COVER SHEET

This is the author version of article published as:

Williamson, Jack and Demirbilek, Nur (2003) The Potential for Increasing Thermal Comfort through Selection of Construction Types in Brisbane. In Proceedings 41st Annual Conference of the Australian NewZealand Solar Energy Society, Melbourne.

The Potential for Increasing Thermal Comfort through Selection of Construction Types in Brisbane

B.J. Williamson and F.N. Demirbilek
School of Design and Built Environment
Queensland University of Technology
2 George Street, GPO Box 2434 Brisbane 4001
AUSTRALIA
E-mail: j.williamson@qut.edu.au, n.demirbilek@qut.edu.au

Abstract

The parametric study explores the potential for reducing cooling and heating loads through changes in construction types for dwellings in Brisbane. Based on a previous study completed at QUT, a plan type and building materials is used as the base case of the computer runs. Various combinations of roof, floor, and wall construction form the control variables. Comparative results exhibit even the simplest changes can help providing an increase in thermal comfort of the occupants and cause a decrease in the dependence on mechanical heating and cooling systems. The study also includes a comparative economic analysis. This approach can provide an increase in occupant satisfaction and result in considerable savings in domestic energy consumption.

1. INTRODUCTION

Architectural design and construction techniques play an important role in buildings from the energy efficiency and thermal comfort points of view. The buildings should modify the natural environment to offer livable and comfortable conditions to the occupants. The envelope plays a particularly important role in fulfilling the task of keeping the indoor environmental conditions at a desirable level.

The study describes a parametric study for the analysis of thermal comfort conditions in a comparative way for the conditions of Brisbane carried out by means of computer simulation. Brisbane is located at 28°57'N latitude and 32°53'E longitude at South East Queensland.

1.1. Software

The indoor thermal comfort is analysed by means of computer simulation using the softwares named ARCHIPAK developed by Dr Steve Szokolay and BERS developed by Dr Holger Willrath.

1.2. Weather Data

Two different climatic data sets as severe and average are used for the calculation of heating and cooling degree days. Extreme temperature data set is generated using the 'extremes' values given by the Bureau of Meteorology, Australia. Brisbane shows temperate-humid climatic characteristics having long and hot summers, short and mild winters.

Average conditions weather data of Brisbane used for the simulations (Table 1) is the 'typical year', which was constructed by Willrath. The Australian Climatic Data Bank established by CSIRO in 1983, later expanded in 1990, was used. Climatic data is available from ACADS, an association of technical computer user organisations, for 83 locations including 18 outside Australia. "Differences between the long term average of mean maximum temperature, mean minimum temperature and mean daily radiation for each month, and that of the data for the same month in each of the ACADS data sets were calculated. For each month, the measured date which showed the smallest differences to the long term date was selected and concatenated to construct the 'typical year' data file for each location"

(Willrath, 1999).

Table 1. Brisbane climate data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tmax (℃)	29.1	29.0	27.9	26.5	23.4	21.1	20.4	22.0	24.0	26.0	27.5	28.5
sdMax (K)	2.5	2.1	2.1	2.2	2.1	1.9	1.9	2.1	2.4	2.5	2.7	2.5
Tmin (℃)	21.0	20.9	19.5	17.1	13.6	11.4	9.8	11.0	13.4	16.3	18.5	19.9
sdMin (K)	1.8	1.7	1.7	1.7	2.8	2.4	2.9	2.5	2.5	2.3	2.2	1.9
Tsd (K)	1.8	1.6	1.6	1.7	2.0	1.8	2.0	1.9	2.0	2.0	2.0	1.8
RHam (%)	65	68	70	69	67	69	65	63	59	59	58	60
RHpm (%)	57	58	56	52	48	49	43	42	44	50	52	56
Rain (K)	166	162	142	87	70	69	57	47	48	75	94	129
Irad (Wh/m²)	6722	6167	5472	4139	3278	3083	3139	4194	5278	5639	6083	6694

1.3. Description of the Test Buildings

The paper is based on a previous study completed by Lim and Williamson (1999a and 1999b), which has used the recommendations of solar house design by Baverstock and Poalino (1986) as a guide. For keeping the house as simple as possible no active systems have been used and passive features such as Trombe walls have not been included. It was assumed that the heating and cooling of the house depends mainly on direct solar gain, insulation, thermal mass, and ventilation. Plan, section, and elevations of the house are given in Figure 1. It has a floor and roof area of 176sqm and a volume of 484qm. Window areas for north, east, and south, are 35, 4.8, and 12sqm, respectively.

With in the framework of the paper the "Solar House" design is used for the analysis of variations in daily and monthly internal temperatures due to the application of various building materials and construction techniques. In order to see the positive and negative effects of changes to the building envelope, elements of the building have been changed step by step. The description of elements of the building construction types and ARCHIPAK codes in parenthesis are given in Table 2.

Windows used in all analysis have 4mm clear glass with wood/PVC frames (100) and a ventilation rate of 3 air change per hour is considered. Sol1 is rated a 5 star category by the BERS program.

The type of construction considered were those commonly used in the Brisbane area but excluding the traditional timber framed 'Queenslander' raised on two meter high stumps and the recent trend towards large single and two storey structures in the upper end of the housing market. Since about the 1960's the majority of houses in South East Queensland have been used timber or brick veneer construction on a concrete slab on the ground. The wide acceptance of the concrete slab on the ground was due mainly to costs. It was cheaper than a low set raised timber floor system; it was quicker to construct; and it made it easier to provide access to outdoor entertainment areas.

The construction systems considered in this study were solid cavity brick, brick veneer, and timber framed and clad structures. Only one building had a raised timber floor as all the other examples used a concrete slab on the ground.

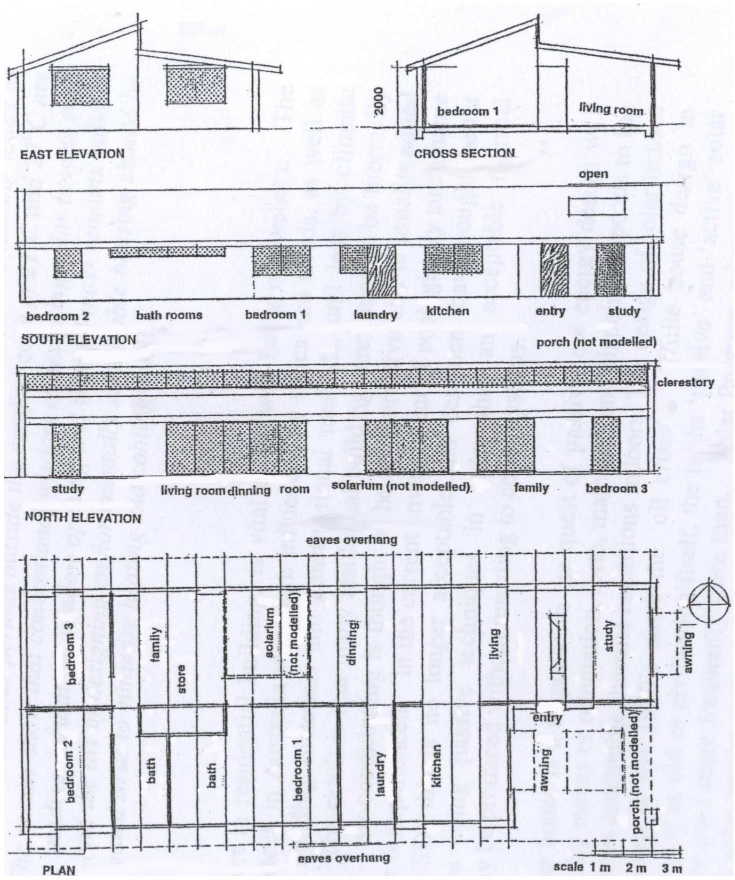

Figure 1 Plan, section, and elevations of the test house (Lim and Williamson, 1999b).

Table 2. Building Description.

Building	Floor	External Walls	Roof/ceiling	Internal Walls
Con1	Tiles and concrete slab on ground (434)	Cavity brick (240)	Tiles, reflective foil as sarking, R2.5 insulation (327)	Timber-framed plaster board (521)
Con2	Tiles and concrete slab on ground (434)	Brick veneer, timber frames, plaster board lining (270)	Tiles, reflective foil as sarking, R2.5 insulation (327)	Timber-framed plaster board (521)
Con3	Tiles and concrete slab on ground (434)	Brick veneer, timber frames, plaster board lining (270)	Colourbond roofing sheets, sarking, R2.5 insulation (347)	Timber-framed plaster board (521)
Con4	Tiles and concrete slab on ground (434)	Timbered frame timber weather boarding, R2.5 insulation on timber boarding (287)	Colourbond roofing sheets, sarking, R2.5 insulation (347)	Timber-framed plaster board (521)
Con5	Carpet on floor raised to 500mm (411)	Timbered frame timber weather boarding, R2.5 insulation on timber boarding (287)	Colourbond roofing sheets, sarking, R2.5 insulation (347)	Timber-framed plaster board (521)
Con6	Tiles and concrete slab on ground (434)	Single skin concrete block, 12mm cement rendering outside, plasterboard glued inside (220)	Tiles, reflective foil as sarking, R2.5 insulation (327)	Timber-framed plaster board (521)
Sol1	Tiles and concrete slab on ground (434)	Cavity brick, R1.5 insulation (245)	Metal, reflective foil, R2.5 insulation (347)	Single brick (500)

2. RESULTS AND DISCUSSION

Analysis of the test buildings for heating and cooling degree days with average and extreme climatic conditions clearly showed the effects of application of various building materials and construction techniques to the very same building. Con5 (shown in dashed line in Figure 2) rated the worst of the seven buildings both for heating and cooling seasons, whereas Con4, Con3, Con2, Con6, and Con1 showed gradual improvement, respectively. Sol1 rated the best of all.

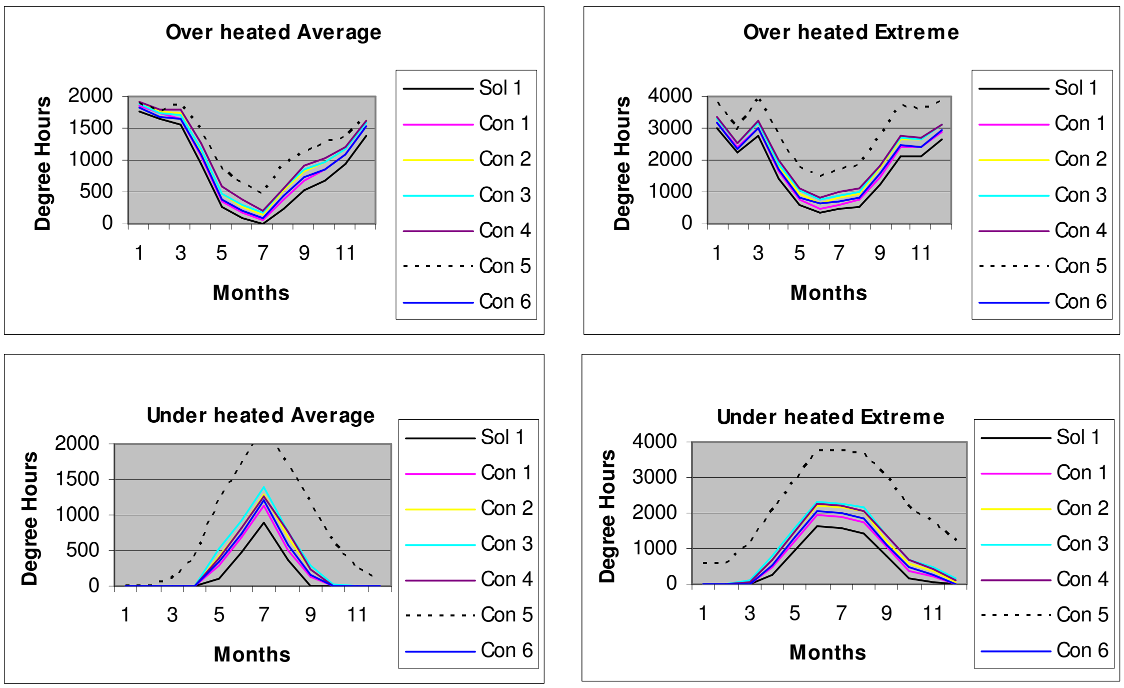

Figure 2 Over heated and under heated degree hours for average and extreme climatic conditions of the test buildings in Brisbane.

In order to see the improvement in the thermal comfort of occupants, indoor design temperature and hourly indoor air temperature values for each month are calculated and compared. The results of buildings for a summer and a winter month, January and July, are given in Figure 3. Design temperatures (Tin) for these months are 25.4 and 22.3℃, respectively. It can be seen that indoor air temperature values of buildings composed of different materials vary significantly. Internal temperature fluctuation of Sol1 is less than the others and Con5 is the one which is affected most from the outside air temperature variations.

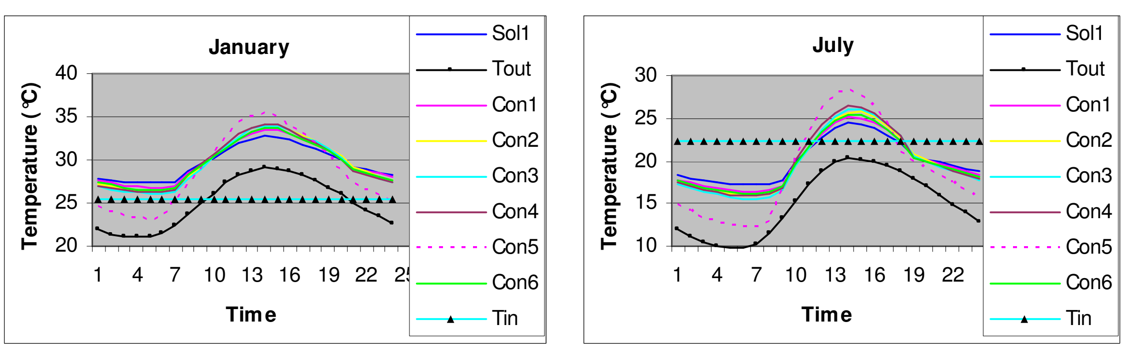

Figure 3 Hourly temperature values of internal air temperature of the test buildings and outdoor air temperature values for January and July of the 'typical year'.

Results of the worst and best buildings, Con5 and Sol1, are given in Figure 4 for every second month in order to show a more detailed comparison. Difference between low and high extreme temperatures of these two buildings is quite notable. Summer evening, night time, and early morning temperatures of Sol1 are 1-5°C higher than internal design temperature, whereas they are 1-3°C lower for Con5. On the other hand, summer daytime thermal performance of Sol1 is much more advantageous than Con5. Internal temperature values of the former are 3-8°C higher than internal design temperature, whereas Con5 temperatures exceed this value by 5-11°C.

When internal temperatures of the buildings for winter are compared, it can be seen that Sol1 values exceed the design temperature by only 2-4°C during mid-day while these reach to 6-8°C for Con5. Night-time temperature values also show a positive tableau for Sol1, providing more comfortable indoor conditions.

These results clearly show that the adoption of the concrete slab on the ground in lieu of the raised timber floor make a noticeable improvement in thermal comfort for the occupants.

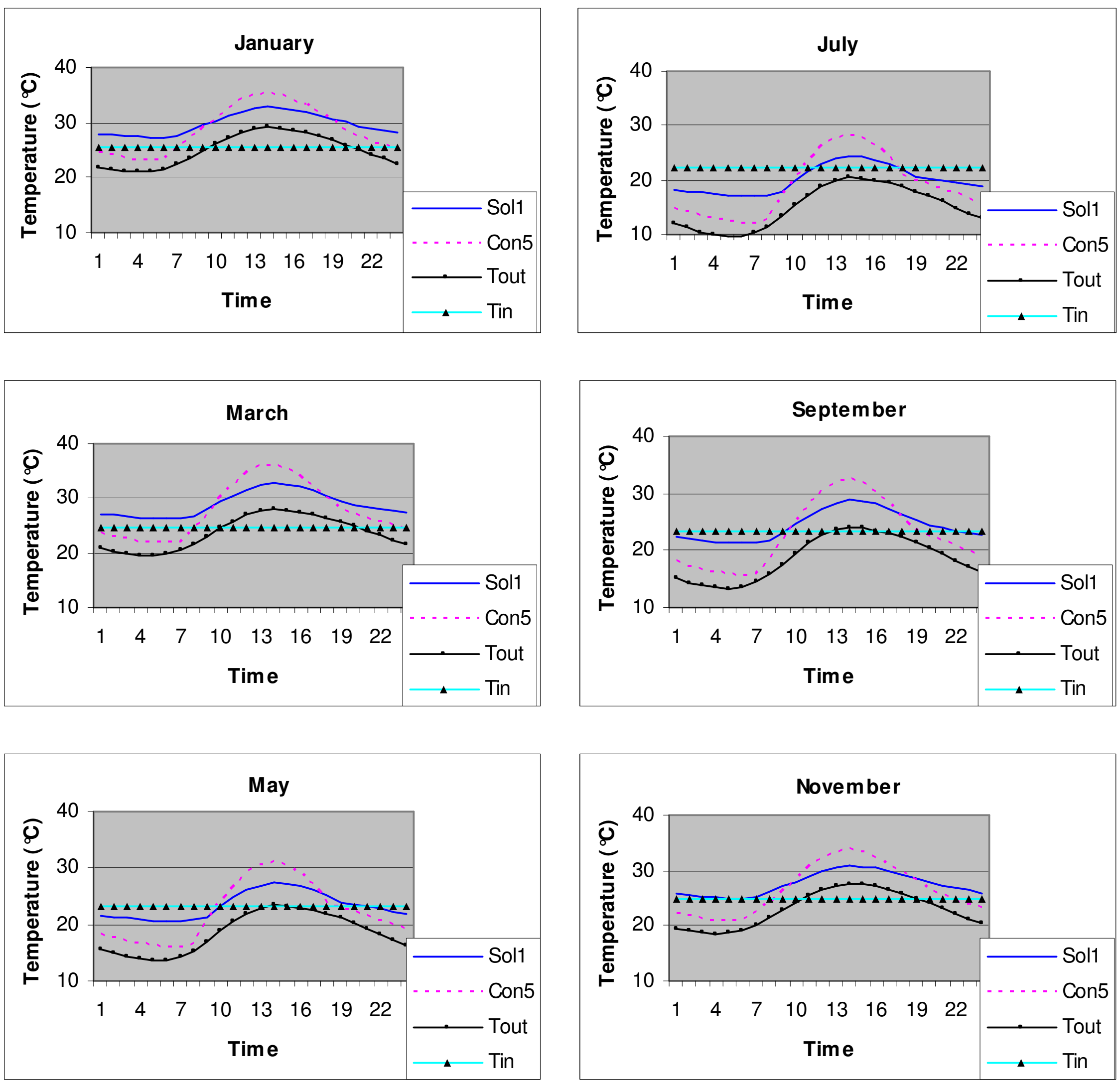

Figure 4 Indoor and outdoor air temperatures for the worst and best buildings for every second month of the 'typical year'.

The economical comparison of the cost of the various construction systems is given below using a base of 100 for construction 3, which was the cheapest of the examples in the study. Base 100 is $117,600 using construction price for Brisbane December 2002. Price does not include cost of land, site works, sewerage and storm water drainage, GST.

Table 3. Multiplier for Comparative Economic Analysis (Base 100.0).

Con1	101.7
Con2	100.8
Con3	**100.0**
Con4	103.4
Con5	107.3
Con6	105.2
Sol1	101.1

3. CONCLUSION

Comparative results of the study exhibit that changes in the use of various building materials can help providing thermal comfort to the occupants. It also shows that being careful in choosing the materials and construction types doesn't necessarily mean that the cost of the building will be high. This approach can result in occupant satisfaction and cause a decrease in the dependence on mechanical heating and cooling systems. Considerable savings in domestic energy consumption can be obtained, and then a decrease in greenhouse gas emissions in return.

4. REFERENCES

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5. ACKNOWLEDGMENTS

The authors would like to acknowledge the Australian Research Council for support for this investigation under the Small Research Grants Scheme and the preliminary investigations by the late Prof. Bill Lim.