# Enhancing Vernacular architecture in Siwa Oasis, Egypt.

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Abstract- Siwa Oasis exemplifies an ancient town undergoing significant transformation during the past decade. The oasis has markedly grown in recent years, although its old urban areas have diminished in functional value.Despite Siwa's distinctive cultural and natural legacy, together with its fascinating history, it does not have a prominent place on Egypt's tourism map; however, visitors spend millions of dollars to enjoy a peaceful lifestyle. So The main aim of this paper is to examine and analyze the key factors that define Siwa a tourist destination, investigate the urban landscape of the oasis to comprehend the connection between the built environment and its inhabitants as two fundamental components of the landscape, and enhance the construction of residential buildings in Siwa through the integration of modern construction techniques and sustainability requirements. Smart and nano materials are high-performance thermal insulation materials that can be utilized to create unique solutions in the skins of buildings when space is constrained. Because they are compatible with historic structures and have thin insulation thicknesses, they are most frequently used in historic buildings. In order to protect cultural heritage and reduce operational and embodied emissions of our building stock by extending the life expectancy and energy efficiency of existing buildings, it is crucial to integrate historic buildings with smart materials. This will also make it easier for planners and heritage offices to apply these materials in the future.
***Keywords –*** *silica aerogel; architecture; thermal insulation; heritage; retrofit; energy efficiency, Siwa oasis- sustainability-smart material.*

## I. INTRODUCTION.

Siwa Oasis is a significant Egyptian governorate with a distinct way of life, but the government ignored it and did not undertake any new initiatives. So the main objective of this paper is to illustrate the essential features in siwa oasis; one of the biggest oases in Egypt's Western Desert, Siwa Oasis is located close to the country's western border with Libya. Also, The usage of karshif, an uncommon material composed of NaCl salt crystals with sand and clay impurities, is a distinctive aspect of Siwa Oasis' architecture.Due to recent environmental change, the building materials in Siwa Oasis have deteriorated. Therefore, the main objective of the article is to highlight new materials that are employed in building construction to preserve its vernacular character, such as smart materials and nanomaterials.

## II. Problem Definition.

1-The choice for materials that are thought to be more dependable and long-lasting, like reinforced concrete, has resulted in the gradual abandonment of karshif building methods in recent decades, as well as the degradation and quick extinction of karshif heritage.

2-Significant structural damage is occurring in Siwa's traditional Karshif buildings due to climate changes such as exceptionally high rainfall, high humidity, and shifting environmental circumstances. These elements have expedited the processes of deterioration, collapse and reduced their structural resilience.

## III. Aim of the Paper

1-Researchers and searches revealed that Siwa's traditional-style structures are increasingly being abandoned. Local builders explained this by saying that the enormous expenditures involved forced them to switch to modern architecture.Siwa's urban morphology and spirit have undergone a dramatic change as a result of the inflow of buildings constructed employing contemporary methods. The Main Aim of the paper is to retain and improve its vernacular style using modern materials.

2-The diagram below summarizes the objectives of creating strategies and resources to address present issues and carry on the application of vernacular knowledge into the future. It demonstrates the connections between vernacular knowledge's past, present, and future. Due to these connections, it is believed that developing a sustainable desert vernacular in the near future is the only way to address present and future issues with desert vernacular architecture.

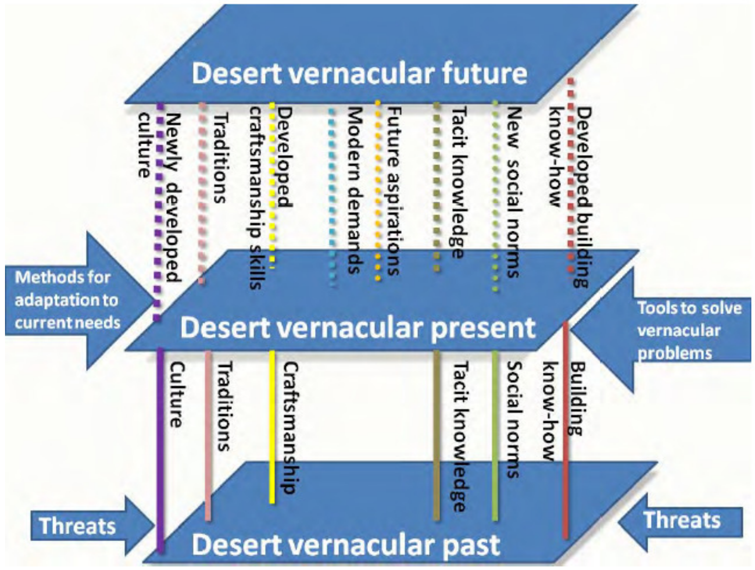



Fig (1) the figure shows that the future of desert vernacular is based on the vernacular
Past and connected to contemporary needs.
(Source: Khalil, 2018).

# IV. Research Questions

1-Whether the traditional vernacular style could be “revitalized” or “resuscitated” through the use of new materials?

2- How can we conserve the future of desert vernacular architecture?

# V. Historical Background of Siwa Oasis

The people who lived west of the Nile Valley are referred to in ancient texts from the First Dynasty as the Tahenu (olive land). It appears that the Tahenu immigrated in large numbers to settle in the fertile lands of the Nile Valley, but the King drove them back to their homeland. These days, archaeologists think that the Oases of Siwa, Bahriyah, and Barqah in Libya were part of the country of Tahenu. The Tahenu were then replaced by the Temehu, whose name appeared for the first time in the ancient Egyptian texts during the Sixth Dynasty, reign of King Pepi I (Fakhry 1950). Wadi el Natrun and the four Oases of Bahriyah, Farafra, Kharga, and Dakhla were undoubtedly fully Egyptianized, under Egyptian rule even prior to the sixth Dynasty, and visited by Egyptian patrols during the Middle Kingdom. Since Siwa is located farther to the west than these oases and no Old, Middle, or New Kingdom monuments have been discovered there, there is no proof that this likewise holds true for Siwa. Furthermore, neither the narrative of the Libyan battles nor any record from the 22nd Dynasty acknowledged its name.(Fakhry 2005).

The Temple of the Oracle of Amun, which was built during the reign of Amasis in the 26th Dynasty, is the oldest structure in Siwa. It is claimed that the Oracle of Amun in Siwa was already famous all over the Mediterranean countries by the 26th Dynasty, which means that it must have originated some time during the 21st dynasty. (Fakery 2005).Cambyses sent a 50,000-man army from Luxor in 524 BC to demolish the Siwan oracle. The army disappeared completely, buried in the seas of sand between Siwa and the inner-Egyptian oases, and it hasn't been discovered. Such an apparently supernatural victory must have enormously increased the prestige of the oracle throughout the region, (Larsen 1988),As a result, the oracle attracted a lot of visitors, but Alexander the Great was by far the most notable. He visited the oracle in Siwa, most likely to mimic the pharaohs of Egypt's 28th Dynasty who came to the temple to be recognized as the son of Amon-Ra. The visit of Alexander the Great has immortalized the name of the small oasis, to the extent that it had been referred to since then as "the Seat of the Oracle of Jupiter Amun". (Fakhry 2005).


Fig (2) Map showing the different elements forming the landscape of the oasis.
Source: Google maps.

## VI-Urban settlement in siwa Oasis.

In Siwan, the word "Shali" signifies "The Town." Built on the typology of a Berber Saharan Ksar, the medieval city of "Shali" is located 200 meters above sea level on the tableland of the high rock of Jabal Siwa. The houses, which are estimated to be 200 feet high, are stacked on top of one another to create a massive wall of battlements with tiny windows.In addition to the population growth and the necessity for urban expansion, this provided the town with the chance to grow outside of Shali's borders.
Modern Expansion of the Oasis; Beginning from the sixties and further on, Political, economic, and demographic shifts have altered Siwa Oasis. This shaped a parallel growing city and had a significant impact on the oasis's urban layout.

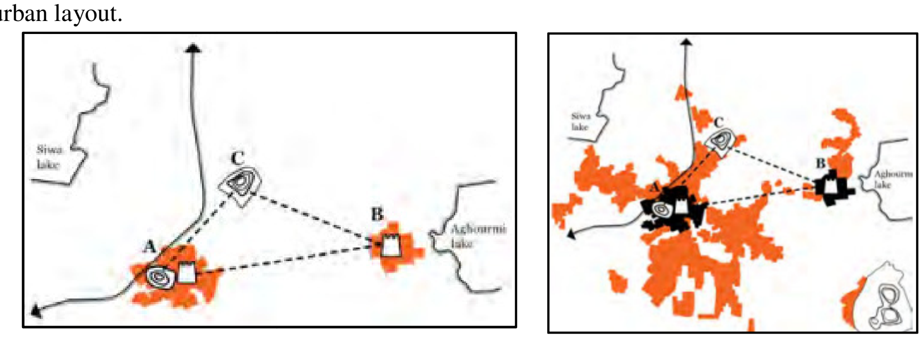



Fig (3) urban growth diagram during expansion
Source: Google maps.

The oasis's HUL's functional integrity was destroyed by modernization, and new functional relationships emerged to create a completely new urban landscape that does not represent or reflect the oasis's cultural identity and designates its historic urban structures as inactive and historic.
-The traditional constructed environment that emerged in response to the distinct climatic, environmental, and cultural conditions of Siwa Oasis is referred to as an urban settlement.
Historically, settlements in Siwa Oasis were compact and organically planned, characterized by:

- Dense urban fabric to prevent sandstorms and minimize heat gain.
- Narrow, shaded streets to improve thermal comfort.
- Buildings constructed from local materials such as karshif (salt–clay mixture) and palm trunks.
- The agricultural, defense, and residential zones are well integrated.

One well-known example of this traditional urban layout is the ancient settlement of Shali, which reflects both local identity preservation and adaptability to the harsh desert environment.

Fig (4) Shali Urban settlement in siwa oasis.
(Source: Dabieh, 2011).

## VII-Customs and traditions

The Siwa community's customs are identical to those of the Bedouin group, which includes conservative peoples, particularly when it comes to interacting with strangers. Numerous features, such as themes and emblems, define the women's clothing. Additionally, precious stone-inlaid silver jewelry. their culture consists of trained or learned activities plus theirmanufactured results (Kroeber, 1952). In the oases, societally inherited standards include respect for elders, generosity, privacy, and child care are still. Because of this, it is almost hard to separate the effect of religion, customs, and everyday activities from cultural and traditional artifacts and methods of productionAs an example, the design of desert communities and oasis cities heavily emphasizes privacy. In those communities, the idea of privacy is founded on a blend of cultural and religious customs. The hierarchy of urban areas both reflects and permits privacy in many social activities. Space is designed to change gradually from semi-publicspaces to semi-private to private. For instance, women can use cool recesses in their entrances and tunnelled streets to interact and converse with one another while completing household tasks

without being seen from the outside.

Fig (5) some of traditions in siwa oasis
(Source: Dabaieh, 2011).

## VIII. Materials &Constructions

The most crucial component is materials and construction methods, with Karshif being used in the majority of Siwa Oasis's structures. Karshif is a mixture of impurities from sand and clay and salt that was extracted from lakes that containa residue of NaCl crystals, They also contain some other secondary salts like KCl. To enhance the jointing between the external and internal components, wood inserts are positioned inside the wall thickness. When the Lurton-8102 LM was used to measure the temperature inside and outside of Karshif buildings, it was discovered that the temperature inside a classic Karshif building was 4ºC lower than the temperature outside. ( De Filippi Francesca, 2010).The Karshif stone have irregular shapes with different sizes, typically varied from 50 to 200 mm .The environment provides Siwa's traditional building materials, which include salt blocks, olive trees, palm tree trunks, and salty mud mortar.

Fig (6) Explain of Karshif
(Source: Rovero, 2009).

Because the buildings in ancient Shali village in Siwa Oasis were constructed using local resources that were taken from the surrounding environment, the traditional bearing walls construction method was cost-effective. Karshif particles were used with Siwan silt mortar to form walls.To make the roof more resilient to rain, ceilings were constructed from palm wood and olive leaves. The rectangular window and entrance openings were constructed from the wood of palm trees. (site investigations). To make the building environmentally sustainable, a unique type of green silt found in Siwa was used to plaster the building's façades. In order to offer shade on the facades for as long as possible and reduce the quantity of heat absorbed, the final walls' texture is rough to break sun rays.

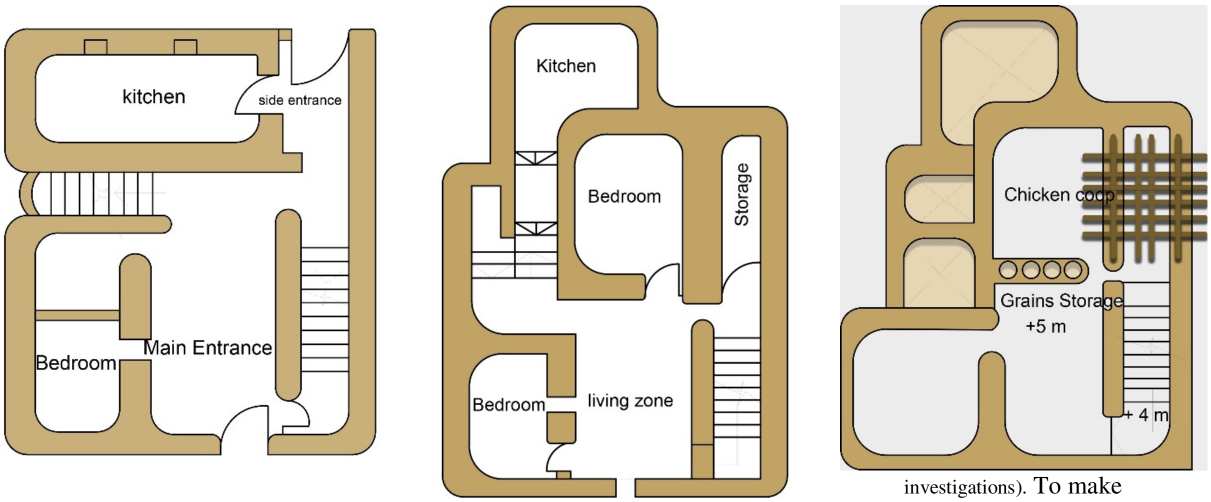


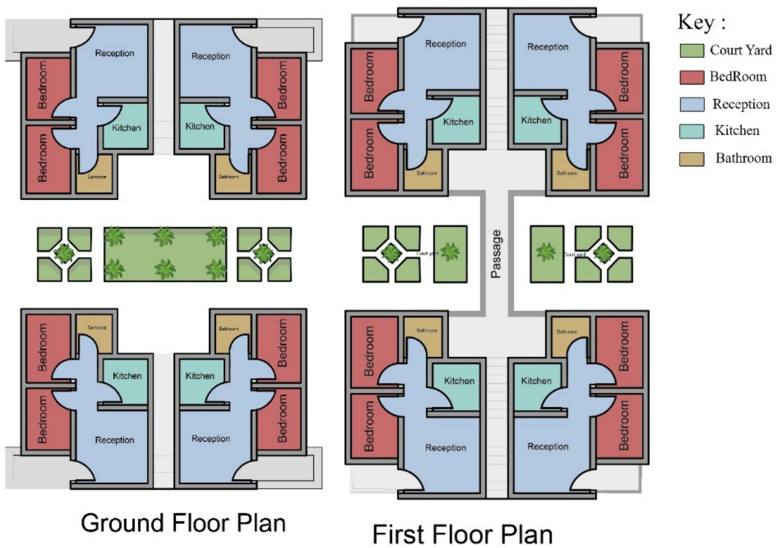

Fig (7) Plans constructed from karshif materials
(Source: authors)

# IX-Modern Building Technique in Siwa

Since Siwa stretches east-west along a depression 17 meters below sea level and is bordered to the south and east by the sand dunes of the Great Sand Sea, it was not surprising to discover that the local builders were employing salt for construction. There are four large salty lakes inside the depression, which are surrounded by salt crusts and salt efflorescence on the top soilThese salt crusts were turned into salt bricks by the locals, who then used them in building using a salt-rich mud mortar produced from various clays. This type of mortar crystallizes inside the mortar during the drying process, creating a kind of monolithic conglomerate that creates a strong bond between the salt blocks and the mortar. This salt brick is known as “Karshif”.

To separate the ground water from the initial layer of Karshif blocks, the builders first build a 50 cm high concrete wall. After deciding on the size of the room they wish to construct, they use wood to mark the axes on the ground for each wall. The thick Karshif blocks and cement "Tlakht" are then placed between them until the necessary height is reached.For every single wall, this procedure is repeated. The structures finish in curves because there isn't a firm bond between the walls. Even more costly when the design includes corners with sharp edges. The palm trunks that support the floors at the various levels play a major role in this building. This technique, which dates mostly to the 19th century, was the primary architectural characteristic of the oasis.

The Egyptian government constructed new public structures, including homes, schools, hospitals, places of worship, and government buildings, using a skeleton construction system. The architectural styles of these buildings were totally distinct. Red brick or cement brick and reinforced concrete were used in its construction. Brick is used for walls, reinforced concrete is used for columns and roofs, and ceramics are used for floor finishing. When compared to the surrounding area and historic oasis structures, their construction methods and materials appear strange. The two architectural styles are clearly different from one another; for instance, the ancient Shali is a distinctive style, whereas the new technology totally destroys the oasis's character. The issue was that the new building materials had an adverse effect on the environment and did not offer thermal comfort to the occupants. In the Siwa Oasis, traditional building methods are more economical, social, and




environmentally friendly than modern methods; yet, they are less stable and long-lasting because of their poor strength and resistance to rain. (Site investigations). Therefore, we must develop a new method that both preserves the distinctive architectural character of the oasis and makes buildings long-lasting.

Fig (8) Plans constructed from Reinforced concrete materials
(Source: Authors)

A comparison of reinforced concrete, a contemporary industrial building material, and Karshif material, the traditional building material used in Siwa, is shown in the following table.

- The source: Karshif is a naturally occurring native salt-clay product that is extracted straight from the Siwan environment, making it resource-efficient and context-based. On the other hand, steel, cement, and aggregates make up reinforced concrete, an industrial material that needs complicated production procedures.
- The **environmental impact** and **embodied energy**: Karshif has an extremely small environmental footprint in terms of embodied energy and environmental impact because of its limited processing and transportation. However, reinforced concrete is less environmentally sustainable due to its high embodied energy and significant $CO_2$ emissions, primarily from the manufacture of cement.
- The thermal performance perspective: In intense desert climates, Karshif performs exceptionally well. Its high thermal mass and thick walls aid in the natural regulation of interior temperatures. Unless additional insulation and mechanical cooling devices are utilized, reinforced concrete provides inadequate to poor thermal performance. This is closely related to climatic adaptability, as reinforced

concrete relies on artificial systems to ensure thermal comfort, but Karshif is naturally adapted to desert conditions.

- **The** structural capacity, Karshif is greatly outperformed by reinforced concrete. Because concrete has a strong compressive and tensile strength (with steel reinforcement), it can support greater spans and multi-story buildings. Karshif, on the other hand, is often appropriate for low-rise constructions and has a restricted load-bearing capability.
- Concerning durability **and** water resistance: Rain and moisture cannot penetrate reinforced concrete as well. Karshif requires more maintenance, particularly after heavy rainfall, because it is less resistant to water exposure and may decay if improperly covered. Under normal circumstances, reinforced concrete requires less frequent maintenance.
- Economically: When using locally produced materials, Karshif construction is inexpensive; yet, due to the use of manual and conventional methods, construction is somewhat slow. Modern technologies make reinforced concrete building faster, but the cost of materials and labor is higher.
- In terms of acoustic performance: Because of the thickness and solidity of its walls, Karshif offers good sound insulation. The acoustic performance of reinforced concrete is mediocre unless further treatments are used.
- **From a** cultural and aesthetic perspective**:**Karshif strongly preserves Siwan heritage and vernacular architecture. Its natural appearance and organic texture strengthen the sense of place. Conversely, reinforced concrete adds a contemporary, standardized architectural vocabulary that may destroy Siwan architecture's traditional identity.
- Regarding **sustainability**: Because it is easily obtainable locally, uses little energy, and is environmentally friendly, karshif is regarded as a sustainable material. Because of its large carbon footprint and resource-intensive manufacturing process, reinforced concrete is typically regarded as less sustainable.

## Comparison between two local material (Karshif and Reinforced Concrete).

Table 1: it explains the comparison between the two materials.

(Source: Authors).

| Aspect | Karshif material | Reinforced Concrete |
|---|---|---|
| **Source** | Natural local salt -clay | Industrial material |
| **Environmental impact** | Very low | High $co_2$ emission |
| **Thermal performance** | Excellent in hot climate | Moderate to poor |
| **Structural capacity** | low | High |
| **durability** | Medium | high |
| **Sustainability** | Sustainable material | Non sustainable material |
| **Cultural identity** | Strongly preserves Siwan heritage and vernacular architecture | Weakens traditional identity and alters local architectural character |
| **Water resistance** | Kershif has lower resistance to rain and moisture. | More resistance to rain and moisture than karshif |
| **Acoustic Performance** | Good sound insulation due to thickness | Moderate acoustic performance |
| **Aesthetic Character** | Organic texture and natural appearance | Modern, standardized appearance |
| **Adaptability to Climate** | Highly adapted to desert climate conditions | Requires mechanical systems to achieve thermal comfort |
| **Construction Time** | Relatively slow (manual techniques) | Faster with modern construction methods |
| **Construction Cost** | Low when locally sourced | Higher cost due to materials and skilled labor |

| | | |
|---|---|---|
| **Maintenance Requirements** | Requires regular maintenance, especially after heavy rain | Low to moderate maintenance |
| **Embodied Energy** | Low | Very high |

## X- Karshif Enhancement

Here are some of the materials that can be added to Karshif to improve its properties and enhance its resistance to rain water:

- **Hydraulic lime:**

  Hydraulic lime strengthens karshif through hydration reactions that produce calcium silicate hydrates (C–S–H), forming a stable mineral binding matrix between salt and clay particles. This process reduces porosity, improves compressive strength, enhances moisture resistance, and minimizes cracking while maintaining reasonable vapor permeability. As a mineral and relatively compatible material, it presents a balanced solution for reinforcing karshif in Siwa Oasis, provided its effect on thermal performance and shrinkage behavior is carefully evaluated.

- **Potassium Silicate:**

  Potassium silicate enhances karshif by forming silicate networks within the pore structure through chemical reactions with clay minerals and salts. This reduces water absorption, limits efflorescence, improves mechanical strength, and maintains breathability due to its inorganic mineral nature. However, its high alkalinity and increased rigidity require controlled application and laboratory validation to prevent long-term chemical imbalance or brittleness in the historic fabric of karshif structures.

- **Acrylic Polymer Emulsions:**

  Acrylic polymer emulsions significantly improve karshif by forming a flexible polymer film that binds particles, reduces porosity, and enhances resistance to rainwater and weathering. They increase compressive and flexural strength while reducing cracking through improved flexibility. Despite offering strong mechanical performance and durability, their synthetic origin, potential reduction in vapor permeability, and sensitivity to application conditions require careful dosage control to ensure compatibility with the traditional, environmentally responsive nature of karshif construction in Siwa Oasis.

Through the following table, a comparison is presented between three materials that contribute to improving the cohesion and development of karshif material. The comparison is based on several key aspects, including their definitions, chemical composition, effects on karshif properties, advantages in construction, and potential disadvantages.

This analytical comparison helps evaluate the suitability of each material for enhancing the structural performance and durability of traditional karshif buildings in Siwa Oasis under changing climatic conditions.

Table 2: it explains the comparison between Nano and smart materials

(Source: Authors).

| Material | Hydraulic lime | Potassium silicate | Acrylic Polymer Emulsions |
|---|---|---|---|
| **definition** | A versatile building material that sets and hardens through hydration, making it suitable for use in wet conditions. (Practical action, 2014). | Potassium silicate is the name for a family of inorganic compounds. These are white solids or colorless solutions. (Lagaly, Gerhard, 2000). | Acrylic polymer emulsion is a water-based mixture containing acrylic polymer particles suspended in water. It is a milky-white liquid that serves as a stable |

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| | | | suspension of microscopic plastic particles. (Wu Zhang, Jingchen Bai, 2022). |
| **Components** | • Contains calcium carbonate together with a proportion of clay.<br>• limestones for hydraulic lime production contain between 15 and 35 per cent silica together with alumina.(Practical action, 2014). | The most common potassium silicate has the formula $K_2SiO_3$, samples of which contain varying amounts of water. (Lagaly, Gerhard, 2000). | Acrylic polymer emulsions are water-based dispersions of acrylic resin particles. They are engineered systems made of several chemical components working together. (Wu Zhang, Jingchen Bai, 2022). |
| **Chemical components** | • CaO (Calcium Oxide)→ 60–75%<br>• $SiO_2$ (Silicon dioxide) → 15–25%<br>• $Al_2O_3$ (Aluminium oxide) → 3–10%<br>• $Fe_2O_3$ (Iron(III) oxide or ferric oxide) → 1–5%<br>• MgO (Magnesium oxide) → small percentage<br>(Ashurst, J, 2000). | Potassium silicate is mainly composed of:<br>• Potassium (K)<br>• Silicon (Si)<br>• Oxygen (O)<br>• mixed with water<br>1- Silicon dioxide ($SiO_2$) 60 – 75%<br>2- Potassium oxide ($K_2O$) 25 – 40%<br>3- Water ($H_2O$) 0 – 5%<br>(Inazumi, Shinya., 2017). | • Polymer Solids (Monomer) like Butyl Acrylate (BA) (45–55%).<br>• Water (40–50%).<br>• Surfactants / Emulsifiers (1–3%).<br>• Initiator Residues like Ammonium persulfate or potassium persulfate (<0.5%).<br>• Coalescing Agent like Texanol or butyl glycol (1–3%).<br>• pH Adjusters like Ammonia or sodium hydroxide (0.1–0.5%).<br>• Additives (<1%)(Singh, Jaspal, 2018). |
| **Its effect** | • Act like binding gel responsible for strength.<br>• Fills micro-voids between salt and clay particles (components of karshif).<br>• Improves particle packing.<br>• Reduces porosity.<br>• Limits internal cracking.<br>• Reduce rain water absorption.(Authors). | • Higher $SiO_2$ = better strength and chemical resistance.<br>• Higher $K_2O$ = higher alkalinity and solubility.(Inazumi, Shinya., 2017). | • Property Effect<br>• Compressive Strength ↑ Significant<br>• Flexural Strength ↑ High<br>• Water Absorption ↓Major reduction<br>• Rain Resistance↑Strong improvement<br>• Crack Formation ↓ Reduced<br>• Vapor Permeability Slightly reduced but acceptable. (Authors). |
| **Advantages in construction** | This makes walls:<br>• More compact.<br>• Less prone to erosion.<br>• Decreases dissolution of salt (the main component of karshif).<br>• Improve durability. (Authors). | • Reduced Porosity and Water Absorption:Silicate reacts to form gels or binding films in pores.This reduces water ingress, which in karshif promotes salt migration and decay.<br>• Enhanced Durability Against Weathering, Treated karshif may be more resistant to the mechanical action of rain and wind, slowing deterioration. | • Increase strength.<br>• Improve water resistance and reduce rain erosion.<br>• Reduce cracking by increasing flexibility.<br>• Improve durability against UV and weather conditions.<br>• Lower long-term maintenance costs.(Wu Zhang, Jingchen Bai, 2022). |

| | | | |
|---|---|---|---|
| | | • Eco-Friendly.<br>• Enhances mechanical properties without compromising the original appearance.(Authors). | |
| **Disadvantages** | • Cost Increase: Hydraulic lime is more expensive than local karshif materials. (Author)<br>• With dessert climate; Rapid evaporation can cause shrinkage cracking.<br>• Adding hydraulic lime can Changes thermal behavior of karshif so it is needed to be tested. (Barbero-Barrera, M., 2020). | • Cost Increase: Not a traditional, low-cost local solution.<br>• Increased Brittleness: Increased rigidity may lead to cracking under thermal movement.<br>(Authors).<br>• Alkalinity Issues: May cause long-term chemical imbalance.(Inazumi, Shinya., 2017). | • Higher initial cost.<br>• Requires proper mixing and quality control to ensure uniform performance.<br>• May reduce breathability if used in high percentages.<br>• Sensitive to application conditions, especially high temperatures during curing.<br>• Synthetic origin, so less environmentally natural than other materials.(Wu Zhang, Jingchen Bai, 2022). |
| **Conclusion** | Hydraulic lime strengthens karshif through hydration reactions that produce calcium silicate hydrates, forming a stable binding matrix between salt and clay particles. This reduces porosity, improves compressive strength, enhances resistance to moisture, and minimizes cracking while maintaining vapor permeability, making it more compatible with the climatic conditions of Siwa Oasis. | Adding potassium silicate to karshif — the traditional salt-rich earthen blocks of Siwa Oasis — could potentially improve mechanical strength, reduce water absorption, limit efflorescence, and enhance durability. Potassium silicate reacts with clay and mineral salts to form silicate networks, which strengthen the material while remaining mineral-based and breathable.<br>its use in karshif requires careful laboratory testing, controlled application, and long-term evaluation to avoid damaging this historic and environmentally adapted material. | Adding acrylic polymer emulsion to karshif can significantly enhance its mechanical strength, water resistance, and durability. The polymer forms a binding film around Karshif particles, reducing porosity and limiting rainwater penetration, which is particularly beneficial in climates like Siwa Oasis where occasional heavy rainfall can damage traditional earthen structures. |

# XI-Conclusion

The degradation of the traditional karshif material, which serves as the main building material for the oasis's historical buildings, is the main topic this study paper discusses in relation to Siwa Oasis' urban environment. Recent climate changes, such as increased rainfall, flash floods, and rising groundwater levels—factors that were historically unusual in this desert region—have caused this material to progressively deteriorate.

Because they are more weather-resistant, some locals and decision-makers are now favoring the use of contemporary building materials such reinforced concrete and red brick. However, Siwa's unique urban and architectural identity—which is strongly linked to heritage buildings constructed by Karshif—has been harmed by this tendency. These structures are a major draw for tourists, who go from all over to witness the genuine architectural character inside the oasis's historic fabric.

The necessary ingredients for making karshif have traditionally come from Siwa's natural surroundings. There are many salt lakes in the region, which provide an abundance of salt that is combined with clay and other regional resources, including palm trunks, to create this traditional building material. As a result, karshif structures serve as an example of sustainable architecture that uses locally available, low-impact resources. A crucial component of Siwan legacy would be lost if this material were abandoned.

The study investigates the possibilities of strengthening karshif with contemporary materials to improve its mechanical qualities and lessen its vulnerability to climatic influences in an effort to find solutions that maintain this tradition while improving the material's structural and environmental performance. Among these materials are:

- **Hydraulic lime**: Reduces rainwater absorption and fills voids between the salt and clay components of karshif, thereby increasing cohesion and improving moisture resistance.
- **Potassium silicate**: Decreases water permeability within salt-rich clay blocks, thus minimizing the risk of structural failure due to water saturation.
- **Acrylic polymers**: Enhance mechanical strength and reduce porosity, improving the durability of karshif and extending its service life.

The study concludes by emphasizing the importance of preserving Siwan architectural heritage through an approach that integrates authenticity with technology. By employing smart and nano-enhanced modern materials, it is possible to improve the performance of karshif without compromising its environmental and cultural value, thereby ensuring the sustainability of Siwa's urban identity in the face of contemporary climatic challenges.

# XII-Recommendations

**-**Based on the findings of this study on the deterioration of heritage buildings in the Siwa Oasis and the significance of preserving traditional karshif material, the following recommendations are proposed:

1. **Preservation of Heritage Buildings**: All heritage buildings in Siwa Oasis should be protected, as they are an integral part of the region's architectural and cultural identity and represent significant historical and tourist value.
2. **Protection of Karshif-Constructed Buildings**: Emphasis should be placed on safeguarding buildings constructed with traditional karshif material, as it relies on local resources and is environmentally sustainable, making it a model of sustainable architecture.
3. **Avoiding Modern Materials that Harm Heritage**: The construction of new buildings using reinforced concrete or red brick within heritage areas should be avoided, as these materials can distort the traditional urban fabric and erode the distinctive architectural identity.
4. **Use of Advanced Materials**: modern technological solutions are recommended for reinforcing and maintaining karshif. These materials enhance mechanical properties, reduce water absorption, and increase cohesion, ensuring the long-term durability of heritage buildings against climatic change

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