CSIR research confirms the superior energy efficiency of light steel frame building

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A recent research project by the Built Environment division of the Council for Scientific and Industrial Research (CSIR) confirmed that a light steel frame (LSF) dwelling, built to SANS 517, will result in significant savings of electricity used for heating and cooling of the building, compared with a conventionally built heavy masonry building.

To obtain an objective prediction of the thermal performance of a LSF dwelling compared with a masonry building in the different South African climate zones, the South African Light Steel Frame Building Association (Sasfa) approached the CSIR to carry out the analyses.

A typical 120 m² single-storey house was used for the comparison. The LSF and the masonry houses were specified to be geometrically identical, with identical orientation. The LSF house complies in all respects to SANS 517 Light Steel Frame Building.

A typical masonry house with double-leaf external clay brick walls, without any insulation in the walls and ceilings, was used as the base case. The effects of adding (i) 40 mm insulation in the ceilings, and (ii) similar ceiling insulation as used for LSF buildings (140 mm) and 50 mm insulation in external walls, were also analysed.

The CSIR's Built Environment division decided to use the Ecotect V 5.6 software to carry out the computer analyses. To eliminate the effect of user input data, which could influence the outcome, it was decided to use a passive analysis, that is, without making assumptions regarding the occupancy and usage patterns of the house. The heating effect of lights and appliances was also not taken into account.

The analyses were aimed at determining the number of hours of uncomfortably high or low temperatures in each of the buildings. The buildings were considered to be naturally ventilated and the thermal comfort temperature range for naturally ventilated buildings in Pretoria is 17.8 °C to 28.3 0C. The adaptive model of thermal comfort was used in calculating the levels of thermal comfort in the two houses.

The electricity needed for heating and cooling each of the buildings to thermal comfort levels (ranging from 20 oC to 24 oC, as recommended by SANS 204) was also determined.

The major differences between the two types of building are the

thermal insulation and the thermal mass. The walls in a LSF building have better thermal insulation, but lower thermal mass than masonry buildings. The higher thermal mass in the walls of brick buildings reduces the diurnal internal temperature swings towards the average temperature, which could be too high or too low for comfort.

Findings

Results indicate that the LSF house will be warmer than a base case masonry building in summer, as well as in winter. If the hours of discomfort owing to high and low temperatures are added together, the LSF house performs somewhat better than the masonry alternative in all locations except Durban.

As example, the indoor temperature of the LSF building was within the thermal comfort range for 74% of the time in Pretoria's climate, compared with 71% for the masonry base case – only a small advantage.

However, the analyses indicate that electricity required to heat the base case brick building to comfort levels will, on average, be double that required for the LSF building, ranging from 89% more in Pretoria, to 112% more in Bloemfontein. If cooling to comfortable temperatures is required, it will take on average three times more electricity to cool the brick building down to thermal comfort levels compared with a LSF building.

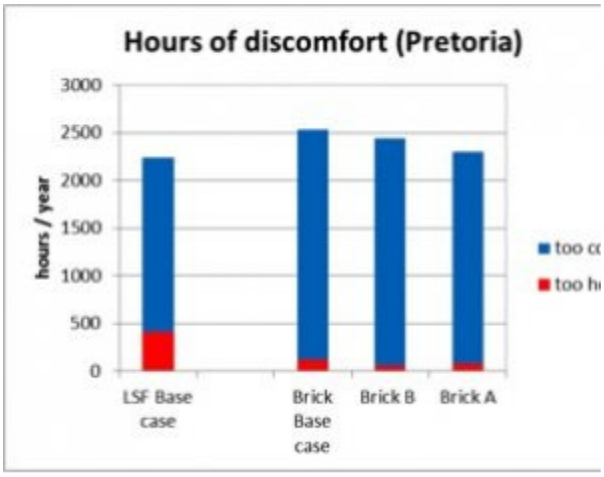
This significant increase in the amount of electricity required to heat or cool the internal spaces can be ascribed to the thermal mass of the masonry building – besides having to heat the air inside the building, the walls of the masonry building absorb some of the heat, resulting in additional energy consumption. The inverse happens when cooling, when the heavy masonry walls have to be cooled down together with the air inside the building.

Thermal performance comparison : LSF vs masonry dwelling

	Discomfort hours (hrs)			Annual heating & cooling		
	too hot	too cool	total	heating	cooling	total
Base case LSF						
Pretoria	414	1824	2237	36.6	6.9	43.5
Durban	562	455	1017	12.8	9.7	22.5
Bloem	299	3229	3528	74.9	4.3	79.2
Cape Town	45	2878	2923	60.7	1.8	62.4
Average	330	2096	2426	46.3	5.6	51.9
Base case brick						
Pretoria	116	2411	2527	69.3	30.6	99.9
Durban	127	749	876	25.1	37.9	63.0
Bloem	80	3820	3900	158.6	22.3	181.0
Cape Town	0	3818	3818	117.4	5.5	122.9
Average	81	2700	2780	92.6	24.1	116.7

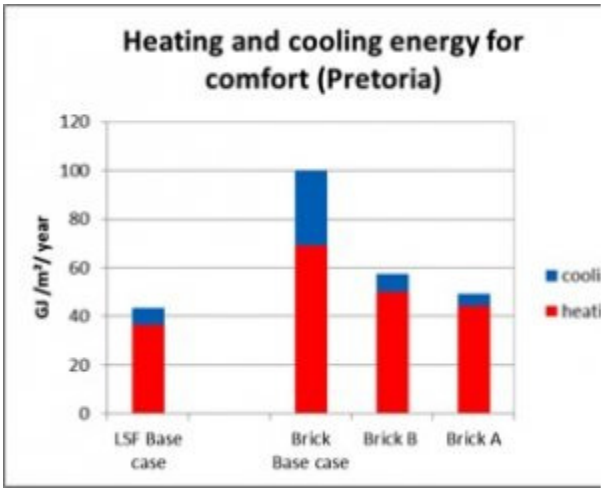
When the brick building is insulated, the performance improves. The graph below compares the hours of thermal discomfort in a LSFB with that in three alternative masonry buildings:

- Base case: no ceiling or wall insulation
- Brick B: 40mm thick glasswool insulation in ceilings
- Brick A: 140mm thick glasswool insulation in ceilings, and 50mm polystyrene insulation in the cavity of all external walls.



While the LSF building will result in more hours of discomfort without heating and cooling in Pretoria's summer climate than the masonry alternatives, occupants will have less discomfort in winter, and less discomfort in total.

The LSF building will require less than half the electricity to heat and cool to thermal comfort levels than the brick base case building, and still notably less than the other two insulated masonry alternatives.



Savings in electricity for heating only:
LSF compared with Brick Base Case: 32.7 GJ/m2 /yr (89%)
Brick B : 13.5 GJ/m2 /yr (37%)
Brick A : 7.7 GJ/m2 /yr (21%)

Conclusion
The CSIR's comparative thermal analyses indicate that LSF buildings offer improved energy efficiency compared with conventional masonry buildings – this means significant savings (between 20% and 90%) of electricity required for heating of residential buildings.

These findings are generally supported by testimonials received from occupants of LSF houses. In a recent survey carried out by Sasfa, 57% of respondents reported that their LSF house was cooler in summer, while 71% said it was warmer in winter.

The CSIR research also indicated specific areas where further gains in energy efficiency can be captured for LSF building and these will be investigated and implemented in the LSF building methodology.

Reference: 'A predictive comparative thermal performance analysis for light steel frame and masonry residential buildings', T Kumirai and Dr D Conradie, CSIR