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Natural Air Change Rate Analysis of a Passive Solar House in Alice, South Africa

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Air tightness is an essential feature for minimizing heat exchange between the inner space and ambient environment of a building. On the other hand, shortage of air exchange can also result in indoor discomfort, which is associated with inadequate ventilation, poor air quality and building related illness. The aim of this study is to analyze the natural air exchange rate and indoor air quality of a passive solar house. The ASTM E741-11 standard method for determining air change rate in a single zone by means of Tracer Gas Dilution was adopted. A Non-Dispersive Infrared CO2 gas sensor was used to measure the indoor CO2 concentration. To investigate the effects of each of the ventilation components of the house, the tests were carried out in four stages; (i) all doors and windows open, (ii) all doors closed and windows open, (iii) all doors open and windows closed, and (iv) all doors and windows closed. Indoor and outdoor meteorological parameters were also monitored. The average indoor temperatures during the test period were 18.5℃, 19.0℃, and 19.5℃ for the north bedroom, south bedroom and living room/kitchen respectively, while the outdoor ambient temperature was 16.7℃. An average wind speed of 1.4 m/s at 158 (68 South of East) was observed. The south bedroom has the longest decay period of 62 min with a CO2 exchange rate of 0.52 per hour. Whilst the living room/kitchen with a CO2 exchange rate of 0.61 per hour had the shortest decay period of 13 min. The heat flow rate through the windows and building envelope were 140 J/s and 24 J/s, respectively. The overnight indoor CO2 concentration was found to be 0.248%, which is less than the indoor air quality maximum safe limit of 0.500%, in South Africa. It was observed that the heat flow rate depends on the ambient wind speed and direction. With proper operation of the widows by the occupants, passive cooling can be achieved in summer and the wind chill factor can be drastically reduced or even avoided in winter. This will promote indoor thermal comfort and enhance thermal energy efficiency.

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