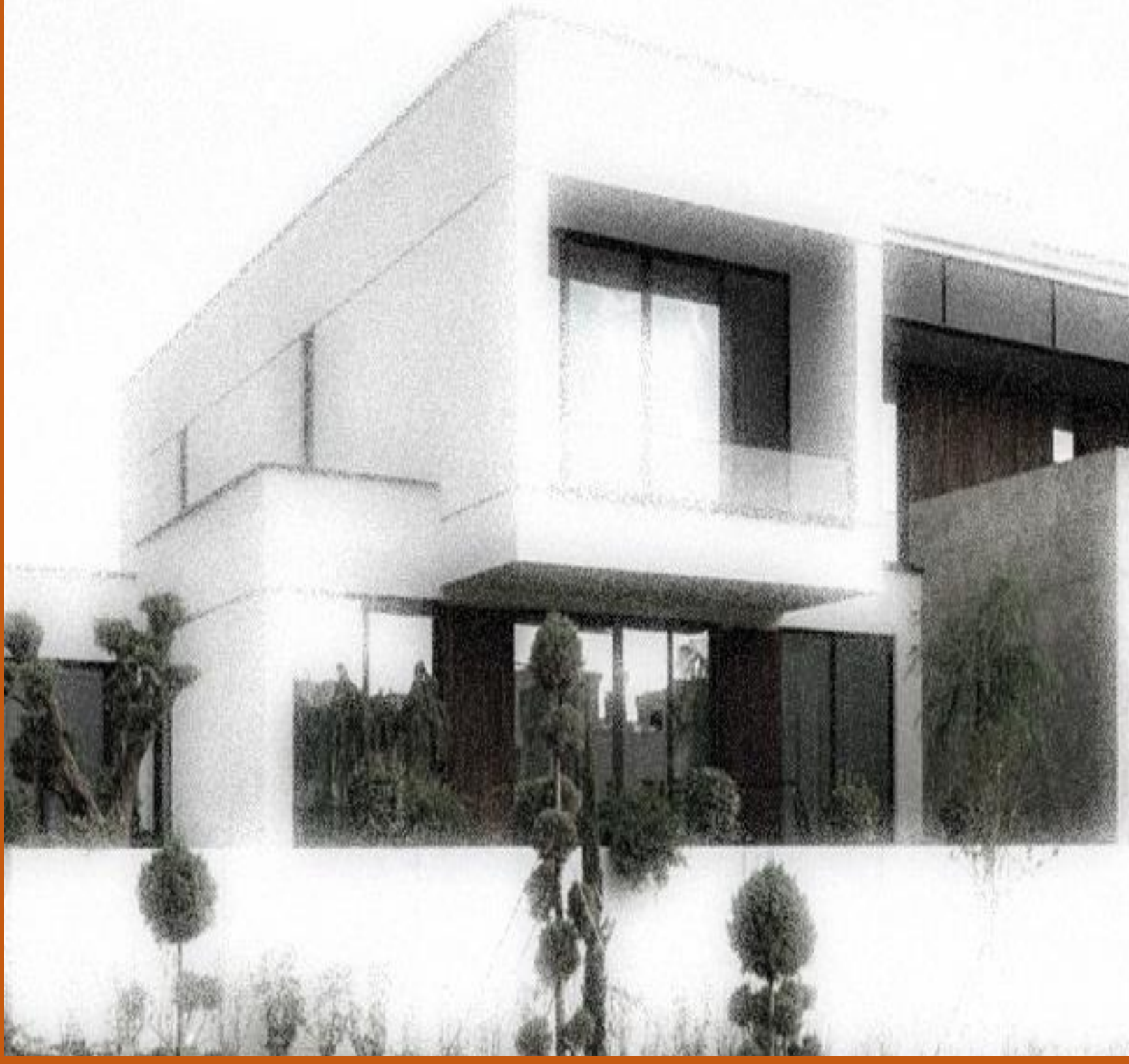
Enhancing Durability and Comfort for Buildings in Extreme Climates:

Rockwool-based Thermal Insulation Composite System



A Comparative Engineering Analysis of Insulation Systems for Sulaymaniyah and Similar Regions

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Sulaymaniyah, October 2023

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Acknowledgments

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The Allngar Company's expertise and insights into construction materials and thermal insulation systems have been indispensable. Their commitment to excellence in providing high-quality materials and dedication to sustainable building practices have greatly enriched this study.

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Your contributions have been essential in advancing our understanding of thermal insulation systems and their role in enhancing building durability and comfort in extreme climates.

Alan Rauf Ahmad Alany

Abstract:

This research explores advancements in thermal insulation practices in Sulaymaniyah, with a focus on the efficacy of Rockwool-based Thermal Insulation Composite Systems.

The study begins by acknowledging the pivotal contributions of **Allngar Company** for Construction Materials and the **Mariwan Bureau's** engineering staff to the research project.

Chapters 1 and 2 provide an overview of historical insulation practices in Sulaymaniyah, emphasizing the transition from traditional to modern systems. The superiority of Rockwool over other materials is examined in Chapter 2, covering factors such as composition, thermal insulation, fire resistance, moisture resistance, sustainability, comfort, energy efficiency, maintenance, and cost-effectiveness.

Chapter 3 outlines the meticulous steps involved in producing Rockwool, detailing raw material selection, melting, fiberization, mat formation, curing, cutting, shaping, quality control, and packaging.

Chapter 4 accentuates the reasons behind selecting Rockwool, emphasizing its climate suitability, outstanding performance, fire resistance, pest resistance, sound insulation, sustainability, comfort, energy efficiency, aesthetics, durability, thermal performance, and environmental considerations.

In Chapter 5, practical aspects of implementing Rockwool in Sulaymaniyah are explored through a case study with the Mariwan Bureau and Allngar Company. The significance of high-quality materials and professional staff in the success of the Rockwool-based Thermal Insulation System is emphasized.

Chapter 6 outlines potential future research areas, including long-term performance assessment, cost-effectiveness analysis, energy consumption impact assessment, environmental sustainability evaluation, and building maintenance studies. The conclusion, in Chapter 7, synthesizes the findings, emphasizing Rockwool's promising role in sustainable and resilient construction for extreme climates. The study draws from diverse references, including technical manuals, research papers, building codes, and collaboration with industry experts.

In summary, this research contributes valuable insights into enhancing building durability and comfort in extreme climates, positioning Rockwool-based Thermal Insulation Composite Systems as a promising solution. Ongoing and future research will further solidify its role in sustainable building practices.

Chapter 1: Latest Updates on Thermal Insulation Practices in Sulaymaniyah

This section provides an overview of the most recent developments in thermal insulation practices in Sulaymaniyah, particularly post-2020. It covers a range of insulation materials and their suitability for the region, including Extruded Polystyrene (XPS) Foam, Expanded Polystyrene (EPS) Foam, and Mineral Wool Insulation, with a special focus on Rock Wool insulation.

- **Traditional Insulation System (Before 2010s):**
- In Sulaymaniyah and similar regions with extreme climates, traditional wall insulation systems have been used to provide some level of thermal comfort and protection against temperature fluctuations. Here are a few traditional wall insulation systems that have been used in Sulaymaniyah:
- **Mud and Adobe Walls**: Mud and adobe walls are traditional building methods that involve mixing clay soil, straw, and sometimes animal dung to create a thick, insulating wall. These walls provide thermal mass and can help regulate indoor temperatures.
- **Brick or Stone Masonry:** Traditional brick or stone masonry walls, when constructed with thick walls and adequate thermal mass, can provide some insulation against temperature extremes. The thickness and density of the masonry contribute to their insulating properties.
- **Straw Bale Construction**: In some rural areas, straw bales have been used as insulation within walls. These bales provide both insulation and thermal mass, helping to keep indoor temperatures more stable.
- **Earth bag Construction**: Earth bag construction involves filling sacks with earth or sand and stacking them to create walls. This method can provide insulation and is sometimes used in sustainable and eco-friendly building practices.
- **Wooden Timber Framing:** Traditional timber-framed buildings may have used straw, reeds, or other natural materials as insulation between the wooden frame members. These materials offer some insulation but may not be as effective as modern insulation materials.
- **Wattle and Daub:** Wattle and daub construction consists of woven sticks or branches covered with a mud-based plaster. While primarily a construction technique, the combination of materials can provide some insulation.

It's important to note that these traditional wall insulation systems may have limitations in terms of thermal performance compared to modern insulation materials. They are often chosen for their availability, cost-effectiveness, and alignment with traditional building practices rather than their high insulation value. In regions like Sulaymaniyah, there is a growing trend toward incorporating modern insulation methods to enhance energy efficiency and indoor comfort in buildings.

1.1. Passing to modern Insulation system: (After 2010s)

Modern wall insulation systems are generally considered better than traditional systems for several reasons, primarily related to their superior performance, energy efficiency, and overall effectiveness. Here are the key reasons why modern wall insulation systems are preferred over traditional ones:

- **Enhanced Thermal Performance:** Advanced materials like foam boards and spray foam offer superior thermal resistance (R-value) compared to fiberglass or loose-fill insulation, improving indoor comfort.
- **Reduced Energy Usage:** They minimize heat loss in winter and heat gain in summer, leading to lower energy consumption and cost savings.
- **Effective Air Sealing:** Modern methods prevent drafts and air leaks, enhancing comfort and indoor air quality.
- **Moisture Management:** They include moisture control features, reducing mold and rot risks.
- **Structural Support:** Some materials, like insulated concrete forms, provide both insulation and structural strength.
- **Fire Resistance:** Many are fire-resistant, enhancing safety.
- **Sustainability:** Eco-friendly materials and manufacturing processes reduce environmental impact.
- **Versatility:** Suitable for walls, roofs, floors, and various applications, offering design flexibility.
- **Longevity:** Durable materials maintain consistent performance over time.
- **Easy Installation:** Efficient methods like spray foam reduce labor and construction time.
- **Climate Adaptation**: Customizable for regional conditions, vital in extreme climates.
- **Building Code Compliance:** Meets or exceeds energy efficiency standards.

In extreme climates like Sulaymaniyah, modern systems enhance comfort and energy efficiency.

Chapter 2: Comparing Rockwool-Based Thermal Insulation with Other Materials commonly used in Sulaymaniyah

The choice between Rockwool, XPS, and EPS insulation materials depends on the specific requirements of the application, such as thermal insulation, fire resistance, moisture resistance, environmental considerations, comfort, Energy Efficiency, Money Savings, and Maintenance.

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Factors	Insulation Materials		
	Rockwool	**XPS (Extruded Polystyrene)**	**EPS (Expanded Polystyrene)**
Composition 	Made from natural rock materials, typically basalt or diabase, which are melted and spun into fibers.	Is a rigid foam board insulation made from polystyrene resin that is melted and extruded into a dense, melted and extruded into a dense, closed-cell structure. structure.	Is a foam board insulation made from expanded polystyrene beads that are fused together during a molding process, creating a more open-cell.
Thermal Insulation 	Provides effective insulation against both heat and cold. It has a higher thermal resistance (R-value) compared to EPS and is often used in high-temperature applications.	Has excellent thermal insulation properties with a relatively high R-value. It is known for its low thermal conductivity, making it effective at preventing heat transfer.	Provides reasonable thermal insulation but typically has a lower R-value compared to XPS and Rockwool. It is better suited for applications where high insulation values are not critical.
Fire Resistance 	highly fire-resistant and can withstand extremely high temperatures without igniting. It is often used in fireproofing applications.	XPS is combustible and will melt when exposed to high heat or an open flame. Special fire-resistant grades are available but are not as effective as Rockwool in fire protection.	Is flammable and will melt when exposed to fire or high temperatures, making it a poor choice for fire-resistant applications.
Moisture Resistance 	Is moisture-resistant and does not absorb water. It retains its insulating properties even when wet.	Is water-resistant and provides a good barrier against moisture. It is often used in below-grade and damp environments.	Can absorb moisture over time, which can reduce its insulation effectiveness. Special treatments or coatings may be needed to enhance its moisture resistance.

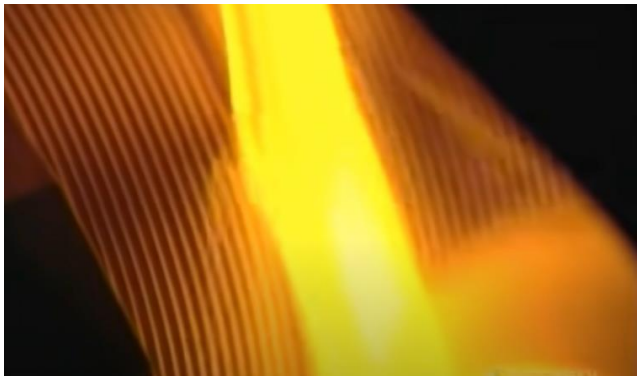
Sustainability 	Considered more environmentally friendly because it is made from abundant natural materials and can be recycled.	It is not biodegradable and can be harmful to the environment when disposed of in landfills.	Is lightweight and recyclable, but it can contribute to plastic pollution if not managed properly.
Comfort 	Excellent soundproofing (including reduction of exterior sounds), High thermal resistance, Fire-resistant, Reduces echo	Good thermal resistance, Lightweight, Limited soundproofing (including exterior sounds), Limited echo reduction	Good thermal resistance, Lightweight, Limited soundproofing (including exterior sounds), Limited echo reduction.
Energy Efficiency 	High thermal resistance, Low energy bills, Suitable for all climates	High thermal resistance, Energy-efficient, Suitable for all climates	Moderate thermal resistance, Reasonable energy savings, Best for milder climates
Maintenance 	Minimal maintenance, Durable and moisture-resistant	Low maintenance, Durable and moisture-resistant, Requires sealing	Low maintenance, Lightweight and durable, Requires proper sealing
Money Savings 	Higher initial cost, Significant long-term savings, Low maintenance	Moderate initial cost, Good long-term value, Low maintenance	Lower initial cost, Reasonable long-term savings, Potential moisture-related maintenance

Chapter 3: Steps to produce Rockwool in the factory

1. Raw Material Selection: Choose rocks rich in minerals like basalt, diabase, or iron slag.




2. Melting: Heat the rocks to over 1,600°C (2,900°F) to create molten material.




3. Fiberization: Spin the molten material into fine fibers using high-speed spinning equipment.

4. Mat Formation: Collect the fibers into a loose mat or blanket.

5. Curing: Heat-treat the mat to cure the binder (if used) and improve bonding.

6. Cutting and Shaping: Cut and shape the cured mat into various insulation products.

7. Quality Control: Ensure the product meets industry standards and specifications.

8. Packaging: Package the finished insulation products for distribution and sale.

Chapter 4: The Choice and the benefits of Rockwool-based Insulation

After a comprehensive evaluation of insulation materials in Sulaymaniyah, Rockwool stands out as the top choice due to its exceptional attributes.

- **Climate Suitability:** Rockwool's durability suits the region's wide temperature fluctuations.
- **Performance:** It excels in various aspects, including thermal insulation, fire resistance, and moisture protection, all of which are crucial in Sulaimanyah's climate.
- **Fire Resistance:** Remarkable fire resistance capable of withstanding temperatures up to 1000 degrees ensures building security in the face of intense fire hazards.
- **Pest Resistance:** Inherent pest resistance protects structures from various pests, ensuring long-term investment protection.
- **Sound Insulation:** Exceptional sound insulation creates serene environments, whether in noisy neighborhoods or peaceful workspaces.
- **Sustainability:** Rockwool's eco-friendliness and recyclability align with global sustainability trends, making it an environmentally conscious choice.
- **Comfort:** Outstanding soundproofing, thermal resistance, and fire resistance enhance safety and tranquility, addressing the needs of a noisy city.
- **Energy Efficiency:** Low maintenance requirements and energy-saving properties provide long-term cost benefits for homeowners and developers.
- **Aesthetics:** Rockwool seamlessly integrates with modern architecture, elevating Sulaimaniyah's visual appeal.
- **Durability:** High-quality materials and exceptional elasticity guarantee the long-term structural integrity of buildings, reducing concerns about destruction and cracks.
- **Thermal Performance:** The system adapts to seasons, offering a comfortable climate year-round, reducing the need for excessive cooling or heating and saving on energy costs.
- **Environmental Considerations:** Incorporation of eco-friendly materials and energy-efficient practices demonstrates commitment to environmental sustainability.
- **Non-Combustibility Assurance:** The non-combustible nature of the system adds an extra layer of protection, ensuring building safety even in the face of unexpected fire hazards.

In summary, Rockwool-based insulation and its utilization in the Thermal Insulation System offer comprehensive solutions with superior performance, safety, and aesthetics, making it an ideal choice for construction in Sulaymaniyah.

Chapter 5: Rockwool-based Insulation Applicability in Sulaymaniyah

In this section, we delve into the practical aspects of implementing the Thermal Insulation System with Rock Wool in Sulaymaniyah. **The Mariwan Bureau's collaboration with Allngar** Company for building materials serves as a case study, highlighting the successful application of the system. Key considerations include:

4.1. Selection of High-Quality Materials: The success of the Rockwool-based Thermal Insulation System is closely tied to the use of high-quality German materials, carefully selected for their reliability and performance. Notable materials include adhesive compounds, Rock Wool layers, Screwed Plugs, PVC membranes, plaster layers, reinforcement mesh, intermediaries coat, Marmor Putz, and elastic silicone resin facade paint. These materials ensure consistency and durability in the system's performance.

Placements of the Rockwool-based Insulation System in Sulaymaniyah

4.2. Professional and trained Staff: The installation of the Thermal Insulation System with Rock Wool is a complex process that demands skilled and trained staff. The involvement of a professional company with expertise in the materials used and experienced staff ensures successful implementation.

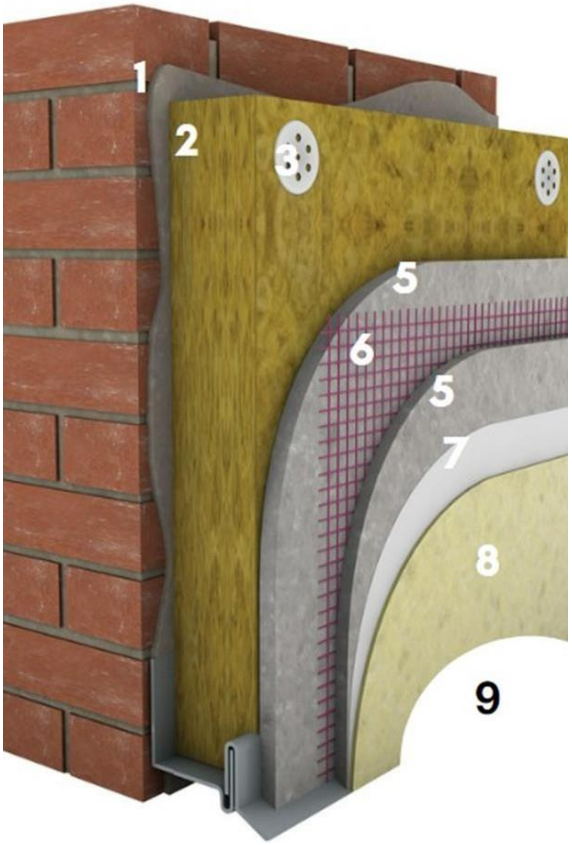
The system is implemented by a professional and experienced staff, further enhancing its effectiveness.

4.3. Layers and procedures of Rock Wool-Based Thermal Insulation System

The Rock Wool-Based Thermal Insulation System under examination comprises multiple layers, each contributing to its overall performance and durability. This system includes:

4.3.1. Application of adhesive compound (MG III Grau): This adhesive compound, specifically MG III Grau, is utilized to securely fix the Rock Wool layer in place. It ensures a strong and lasting attachment, crucial for the insulation system's effectiveness.

4.3.2. Rock Wool layer: This critical layer, resembling a strong mattress, is produced in block shapes with dimensions of 100 cm in length, 50 cm in width, and various thicknesses ranging from 4 to 10 cm. Its density can reach up to 150 KG/M3. Produced by Mega Company, it forms the core of the insulation system's thermal resistance.



4.3.3. Use of Screwed Plug: To enhance the insulation system's performance and ease of installation, Screwed Plugs are used. These plugs are approved for all building material classes, and their design optimizes thermal bridging, ensuring energy efficiency.

4.3.4. Application of PVC membrane: The PVC membrane is employed for edge protection and finishing in the hawo ETIC systems. It enhances the aesthetics and longevity of the insulation system.

4.3.5.Two layers of Kam Leicht Premium as plaster: These layers of Kam Leicht Premium plaster offer weather resistance and long-term durability, ensuring the insulation system's effectiveness and longevity.

4.3.6. Laying reinforcement mesh between the layers: Reinforcement mesh is strategically placed between layers to enhance the insulation system's structural integrity, ensuring it can withstand the demands of extreme climates.

4.3.7. Application of intermediaries' coat: An intermediaries coat is applied to unify substrate absorption and promote adhesion for subsequent coatings and finishing plasters. This step contributes to the system's overall effectiveness.

4.3.8. Marmor Putz for decorative purposes: Marmor Putz, a highly modified mineral ready mix dry mortar with brilliant white marble sands, is used for decorative purposes. It not only enhances the aesthetics of the insulation system but also provides resistance to weather and environmental factors.

4.3.9. Elastic silicone resin facade paint: To further protect the insulation system, an elastic silicone resin facade paint is applied. This paint exhibits properties such as cold elasticity, crack bridging, capillary hydrophobicity, and water vapor permeability. It contributes to the insulation system's durability and resistance to external elements.

Chapter 6: Future Researches

Exploring Future Avenues for Rock Wool-Based Insulation:

The pursuit of knowledge is a never-ending journey, as we wrap up our study of Rock Wool-Based Thermal Insulation Systems, we look to the future. We discuss potential areas for further research:

- **Long-term Performance Assessment:** We propose assessing the system's performance over many years to understand its patterns, maintenance needs, and longevity, benefiting architects and builders.

- **Cost-Effectiveness Analysis:** Delving into economic aspects, we suggest analyzing costs, operational savings, and return on investment to make informed decisions about adopting the system.

- **Energy Consumption Impact:** We highlight the system's role in reducing energy consumption, aiming to drive policy discussions and promote sustainable practices.

- **Environmental Sustainability Assessment:** We propose a comprehensive evaluation of its environmental impact, comparing it with alternatives to contribute to sustainable construction discourse.

- **Building Maintenance Studies:** We suggest studying long-term maintenance needs to ensure building resilience and functionality.

In short, the Rock Wool-Based Thermal Insulation System is a promising start in the journey toward sustainable building. Future research will explore its performance, cost-effectiveness, energy efficiency, environmental impact, and maintenance. We are committed to creating a sustainable, resilient future.

Chapter 7: Conclusion

This research provides valuable insights into enhancing building durability and comfort in extreme climates, focusing on Sulaymaniyah, through Rockwool-based Thermal Insulation Composite Systems. We've explored its advantages over other materials, detailed its production process, and highlighted its suitability for Sulaymaniyah. Future studies can further deepen our understanding of sustainable building practices.

Chapter 1 discussed the historical shift from traditional to modern insulation practices in Sulaymaniyah, emphasizing the importance of modern systems in extreme climates.

Chapter 2 compared Rockwool with other materials like XPS and EPS, covering composition, thermal insulation, fire and moisture resistance, sustainability, comfort, energy efficiency, maintenance, and cost-effectiveness. Rockwool emerged as the superior choice for Sulaymaniyah's climate.
Chapter 3 explained the Rockwool production process, crucial for understanding its quality and reliability.
Chapter 4 emphasized Rockwool's benefits, including climate suitability, performance, fire and pest resistance, sound insulation, sustainability, comfort, energy efficiency, aesthetics, durability, thermal performance, and environmental considerations, reinforcing its suitability for Sulaymaniyah.
Chapter 5 presented practical insights into Rockwool application in Sulaymaniyah, using a case study. It showcased the importance of quality materials and professional installation.

Chapter 6 suggested future research directions, including long-term performance assessment, cost-effectiveness analysis, energy consumption impact assessment, sustainability evaluation, and building maintenance studies. These studies will contribute to sustainable and resilient building practices.

In conclusion, Rockwool-based Thermal Insulation Composite Systems offer a promising solution for extreme climates like Sulaymaniyah. Ongoing research positions it as a key contributor to sustainable, durable, and comfortable construction. We are paving the way for a brighter and more comfortable future for generations to come.

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