in Indonesia in the 1970s. The development started to involve Bali in the 1980s and since then it had extended to suburban areas of Denpasar, even also to some rural areas in Bali. The increasing number of population is one of the factors that caused the high demand for housing.

The ever increasing demand for housing in the future needs to be anticipated by making a regulation on the use of land for housing, so developers, government and community have a legal reference and rule concerning management and use of land for housing. Increase of quantity in the housing development should parallel with improvement of the quality (Newmark and Thompson, 1977). The quality referred here is concerned with houses that are healthy and comfortable to live in.

Results of a study previously carried out in Nuansa Kori Housing Sading Mengwi in September 2006 showed: a) in living rooms of 15 m width, the average indoor wet temperature was 25 ºC, average natural light intensity 200 lux, bulb light intensity 250 lux, indoor airflow 0.3 m/sec, outdoor airflow 1.8 m/sec, outdoor light intensity 45,000 lux, outdoor wet temperature 26 ºC, outdoor dry temperature 31 ºC; b) in bedroom of 9 m^2 width, the average wet temperature was 25.5 ºC, dry temperature 30 ºC, natural light intensity 20 lux, bulb light intensity 50 lux, and indoor airflow 0 m/sec; c) in kitchens of 3 m^2 width, average indoor wet temperature was 24 ºC, dry temperature 29 ºC, natural light intensity 125 lux, bulb light intensity 200 lux, and indoor airflow 0 m/sec.

There were several causal factors of the inconvenience in the three rooms, such as outlay, model, size and location of ventilation, model and size of windows as well the lower opening direction (vertical). Thus, both factors result in the less optimum air circulation in the rooms (no cross ventilation) and limitation of lighting and natural air circulation into the rooms. These factors cause the rooms to become damp, stifled and electricity wasting.

The previous study on houses of type 36/120 at Nuansa Kori Housing Sading Mengwi Badung that involved 20 respondents showed: a) 55% respondents complained about comfort aspect such as air circulation and natural lighting in the rooms; b) 30% respondents complained about security aspect (placement of bars on ventilation and window); and c) 15% respondents complained about interior and furniture aspects such as concerning arrangement of facilities that are related to the pattern of indoor activities. Results of a questionnaire survey on the occupants' expectations done previously showed: a) 58% respondents expected improvement of the model and location of ventilation and windows; b) 31% respondents wished for more flexible furniture; and c) 11% respondents expected improvement of arrangement of facilities.

An ergonomic intervention by remodeling ventilation and windows of the livi ng rooms, bedrooms and kitchens of the houses of type 36/120 is thought to be able to save electricity as well as increase comfort of the occupants.

2. Materials and methods

This study was an experimental study using treatment by subject design. The study sample involved eight houses with two houses each facing North, South, East and West, respectively. The study also involved 26 respondents who were occupants of the sample houses of type 36/120 at Nuansa Kori Housing Sading Mengwi Bsdung. The samples were chosen by stratified random sampling method. The ergonomic intervention was remodeling of ventilation and windows done to all the sample houses. Objective data on convenience were collected before and after intervention i.e. at 8 am, 10 am, 12 pm, 2 pm, 4 pm and 8 pm Central Indonesian Time, by measuring temperature, humidity, light intensity and airflow. Subjective data were collected using a questionnaire, whose validity and reliability had been examined earlier.

3. Results and Discussion

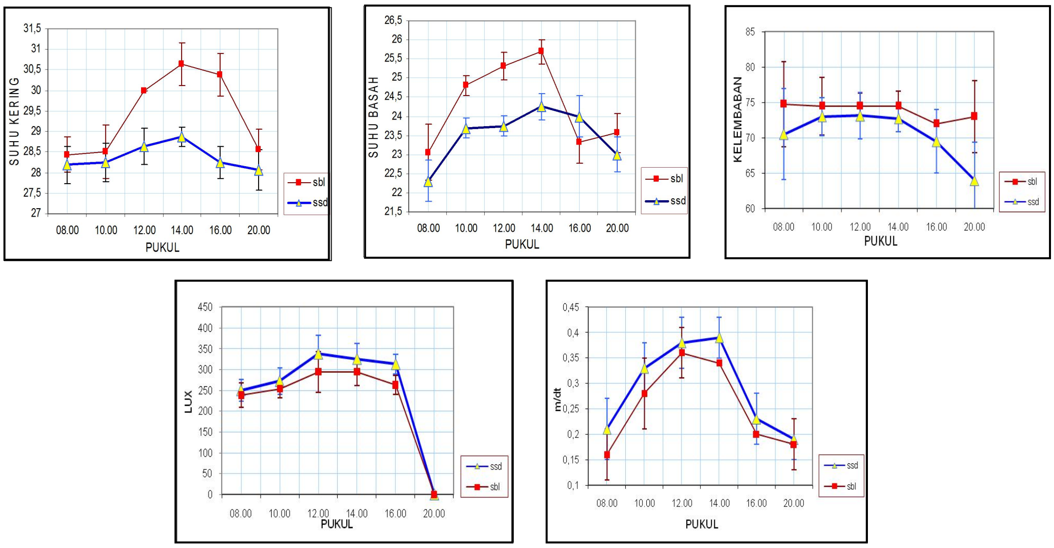

Figure 1 Condition of Living Rooms before and after improvement at Nuansa Kori Housing Sading Mengwi Badung

Figure 1 shows wet temperature, dry temperature, relative humidity, natural light intensity and airflow in the living rooms before and after improvement taken at 8 am, 10 am, 12 pm, 2 pm, 4 pm and 8 pm, Central Indonesian Time. All measurement values differed significantly ($p<0.05$). Wet temperature, dry temperature, relative humidity, natural light intensity and airflow of living rooms before and after improvement taken at 8 am, 10 am, 12 pm, 2 pm, 4 pm and 8 pm decreases wet temperature by 0,033%, dry temperature by 0,036% and decreases relative humidity by 0,048%, but increases natural light intensity by 0,11% and increases airflow by 0,13%. This means that ergonomic intervention by remodeling ventilation and windows of houses type 36/120 changed significantly the status of wet temperature, dry temperature, relative humidity, natural light intensity and airflow of living rooms.

Wet temperature, dry temperature, relative humidity, natural light intensity and airflow of living rooms before and after improvement in accordance with the orientation of the houses facing North, South, East, and West did not show any significant difference ($p>0.05$). This means that ergonomic intervention by remodeling ventilation and windows of living rooms could overcome the influence of the aspect of houses' orientation (facing North, South, East and West) to the level of comfort of the living rooms.

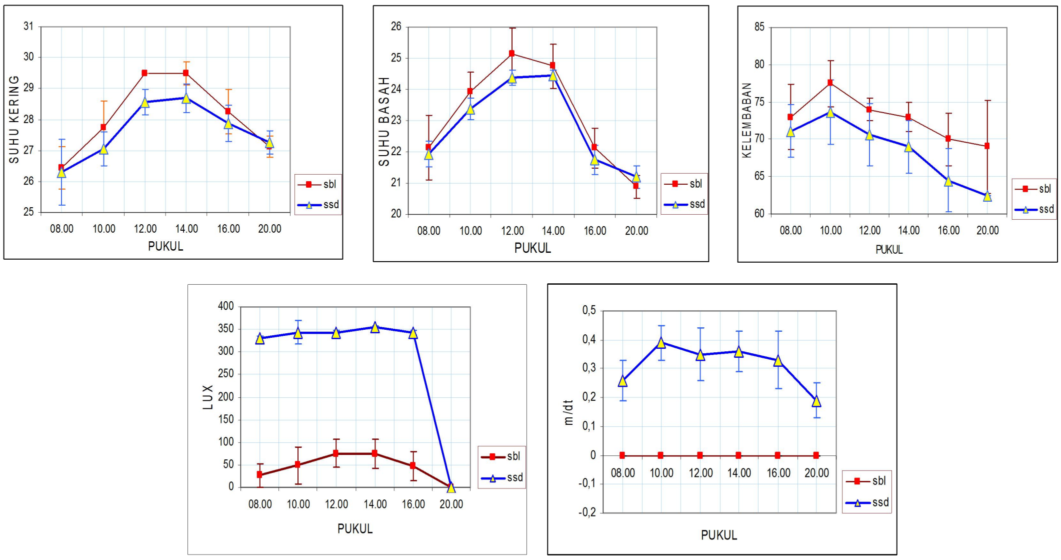

Figure 2 Condition of bedrooms before and after improvement
at Nuansa Kori Housing Sading Mengwi Badung

Figure 2 shows significant difference ($p<0.05$) on the measurement values of wet temperature, dry temperature, relative humidity, natural light intensity and airflow in bedrooms before and after improvement collected at 8 am, 10 am, 12 pm, 2 pm, 4 pm and 8 pm, Central Indonesian Time. Wet temperature, dry temperature, relative humidity, natural light intensity and airflow of bedrooms before and after improvement taken at 8 am, 10 am, 12 pm, 2 pm, 4 pm and 8 pm decreases wet temperature by 0,013%, dry temperature by 0,017% and decreases relative humidity by 0,061%, but increases natural light intensity by 5,27% and increases airflow by 0,31%. This means that ergonomic intervention by remodeling ventilation and windows of houses type 36/120 changed significantly the status of wet temperature, dry temperature, relative humidity, natural light intensity and airflow of bedrooms.

Wet temperature, dry temperature, relative humidity, natural light intensity and airflow in in bedrooms before and after improvement according to front houses facing North, South, East and West did not show any significant difference ($p>0.05$). It signified that ergonomic intervention by remodeling ventilation and windows could overcome the influence of the houses' orientation (facing North, South, East and West) to the comfort of bedrooms.

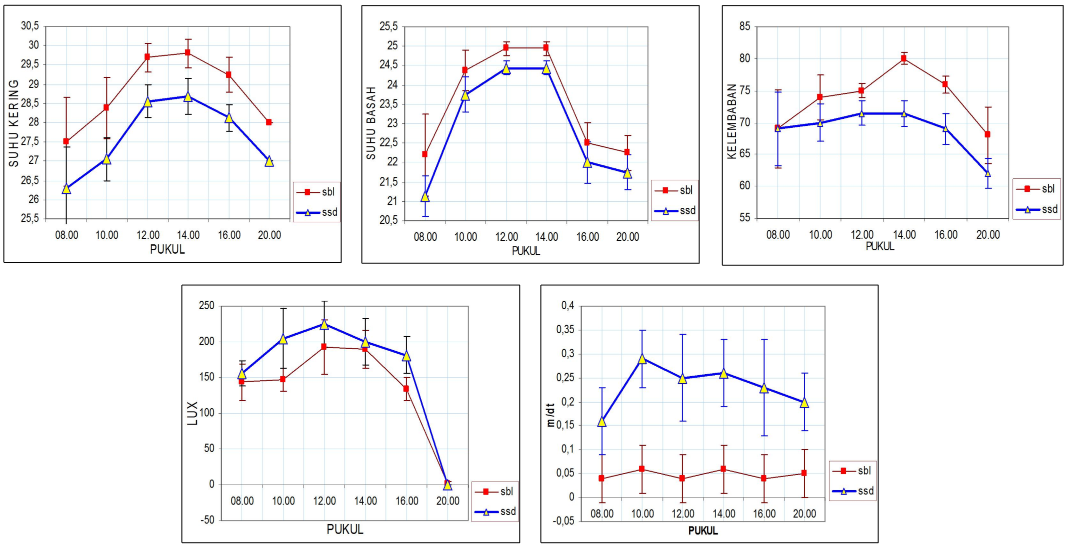

Figure 3 Condition of Kitchen before and after improvement
at Nuansa Kori Housing Sading Mengwi Badung

Figure 3 shows obvious changes that occurred to the wet temperature, dry temperature, relative humidity, natural light intensity, airflow in kitchens before and after remodeling which taken at 8 am, 10 am, 12 pm, 2 pm, 4 pm and 8 pm, Central Indonesian Time, showing a significant difference ($p<0.05$). Wet temperature, dry temperature, relative humidity, natural light intensity and airflow in the kitchens before and after improvement taken at 8 am, 10 am, 12 pm, 2 pm, 4 pm and 8 pm decreases wet temperature by 0,026%, dry temperature by 0,041% and decreases relative humidity by 0,070%, but increases natural light intensity by 0,19% and increases airflow by 3,79%. It indicates that ergonomic intervention by remodeling ventilation and windows of house type 36/120 gave significant changes to wet temperature, dry temperature, relative humidity, natural light intensity and airflow in the kitchens.

Wet temperature, dry temperature, relative humidity, natural light intensity and airflow in the kitchens before and after improvement according to front houses facing North, South, East and West did not show any significant difference ($p>0.05$). It signified that ergonomic intervention by remodeling ventilation and windows could overcome the influence of the houses orientation (facing North, South, East and West) to the comfort of kitchens.

The average of temperature in the living rooms, bedrooms and kitchens was 27 ºC with interval 26 – 29 ºC. The result of this study matched with Manuaba's statement (1983) that satisfactory level of objective comfort of houses was that with a temperature between 24 - 28 ºC. In this study, the relative humidity average of living rooms, bedrooms and kitchens was 68% with interval 60 – 80%. The result was in accordance with Meijs (1983) who stated that satisfactory level of objective comfort of houses was at a humidity of 40% - 70%. On the other hand, examination on light intensity of living rooms, bedrooms and kitchens showed an average of 350 lux with interval 175 – 400 lux. The result was lower than that stated by Grandjean (1993) and Mangunwijaya (1997), in which satisfactory level of objective comfort of houses seen from light intensity aspect was 500 – 700 lux. Examination on airflow likewise gave result of 0.2 m/sec on average with interval 0.1 – 0.5 m/sec. The result of this study was in the range of comfortable airflow that is 0.1 – 0.5 m/sec (Mangunwijaya, 1997).

The result was somewhat similar to that of Lippsmeier (1994), who stated that comfort standard of temperature in the equator areas was 22.5 ºC – 29.5 ºC with relative humidity 20 – 50%. Meanwhile, Sujadnja (1998) stated that in relation with the construction of *Bale Meten* in Bali, microclimate factors (lighting, temperature, humidity, and air circulation) affected the indoor comfort with relative contribution as follows: 8% from temperature and humidity, 0.41% from lighting and air circulation, with total relative contribution of 9.35%. Moreover, it can be explained that factors strongly influenced the microclimate were ventilation and windows. Windows had positive correlation to lighting with *weak classification* (r = 0.32). It was also correlated positively to air circulation with moderate classification (r = 0.41). While ventilation also had similar positive correlation to air circulation in moderate classification (r = 0.44). Next Darmawan (2005) did modification to the building of LPD Desa Pakraman Sibang kaja by choosing material that may decrease translocation efficiency of entire heat that the building received. The modification was replacing terrazzo with red bricks without using cement, replacing bricks of 115 mm to 220 mm, replacing glass from thickness of 3 mm to 8 mm and placing gypsum board on the wall of houses. The modification made significant decrease of heat acceptance value for 9.84% from 15602 Watt or 15.6 kW to 14122.49 Watt or 14.12 kW per day after modification. The study result of Nityasa (1999) also showed that improvement of houses type 36/100 by using rain drain of 1.30 meter width could increase comfort. Furthermore, it proved that South oriented houses were most comfortable, next were houses oriented to East, North and West.

The intervention also could make temperature, humidity, light intensity, and airflow remain in a comfort zone in which dry temperature was 25 ºC – 27 ºC, humidity 56% - 72%, light intensity 350 – 460 lux and airflow 0.22 m/sec – 0.34 m/sec. It means that ergonomic intervention by remodeling ventilation and windows can overcome the inconvenience effect caused by the difference of direction or orientation of the houses.

Subjective comfort was measured by a questionnaire which consisted of 16 question items. These items related with the conditions of room such as temperature, humidity, light intensity, and airflow. The data collected by using the questionnaire showed increased score of comfort from 30.50 ± 1.16 to 62.80 ±1.46. Subjective comfort score after and before intervention significantly differed. It indicates that after ergonomic intervention by remodeling ventilation and windows of houses type 36/120, there was increase of subjective comfort score of occupants in living rooms, bedrooms and kitchens.

Novelty in research that: (1) comfort of houses type 36/120 which measured by the wet temperature, dry temperature, relative humidity, natural light intensity, airflow can be achieved by the ergonomic intervention; (2) the objective comfort index of houses type 36/120 inherent with the subjective comfort of occupants; and (3) comfort of houses type 36/120 with four orientations of houses ie. North, South, East and West could be achieved similarly by the ergonomic intervention.

4. Conclusion

Based on the study result, analysis and discussion by ergonomic intervention of houses type 36/120 at Nuansa Kori Housing Sading Mengwi Badung, it can be concluded that: ergonomic intervention by remodeling ventilation and windows of houses type 36/120 increases objective comfort in 12.4% along with subjective comfort of occupants of four orientations of houses ie. North, South, East and West.

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