The Thermal Impact of Using Heavy Materials Without Insulation in Arid zone Countries: A Case Study in Tripoli, Libya

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الملخص

تهدف هذه الورقة إلى تحليل التأثير الحراري لاستخدام المواد الثقيلة مثل الخرسانة بدون عزل حراري في المناطق التي تتصف بالمناخ الحار والجاف، تم إجراء هذه التجربة على دراسة حالة في مدينة طرابلس بليبيا. حيث تم إجراء محاولة تجريبية لقياس انتقال الحرارة عبر الجدران المصنوعة من وحدات خرسانية . بالإضافة إلى ذلك ، جرت هذه المحاولة لتحديد مدى تأثير هذه المواد على الراحة الحرارية داخل الفراغات. ومن خلال النتائج المتحصل عليها من هذه التجربة تم الحصول على أن استخدام المواد الثقيلة بدون استخدام عزل يؤدي إلى زيادة كبيرة في درجات الحرارة الداخلية ، وبالتالي التأثير سلبا على الراحة الحرارية. ومن خلال ذلك ونتيجة لأزمة الكهرباء المستمرة في ليبيا وتغير المناخ ، توصي الدراسة باستخدام المواد العازلة بالإضافة إلى تقنيات التبريد المستدامة لتحسين كفاءة الطاقة في المباني .

Abstract

This paper aims to analyze the thermal impact of using heavy materials such as concrete without thermal insulation in hot and dry climate regions, with an emphasis on a case study in Tripoli, Libya. An experimental attempt was conducted to measure heat transfer through walls made of concrete units. In addition, this attempt was made to determine the extent of the impact of these materials on thermal comfort within spaces. The results showed that using heavy materials without insulation leads to a significant increase in indoor temperatures, and thus negatively affecting thermal comfort. As a result of the electricity crisis in Libya and climate change, the study recommends the use of insulating materials in addition to sustainable cooling techniques to improve energy efficiency in buildings.

[Keywords]: Arid zone, thermal comfort, thermal insulation, climate change, Global warming, Libya, heavy building materials.

1. Introduction

As a result of the phenomenon of climate changes and its impacts such as global warming, the issue of thermal comfort in buildings has gained significant attention from designers and construction experts. Hot climate regions, such as Libya, are among the most affected by these changes, where the use of heavy materials in construction without thermal insulation can exacerbate the problem of rising indoor temperatures. This study aims to analyze the impact of using heavy materials without thermal insulation on thermal comfort in buildings in hot climates, with a focus on a case study in Tripoli, Libya.

The studies indicate that the global average temperature has risen by approximately 0.2°C over the past century and 0.8°C since the end of the 19th century (Jenkins, 2009). This increases the importance of understanding how building materials interact with heat and how to improve building thermal performance. This study relies on an experimental technique to measure heat transfer through walls made of concrete units, in addition to determining the extent of these materials' impact on thermal comfort within spaces.

2. Literature Review

2.1. The Impact of Building Materials on Thermal Comfort

Most studies in the same field have shown that the choice of appropriate building materials plays a crucial role in achieving thermal comfort within buildings. Smith et al. (2018) indicated that the use of heavy materials such as concrete without thermal insulation leads to increased heat absorption, transfer of heat indoors, and subsequently raising indoor temperatures.

2.2. Thermal Insulation and Its Importance in Hot Climates

In hot regions, thermal insulation is one of the primary solutions to reduce heat transfer through walls. According to a study by Brown (2020), the use of insulating materials such as polystyrene or rock wool can reduce heat transfer by up to 40%, improving thermal comfort and reducing energy consumption for cooling.

2.3. The Impact of Wall Orientation on Heat Absorption

A study by Lee (2021) showed that wall orientation plays a significant role in the amount of heat absorbed. For instance, south- and west-facing walls absorb more heat compared to east-facing walls due to longer exposure to direct sunlight.

2.4. Climate Change and Its Impact on the Construction Sector

An organizational Study declared that climate change exacerbates problems related to rising temperatures, especially in hot regions. According to the UKCIP02 report (2002), rising temperatures will lead to increased demand for cooling systems, increasing energy consumption, and carbon emissions.

2.5. The Electricity Crisis in Libya

Libya suffers from persistent Instability in the electrical network. The power supply cannot meet the increasing energy demand, especially during summer when the use of cooling systems increases. According to a study by Al-Tamimi (2017), frequent power outages make it more difficult to achieve thermal comfort indoors. In addition, he stated that solutions based on renewable energy and thermal insulation are essential.

2.6. Sustainability and Environmental Preservation

Referring to environmental and climate challenges, sustainability has become a fundamental element in building design. A study by Givoni (1994) suggests that the use of sustainable building materials and passive cooling techniques can reduce energy consumption and preserve the environment.

3. Methodology

An experiment was conducted in an open area in Tripoli, Libya, to measure the impact of using heavy materials without thermal insulation. furthermore, an experimental room with dimensions of (1600 × 1600 × 1400 mm) was constructed using concrete units with a thickness of 200 mm. Within the same context, aluminum windows with dimensions (1230 × 560 mm) and single glazing were installed on the eastern side of the room.

Sensors were installed to measure temperature at various locations inside and outside the room, including the internal and external surfaces of the walls and windows. Data was recorded for 24 hours on July 21, 2023, one of the longest days of the year in Libya as shown in figure (1).

Figure (1) shows the room and temperature sensors.

4. Results

4.1. Southern wall

As shown in figure (2), the lowest temperature on the external surface of the southern wall (T9) was recorded at 6 AM, at less than 25°C. After that, the temperature gradually increased, reaching its peak at 6 PM, recording 35°C. Subsequently, the temperature dropped sharply from around 34°C to 26.5°C at 9 PM, indicating significant heat exchange between the interior and exterior.

On the other hand, measurements inside the wall (T1 and T2) showed similar behavior but gradually decreased temperature after 9 PM, indicating slower heat exchange. The temperature on the internal surface of the southern wall (T2) reached around 40°C after 6 PM, indicating thermal discomfort.

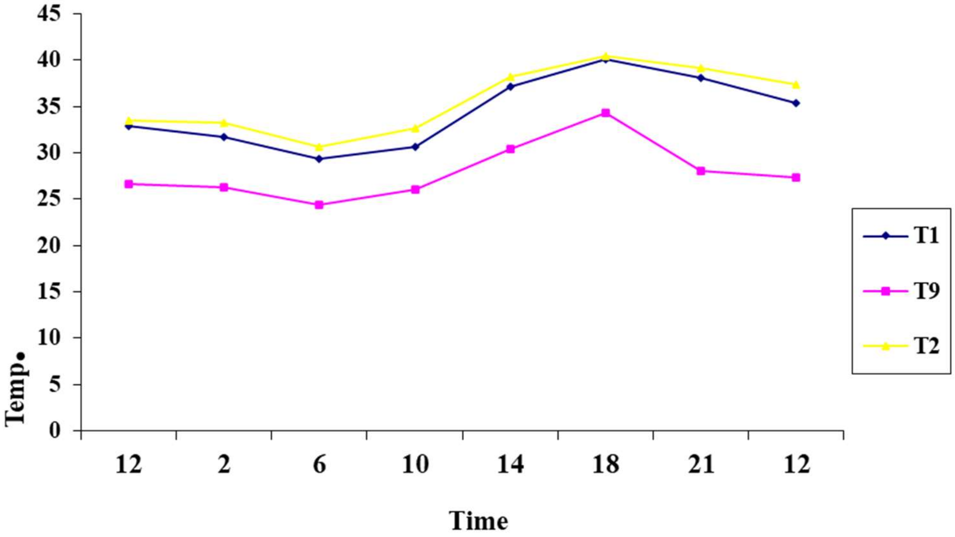

Figure (2) Temperature recorded on the South wall.

4.2. Western wall

As shown in figure (3), temperatures on the western wall were relatively lower between midnight and 6 AM, and between 9 PM and midnight. However, the temperature began to rise steadily after 6 AM, reaching its highest temperature (over 41°C) at 6 PM. After that, the temperature dropped to around 30°C, which indicated thermal discomfort.

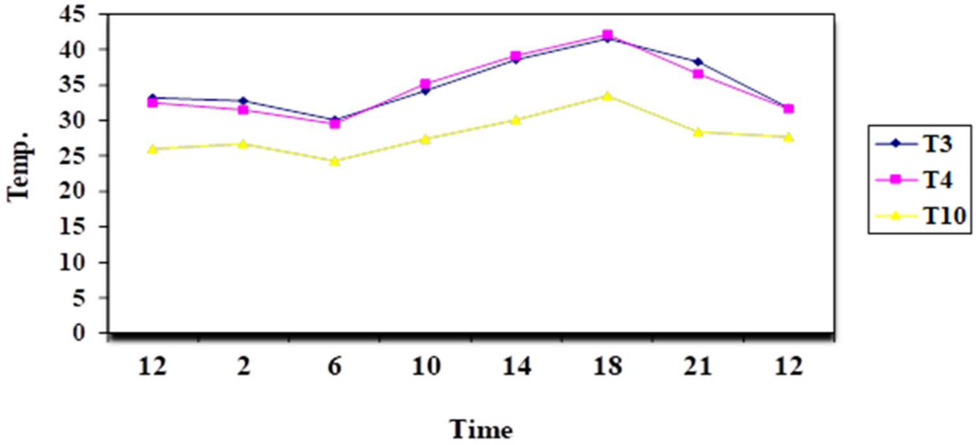

Figure (3) Temperature recorded on the West wall.

4.3. Eastern wall

The eastern wall exhibited slightly different behavior compared to the southern and western walls. As shown in figure (4), temperatures on the external surface of the eastern window (T6) and the external surface of the eastern wall (T7) were almost identical, rising noticeably after 8 AM to reach around 40°C at 7 PM. On the other hand, the temperature inside the eastern wall (T8) dropped from around 30°C to less than 29°C after 6 AM, then rose again to around 38°C at 6 PM.

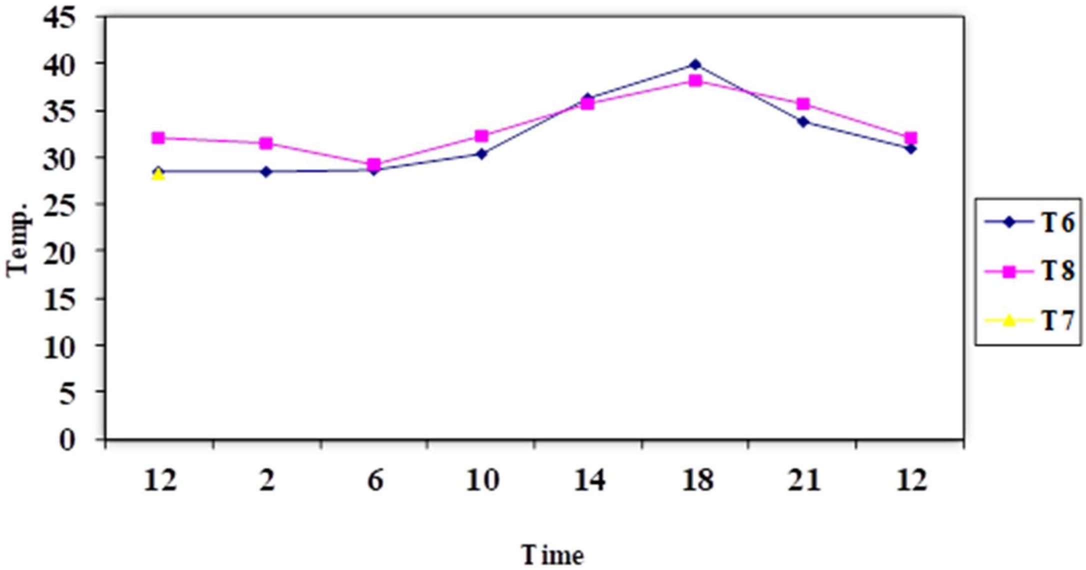

Figure (4) Temperature recorded on the East wall.

5. Discussion

From the result above, it is clear that overheating is a major problem. As a result of that adding insulation materials is important to reduce the heat gain through the building fabrics. In addition, applying cooling applications to reduce heating inside the space is the second stage to obtain comfort. The South and the West wall in particular have obtained more heat than the East wall as can be seen in the above graphs. The period to overheat is less long in the East wall than others even with a single glass window installed in the East wall. Thus, the amount of insulation materials will be different at different orientations and even the time of cooling will be different.

The results of this experiment advocated previous studies indicated that the use of heavy materials without thermal insulation leads to a significant increase in indoor temperatures. Referring to the electricity instability in Libya, it becomes essential to rely on sustainable solutions such as thermal insulation and passive cooling.

6. Conclusion

In conclusion, the study showed that the use of heavy materials without thermal insulation in hot climate regions leads to a significant increase in indoor temperatures. Therefore, using insulation materials and effective cooling techniques is essential to improve thermal comfort and reduce energy consumption. Libya is one of the arid zone countries suffering from electricity scarcity, which in turn needs more attention to provide a stable electrical supply. The use of insulating material and cooling systems is the optimal demand to solve this issue.

7. Recommendations

1. Use of Insulating Materials Such as polystyrene or rock wool to reduce heat transfer through walls.
2. Improving windows by utilizing double-glazed or low-emissivity glass (E-Glass) to reduce heat transfer.
3. Consider wall orientation during design to reduce direct exposure to sunlight.
4. Use effective cooling systems to improve thermal comfort within spaces.

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