

**UNIVERSITI TEKNOLOGI MARA**

**COURTYARD AS A PASSIVE  
COOLING DESIGN STRATEGY IN  
MALAYSIAN LINKED HOUSES**

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## ABSTRACT

Sixty percent of Malaysians prefer to stay in linked houses for reasons of location, space and aesthetic. Most of these houses are installed with mechanical cooling and air circulating fans for thermal comfort instead of a more passive means. There are less demand for courtyard linked houses although the courtyard could hypothetically to be the answer for a passive cooling design strategy. Hence, the aim of this research is to explore the possibilities of enhancing indoor thermal comfort condition by determining the effectiveness of courtyard as a passive cooling building element. The objectives of this thesis are: i) to study the types of courtyard configuration in existing linked houses; ii) to investigate the environmental condition of the courtyard and its effect to the indoor thermal comfort; iii) to explore the importance of courtyard configuration in providing good natural ventilation and iv) to determine the best courtyard configuration that create best indoor thermal comfort of a linked house. This study investigated two similar urban linked houses (with and without internal courtyard) in terms of size and specifications in Shah Alam and Klang. Data based on two days of measurements and observations at both houses for outdoor, indoor temperature, relative humidity and air velocity revealed that the indoor thermal conditions for both houses exceeded the thermal comfort zone recommended by Givoni's Bio-Climatic chart and ASHRAE. However, through comparative analysis, the house with internal centre courtyard produced better results and maintained a more comfortable indoor condition due to its horizontal and vertical natural cross ventilation which occurred during the day time and night time. Further predictive investigations on the courtyard linked house, based on CFD simulations using Flovent 7.2 and AnSys were conducted. Three variations of design models were studied namely enlarged courtyard area, increased courtyard walls height and enlarged openings at the front and rear. Diurnal simulations concluded that the increased of courtyard surrounding wall height and enlarged openings at front and rear options were the most effective, whereas the enlarged courtyard area (footprint) type were less effective, regardless of which operation mode were applied. Hence, linked houses with courtyards are proven to be beneficial to the occupants by providing passive cooling through natural ventilation.

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# **CHAPTER ONE**

## **INTRODUCTION**

This thesis explores the potential of improving indoor thermal comfort in intermediate linked houses through centre courtyard. This courtyard provides an opening that allows thermal built up. The housing development in Malaysia demand more linked houses type residential unit as compared to other types. Even though the design of linked houses complies to the Uniform Building By-Law (UBBL 1984) standards but with reference to researches (Pan, 1997; Tan, 1997; Jones, *et.al.*, 1993 & 1994; Zulkifli, 1992a, 1992b, 1994a, 1994b; Hui, 1998; Abdul Razak, *et.al.*, 2000, 2001) confirmed that internal thermal comfort cannot rely on natural ventilation performance. By observation and theory, it is understood that hot air rises and cold air replaces which called stack effect, this will have advantages for front and rear opening intermediate linked houses to benefit from this open courtyard. However this theory has not been investigated, therefore investigation to promote natural flow ventilation in intermediate linked houses should be carried out.

### **1.1 BACKGROUND**

Malaysia is a developing country with hot and high humidity climate condition throughout the year. This has urged working citizen to realise the importance of working and living in a conducive and comfortable environment so as to ensure higher quality of productivity and pleasant time to relax at home. “Thermal comfort must be created to satisfy the needs of man so that he may perform efficiently” (Zain-Ahmed, 2000). To buy a house is something precious that a consumer would only spend once in his lifetime. This demand for houses would be the first upsetting thing when consumers shy away because of the price was beyond their capacity. Although with high price, majority of middle to upper income group of Malaysian preferred linked houses because it is affordable, convenient, landed and saleable (REHDA, 2006). Generally the demand for low cost houses is always