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A Sustainable Approach for the Rehabilitation of the Existing Housing in Cairo

Rehabilitation of houses' buildings is one of the current international trends. The research works on utilizing the principles of sustainability in the rehabilitation processes of the existing houses buildings. Cairo city has many old buildings, in the current period there are many renovation and rehabilitation processes of many housing buildings in Cairo. The research problem is the lack of interest in integrating sustainable aspects and principles in the rehabilitation of houses in Cairo. The research included a theoretical study on the rehabilitation processes of houses' buildings considering the sustainability requirements while analyzing the most important international case studies in this field. This research also studied and analyzed the methods and the processes to development and rehabilitate of the existing houses buildings and the used techniques to rehabilitate these buildings to be adequately sustainable buildings, considering the sustainable methods and tools used in the processes that to conclude the required conceptual framework. The scope of the research is the rehabilitation processes of houses buildings matching with the rules of sustainability and the application is limited by the houses' buildings in Cairo city. The research method is the qualitative method; the data collection tool is the interviews. The research aims at submitting a conceptual framework for the sustainable rehabilitation of the existing housing in Cairo.

Keywords: *rehabilitation, sustainability, sustainable rehabilitation, housing rehabilitation, housing rehabilitation in Cairo*

Introduction

Rehabilitation of houses buildings is considered one of the well-known trends in the field of the built environment, either by developing of the existing buildings with maintaining of the same function or by changing the functions of the buildings that by reusing the building in another function. The practices that take place during the rehabilitation processes should be planned carefully. Cairo city has a huge number of residential buildings which are considered a huge wealth of structure. There is an orientation by the government to develop some areas which contain housing and other functions to cope with the achievements in the twenty-first century.

Housing rehabilitation concerns the repair, renovation, or other improvement of housing to make the housing decent, safe, sanitary, and more habitable.

The process of Rehabilitation construction addresses the need to significantly improve failing features of a building, essentially including repairing or restoring (by strengthening or replacing) the structure in a manner that "restores its performance to levels approaching or exceeding those of a newly constructed facility."

Literature Review

Rehabilitation Instead of Creating New Construction

Sam Lund of Simply Sam asserts that rehabilitation is always preferable to starting from scratch if you have the choice. "We think it's much greener to make something old feel new again than to build a bunch of new homes " Lund adds. (Chalmers, 2023) Sadly, older homes are often inefficient, so we probably have a lot of updating, adjusting, or fixing to do. To increase efficiency, "we usually use a larger remodeling," according to Lund. "The ideal situation would be to update an old house from top to bottom" (Chalmers, 2023).

Sustainable Houses

Green houses choose sustainable and eco-friendly options, minimizing the impact on the environment," explained by Dierdre Gaddy, the director of design in Terra Firma Vegas (Chalmers, 2023). "That is translated to building materials and energy usage for houses." According to Gaddy, the most energy-efficient houses make use of solar and wind energy, among other natural resources. A sustainable house emphasizes things like insulation, power consumption, and the special kinds of sustainable finishes (Chalmers, 2023).

Some Sustainable Solutions in the Rehabilitation Processes

There are more accessible options for incorporating sustainability into rehabilitation processes. Keeping sustainability as an important item will streamline

the decision-making and help to rehabilitate the houses in a sustainable way (Hohenadel, 2022).

Install of Smart Home Systems

Gaddy recommended overhauls houses to be shrewd smart such as indoor regulators and lighting control. These contraptions will help client to screen and analyze utilization also that will help to reduce the energy consumption. It too gives the capacity to control things remotely so that in times of travel or taking off the house in a surge, the client can basically control it from the gadgets (Chalmers, 2023).

Install of Sustainable Appliances

Installing water-saving low-flush toilets and low-flow faucets. Whenever feasible, selecting large appliances with the highest energy rating available, and installing LED lighting to reduce energy consumption and costs over time. Induction stoves are a better option for cutting back on fossil fuel use in the kitchen. Furthermore, heat pumps are far more effective at heating your water or cooling your house. It is preferable to switch from fossil fuel-powered products to electricity-powered ones in order to achieve a more sustainable process. An essential first step toward zero carbon buildings is the removal of fossil fuels (Hohenadel, 2022).

Upgrade Insulation

There's one thing that's key for making beyond any doubt the vitality is being utilized effectively is the separator. It's required to guarantee that all major openings are legitimately protected by doing an assessment like HERS (a Domestic Vitality Rating Framework test). Creator and builder Luke Caldwell concurs, expressing that overhauling through the recovery of the house's cover can moreover offer assistance diminish warming and cooling costs, as well as make the house more comfortable. Including covers to the dividers, upper room, and floors can offer assistance keep the house hotter within the winter and cooler in summer (Chalmers, 2023).

Installing of Energy-Efficient Windows

By keeping the house more insulated, replacing outdated windows with energy-efficient ones can help lower heating and cooling expenses. This can also help you lower your carbon footprint by using less energy to maintain a comfortable home. It's crucial to remember that while replacing windows is environmentally beneficial, adding more windows is not Beautiful as the results of this practice are, it also exacerbates the problem by increasing the amount of solar heat gain in the house, requiring more heating and cooling to maintain a comfortable temperature (Hohenadel, 2022).

Installing for Low-Flow Fixtures (Showers, Toilets, and Faucets)

Energy-efficient fixtures are one of the best ways to manage the water usage in the house. Gaddy says you can simply select low-flow fixtures to

regulate the water supply and pull-on energy. It makes a big difference in how much water each household saves, particularly when it comes to the distribution of hot water (Chalmers, 2023).

Adding of Renewable Energy Devices Like Solar Panels/Wind Turbines

Installing renewable energy devices, such as solar panels, wind turbines, or geothermal energy techniques, is one of the major remodeling projects that will pay off handsomely in the long run. For instance, solar panels will use sunlight to generate energy for home use. It's a fantastic method for producing clean energy for the user (Hohenadel, 2022).

Upgrade to a VRF System to Control Temperatures by Room

It is crucial to replace the HVAC system with a VRF (Variable Refrigerant Flow) system. Although switching from a traditional HVAC system to a VRF system is a major undertaking, it enables independent temperature control for each space. The user only needs to adjust the temperature in the rooms that are occupied, rather than the entire house (Chalmers, 2023).

Use Materials with Low Environmental Impact

Using materials with less of an impact on the environment is crucial, according to Gaddy, for promoting sustainability in the rehabilitation process. Choosing materials such as wood, quartz, agates, concrete, and natural stones that are bio-based and recycled is a suitable way to support sustainability (Chalmers, 2023).

Using of Regenerative Materials and Natural Finishes

Giving naturally regenerative materials like bamboo or cork priority when choosing materials for construction or renovation. Using natural materials like wood, straw, and hemp can also contribute to better indoor air quality and eliminate toxic chemicals found in synthetic products. Selecting low- or no-VOC paint from manufacturers. Also, the use of a natural clay plaster wall finish created by some companies which make a sustainable wall paint substitute by combining unfired clays with minerals and natural pigments (Hohenadel, 2022).

Reducing the Number of New Materials With the Use of Reused and Recycled Materials Is the Best Way to Not Consume More Resources

When looking for sustainable material usage, it is preferred to use the old methods of reducing, reusing, or recycling materials. Reducing the number of new materials is the most effective way to support sustainability without using more resources. Caldwell promotes bringing in materials from nearby suppliers of used building materials and reusing remodeling materials as much as possible. Trying to recycle the materials as much as we can when disposing of waste, and when going shopping for new materials, it's better to select those with a high percentage of recycled content (Chalmers, 2023).

Rely On the Experts

Utilizing professionals in sustainable rehabilitation is crucial. Eventually, things can become less wasteful and more environmentally friendly by hiring the right experts (Chalmers, 2023).

New Sustainable Construction Materials

There're new sustainable construction materials like: Translucent wood, luminescent cement, bricks made of cigarette butts and Martin concrete. That's a part of rethinking sustainable architecture to make it more innovative.

Transparent Wood

A team of researchers from Stockholm's KTH Royal Institute of Technology discovered optically transparent wood (TW), a novel material that has the potential to drastically alter the way that architectural projects are designed. An article in the journal Biomacromolecules published by the American Chemical Society describes the procedure as chemically removing lignin from wood to make it incredibly white and translucent (Uribe, 2016).

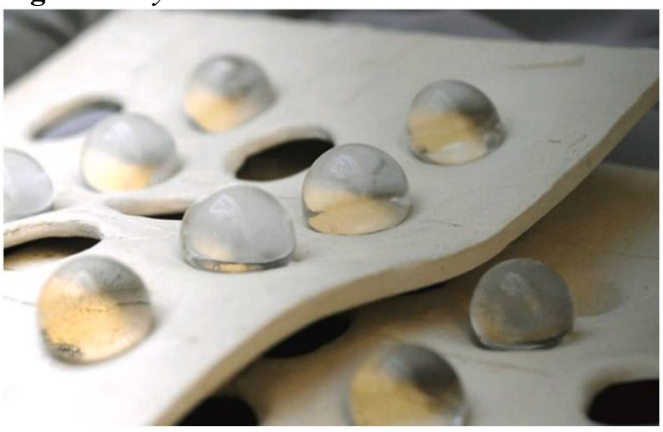
Martin Concrete

Aggregate, which includes crushed rocks like limestone, granite, sand, and others, is combined with cement and water to form concrete. Concrete and water combine chemically to create a solid, long-lasting, and stiff matrix that solidifies when it dries (Brownlee, 2016). The Northwestern team found that it was possible to make sulfur concrete. They were able to create quasi-Martian concrete blocks by mixing silicon dioxide, aluminum oxide, iron oxide, and titanium dioxide, which is replicated Martian soil, 50/50 with molten sulfur. According to (Uribe, 2016), it is 2.5 times stronger than regular concrete. Additionally, Martian concrete has an edge over regular concrete. The third-biggest contributor is the manufacturing of concrete (Brownlee, 2016).

Hydroceramics, Walls That Could Replace Air Conditioning

Hydroceramics is the new substance that the team at the Institute for Advanced Architecture of Catalonia has invented. It is composed of hydrogel bubbles, which hold 400 times their volume in water. The spheres' ability to absorb liquid causes their contents to evaporate on hot days, lowering the temperature inside the area (Rathee, 2014).

Figure 1. *Hydroceramics*



Source: Rathee 2014.

Cigarette Butts Used To Make More Effective Bricks

What's trash to one item is building material to another. Scientists at RMIT University, also referred to as the Royal Melbourne Institute of Technology, have created a method for producing bricks out of cigarette butts. The group, under the direction of Dr. Abbas Mohajerani, discovered that producing clay bricks that contain 1% of the volume of cigarette butts could totally counteract the yearly global production of cigarettes while also producing bricks that are lighter, more thermally resistant, and more effective (Uribe, 2016).

Figure 2. *Cigarette butts used to make bricks*

Source: Uribe 2016.

Biodegradable Furniture

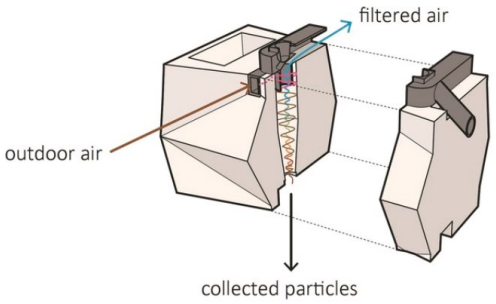
Furniture made using biological means. Terreform ONE and Genspace worked together to create two bioplastic chairs using comparable techniques: The first one is a chaise lounge with a padded top made of a row of white ribs arranged in a parametric design. The second chair is meant for kids and is made up of components that fit together to form various shapes (Imnovation-hub, 2022).

Pollution Absorbed and Filtered by Bricks

Breathe brick is made with specialty bricks on the outside and regular insulation on the inside, and it is intended to be a component of a building's standard ventilation system. Breath Brick works on the principle of Cyclone

Filtration, which takes heavy airborne pollutants and deposits them in a detachable hopper at the base of the wall (Uribe, 2016).

Figure 3. *Pollution Absorbed Through a Double-Layer Brick*



Source: Uribe 2016.

Community Engagement of the Residents and Local Factors

Social aspects and community engagement are considered important elements in the aspects of implementing sustainability, with taking into account the humanitarian aspects of society and local factors are among the elements when making any development of residential building projects (Sánchez, 2022).

Case Studies

Brogården, Residential Building in Sweden

Figure 4. *Brogården Project, Sweden*

Source: Jorlöv 2015.

Project Overview

Skanska Sweden applied passive house principles in order to transform dilapidated apartment buildings in Brogården, Alingsås, Southern Sweden, into contemporary, energy-efficient dwellings, Alingsâs's Brogården is a residential neighborhood with 16 three-story buildings with 299 units. The neighborhood was first built in 1971–1973, (European Commission, 2013). Thirty-five years later, the Brogården flats were dilapidated, with insufficient insulation and disintegrating brick facades that resulted in drafts and chilly inside temperatures.

In addition, the apartments' inadequate internal climate and broken ventilation systems made them unsuitable for senior citizens. In 2013, Skanska began renovating the flats in Brogården. The project entails a thorough passive house refurbishment of the structures, which includes the installation of new façades using passive house methods, the buildings will be extensively renovated as part of the project. New ventilation systems, thicker insulation, and new façades and roofing will all be installed. 2013 saw the completion of the 16 buildings' renovations. Passive house principles were employed during the renovation of the Brogården apartments. The buildings utilize relatively little energy for space heating and don't have traditional heating systems. Under normal circumstances, the heat produced by electric lights and household equipment provides adequate warmth for the flats. The flats have extremely effective heat recovery ventilation systems and are more insulated and airtight than traditional buildings. In the "living" category, the Brogården project took home the 2014 Sustainable Energy Europe award (Jorlöv, 2015). The project is a part of an EU initiative (BEEM-UP) (Inno4sd, 2019).

Contribution to Sustainability in the Rehabilitation Process

The apartments of the project are energy-efficient apartments that get their minimal heating from a district heating system that runs on renewable energy. Additionally, the flats were renovated to encourage high-quality internal spaces for inhabitants and to make them more adaptable and functional. As the project moved forward to encourage innovation, Skanska worked closely with the client and other project partners to develop it. In order to increase public knowledge of energy-efficient home renovation projects, Skanska organized study tours for the general public and educated project partners throughout. The construction crew made an effort to cause as little disruption as possible for the Brogården residents while also keeping them updated on the project's status. The project team emphasized local laborers and subcontractors, and they all adhered to strict health and safety regulations. Waste was recycled off site and environmental effects were kept to a minimum while building was underway (Jorlöv, 2015).

Social Aspects

Project partner collaboration

All the main project partners took part, including hosting seminars where people could present their ideas for improvements. Additionally, contractors that specialize in plumbing, electrical work, and ventilation attended the planning stages to offer their knowledge and skills to the project. As the project developed, the project team also promoted innovation. Skanska optimized the wall structure and ventilation system in collaboration with material suppliers and project partners (Inno4sd, 2019).

Occupational health and safety

As of November 2009, there had been zero accidents reported at the site and the accident rate was at zero. The construction team adhered to safety protocols for every project stakeholder. An electronic system is in place to restrict access

to the site to only those authorized individuals who have finished their safety briefing (Jorlöv, 2015)

Reducing Public Noise during the Rehabilitation Process

Brogården's structures are situated around central gardens that are designated outside the building project boundaries to protect the gardens and reduce disruptions to neighboring buildings. The buildings undergoing renovation have project canteens and temporary storage rooms that were designed to bypass passive house technologies. They are well insulated to maintain a constant temperature indoors, ensuring comfortable environments all year round. Around 20°C. Each apartment is equipped with its own ventilation system that brings in fresh air from outside, promoting good air circulation in bedrooms and living rooms. The project's indoor air quality was improved by using low-VOC and non-toxic materials that were checked against Skanska Sweden's chemicals database (Inno4sd, 2019).

Construction of Functional and Flexible Buildings

The apartments are designed with flexibility to accommodate the varying needs of families both currently and in the future. Before the renovation, none of the buildings had elevators, but around 60 percent of the apartments have since been transformed into units with elevator access. A ramp has been added to each building entrance to enhance accessibility, replacing the steps. Additionally, strollers and wheelchairs can be stored in interior spaces, and kitchen designs and bathrooms were updated to cater to the requirements of contemporary families. The apartments feature modern IT infrastructure, with each room having a socket for connecting telephones, TVs, or computers to accommodate various room configurations and apartment designs. Before the project, each apartment was essentially the same, but Skanska has diversified the types of apartments to offer residents more options and uniqueness (Jorlöv, 2015).

Sustainable Urban Planning

Brogården's residential area is situated approximately 1 km away from the town center of Alingsâs. In the Brogården regeneration project, the neighborhood is being enhanced to better serve residents by increasing habitability, establishing communal meeting areas, and enhancing access to shops and amenities.

Economic Aspects

Local Workers and Subcontractors

Most of the project team were residents of Alingsâs, while the remaining members lived within a 30-kilometer radius of the site. The plumbing contractor was a local company from Allings, while the electrical contractor was a national company with an office in the city (Jorlöv, 2015).

Local Building Materials

A large portion of the building materials were acquired from the local area, supporting the regional economy and cutting down on transportation emissions. Most of the timber utilized in the project came from a source just 30 km away from the site.

The Technical Training

All members of the project team took part in a pre-construction training day that addressed various aspects of the project and included training on passive house construction. Skanska conducted a training session to investigate the possibilities of low-energy buildings that can produce their own energy (Inno4sd, 2019).

Financial Savings due to Energy Efficiency

The Brogården renovation project ended up costing approximately 25 percent more than a regular renovation project because of the passive house techniques that were implemented. Nonetheless, the updated Brogården apartments use around 75 percent less energy after the renovation, allowing residents to save a substantial amount of money throughout the buildings' lifespan. A rent hike of US$40 per square meter has been agreed upon by Alingsåshem and the tenants of Brogården, guaranteeing the repayment of the redevelopment expenses within 6-10 years. The new apartments also come with separate water and electricity meters, allowing residents to track and manage their resource usage for greater cost savings (Jorlöv, 2015).

Environmental Aspects

Minimizing Environmental Impacts during Construction

The construction site in Brogården is certified according to Skanska's internal environmental management system (Grön Arbetsplats), and energy-efficient building lighting and waste management system are used. Energy consumption was also continuously monitored during construction, and losses were avoided by supplying tap water instead of bottled water.

Waste Recycling

Waste was sorted into different streams on site and approximately 85% of construction waste was recycled. Approximately 25% of the off-site was reused as filler material, and 5% of the waste was recycled into metal. Wood waste and other combustible waste, accounting for approximately 20% and 35% of the total waste, was sent to central thermal power plants to generate electricity. The Brogården project also increased resource efficiency by recycling and reusing existing buildings rather than building entirely new ones (European Commission, 2013).

Energy Efficiency

The Brogården redesign venture decreased the normal add up to vitality utilization of a flat by 75 percent and the vitality utilized for warming by around

80 percent. The lofts are made waterproof and protected with thick cover. The dividers have been protecting with around 440mm of polystyrene, mineral fleece and cover board, compared to 100mm of cover some time recently the redevelopment, and the thickness of the dividers is presently 520mm counting the exterior. The dividers have a u-value of between 0.11 and 0.095 W/m2 K, compared to around 3.0 W/m2 K some time recently the redevelopment. The roof contains between 400 and 550 mm of separator. Protects entryways and triple-glazed windows filled with xenon gas with an normal U esteem of 0.85 W/m2 K were used. The ancient concrete establishments of the overhang were evacuated as they were associated to the loft floor and served as warm bridges that spilled warm from the flats. Unused overhangs were hung on the external divider to decrease the plausibility of warm misfortune. Unused warm recuperation ventilation frameworks have been introduced, which recuperate around 85 percent of the vitality from the debilitate discuss. Ventilation frameworks can moreover give extra warming, which is given by an effective wood-fueled warming framework. Alinsåshem has moreover introduced energy-efficient domestic apparatuses in the apartments (Jorlöv, 2015).

Table 1. *Comparison of Energy Consumption in One of the Flats at Brogarden, Before and After Renovation)*

	Before renovation	After renovation
	[KWh/m^2yr]	[KWh/m^2yr]
Heating	115	19
Hot water	42	18
Household electricity	39	28
Residential electricity	20	21
Total consumption	216	86

Source: European Commission 2013.

Water Efficiency

Individually metered hot water and low flow toilets and fittings are features of the apartments. By taking these steps, water use has dropped by about 15% from before the project began (Jorlöv, 2015).

Durable Building Materials and Techniques

Brick façades made of crumbling natural clay were replaced with freeze-resistant bricks. The clay bricks are more weather resistant than the old façade, and replacing a damaged brick is a simple process, saving the need to rebuild the complete façade. Although the foundations were prone to damp before the

redevelopment, they have been shielded against moisture damage. In addition, the roofs have been reinforced and rebuilt.

Reducing Carbon Dioxide Emissions

The buildings' overall energy usage has been cut in half because to the Brogården project, which has decreased carbon dioxide emissions. The flats save around 22 kg/m2 of carbon dioxide yearly because they use about 120 kWh/m2 less than they did before the refurbishment (Jorlöv, 2015).

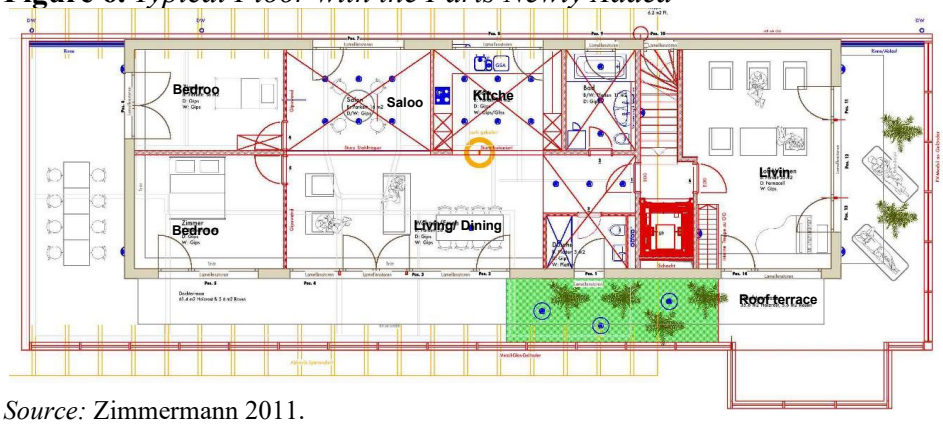
Passive House Rehabilitation of Post War Residential Building in Zug, Switzerland

Figure 5. *Zug Residential Building, Switzerland*

Source: Zimmermann 2011.

Project Overview

Figure 6. *Typical Floor with the Parts Newly Added*



Source: Zimmermann 2011.

The residential building locates in Zug Switzerland had been constructed after the second world war in 1946, the total area is 442 m², the building had been renovated in 2009. The reasons to rehabilitate of the old building were insufficient insulation, excessive thermal bridges, low thermal comfort and consequently higher annual energy expenditures and non-compliance with fire regulations that were the grounds for the rehabilitation. The building has been scheduled for renovation with the addition of a new section and a penthouse

apartment because it is situated in a lovely residential area overlooking Lake Zug (Zimmermann, 2011).

Renovation Strategy

The building had to maintain social, environmental and financial sustainability. The renovated building and newly added parts had to meet the passive House standard requirements.

Social Aspects

Community interviews were held with residents to express their opinions and suggestions before and during the rehabilitation process.

Economic Aspects

There is an 80% or greater energy savings that for using in heating, ventilation, and domestic hot water. Achieving the target of 17 kWh/(m²·y) of electricity being used for home hot water, heating, and ventilation If PV systems are deployed (Maffeo, 2016).

Table 2. *Overview of Demonstrated Energy Systems and Savings Achieved (Primary Energy Values in Brackets)*

	Consumption before renovation kWh/(m²·y)	Consumption After renovation kWh/(m²·y)	Heating system	Thermal Solar system	PV systems Electricity produced kWh/(m²·y)	Primary Energy savings %
ZUG	226 (280)	25 (74.3)	Ground coupled heat pump	x	9.5 (28.2)	93.3 (83.5)

Source: Zimmermann, 2011

Environmental Aspects

The rehabilitation included facades & roof solutions, heating system, hot and grey water, and adding PV units and the ventilation system.

Façade & Roof Solutions

The ancient brick walls were insulated with polystyrene with a polyurethane core on the first three floors. The roof and the upper story were constructed using prefabricated, light-weight timber components filled with glass wool. Poor-quality double-glazed windows and all doors were replaced.

Heating System

The heat pump and regulated ventilation make up the modern heating system. Every unit has a heat exchanger built right into the duct system to warm the supply air. The temperature of the air in each unit can be separately adjusted (Maffeo, 2016).

Hot and Grey Water

A 2,850-liter hot water storage tank and ten vacuum collectors totaling 15. 5 m2 was installed. A rainwater collection system was added to reduce the expense of fresh water for the irrigation system. Grey water is supplied for garden appliances and toilets (Zimmermann, 2011).

Photo Voltaic system

36 photovoltaic modules totaling 210 watts (7.6 kW) are used on the roof to produce solar electricity. There are 53.5 m² of PV in all (Maffeo, 2016).

Figure 7. *PV Panels Were Added on the Top Roof in the Rehabilitation Process*

Source: Zimmermann 2011.

The ventilation system

Every apartment is supplied with fresh air by the ventilation system, which gathers it from the central air intake. The new apartments have a humidity recovery system installed in addition to the well-known heat recovery system to prevent dry air during the winter (Maffeo, 2016).

The Energy Efficiency

Energy usage dropped from the poorest category (G) to the best category (A) as a result of the rehabilitation. The total energy used for technical installations and residential electricity was 50.6 kWh/(m²·y) or 40.625 kWh/y. 9.5% was utilized for ventilation and heat distribution, and 40% was used by the heat pump. Between October 2009 and October 2011, the solar thermal system contributed 8,061 kWh/y while the PV system decreased the electricity bill by 7.645 kWh/y. (Including PV gains) The net power used for heating, hot water, and ventilation was 12367 kWh/y (Zimmermann, 2011).

The Construction Process

Traditional concrete floor slabs and brick walls were used in the construction of the new apartment building; the light roof structure was entirely prefabricated. For static reasons, it was crucial to keep the roof structure's weight under control. Additionally, it made it possible to build wall elements that did not line up with the walls of the building below. Sun breakers and aluminum cladding have been installed, and prefabricated components have been utilized (Maffeo, 2016).

Rehabilitation of the Housing Buildings Projects in Cairo

Rehabilitation of the Housing Buildings in Haret Al-Rum in Cairo

Figure 8. *The Rehabilitation of Haret Al-Rum in Cairo*

Before After Before After

Source: Urban Development Fund 2022.

The project included developing residential buildings in an area called Haret Al-Rum, located in Cairo. The development included refinishing the facades of residential buildings, upgrading the interior finishes, adding some shading devices on the facades and developing sanitation and plumbing works for the buildings. The project aimed to improve the current condition of residential buildings, without significantly considering the sustainability aspects.

Rehabilitation of the Housing Buildings in Al Darb Al Ahmar in Cairo

The project included Rehabilitation program in Al-Darb Al-Ahmar district has commenced with funding from the AGA KHAN Trust for Culture for implementation of the Residential Building in Al Darb Al Ahmar area and some historical mosques.

The rehabilitation process included improving the existing condition of the buildings, rebuilding the vulnerable and dilapidated parts of some residential buildings, developing sewage and electricity connections, and refinishing the facades and interior spaces of the residential buildings.

Figure 9. *The Rehabilitation of Al Darb Al Ahmar Buildings in Cairo*

Before After Before After

Source: Urban Development Fund 2022.

Methodology/Materials and Methods

Research methodology depended on theoretical and analytical study of the theoretical data and the case studies that include local and international case studies, in order to conclude the conceptual framework for the existing housing to be sustainable in the rehabilitation processes in Cairo.

Data gathered from different references. In this study, methods include selecting the most appropriate solution to achieve the conceptual framework. It also includes collecting data regarding accuracy and reliability.

Research has a qualitative approach. The research instrument is through interviews ,the analysis was made of the results of the interviews, to reach the most important elements in the sustainable rehabilitation process to conclude the major practical elements to be used in the proposed conceptual framework expressing the main items in the existing built environment and to indicate to what extent the proposed framework will be benefit for obtaining the solutions. Samples had been selected as a set of expert architects and professors in the field.

Results

The research highlighted new sustainable materials that can be used in the rehabilitation of residential buildings.

The research highlighted and analyzed two case studies for housing projects that were rehabilitated to support the sustainability requirements.

The research submitted a conceptual framework to rehabilitate the existing housing building in Cairo, this conceptual theoretical framework consists of the following:

- *Sustainable Construction*
-
    - Using sustainable construction techniques.
    - Using sustainable construction materials.
    - Applying sustainable construction waste management.
    - Minimizing the negative impact on the environment during construction.

- *The sustainable process*
    - Sustainable construction process.
    - Trained workers for sustainable practice.
    - Recycling of construction waste.

- *Improvement & development*

    - Modifications or additions to improve the spaces and functions.

- *Rehabilitation for Long Lasting sustainability*

- The Rehabilitation should be for long lasting sustainability.

- *Waste management*

  - Waste management that includes a clear sustainable plan for the wase.

- *Local Factors*

  - The special local requirements and architectural solutions related to the climate.
  - The local requirements related to the materials.
  - The local requirements are related to society, nature of the residents and residents' social and economic level.

- *Passive Solar Energy Solutions*

  - Natural lighting
  - Natural ventilation.

- *Energy Efficiency*

  - Efficient use of energy
  - Installing renewable energy devices.
  - Using LED lighting.

- *Water Efficiency*

  - Enhancement of Water efficiency
  - Enhancement of reuse and recycle of water.

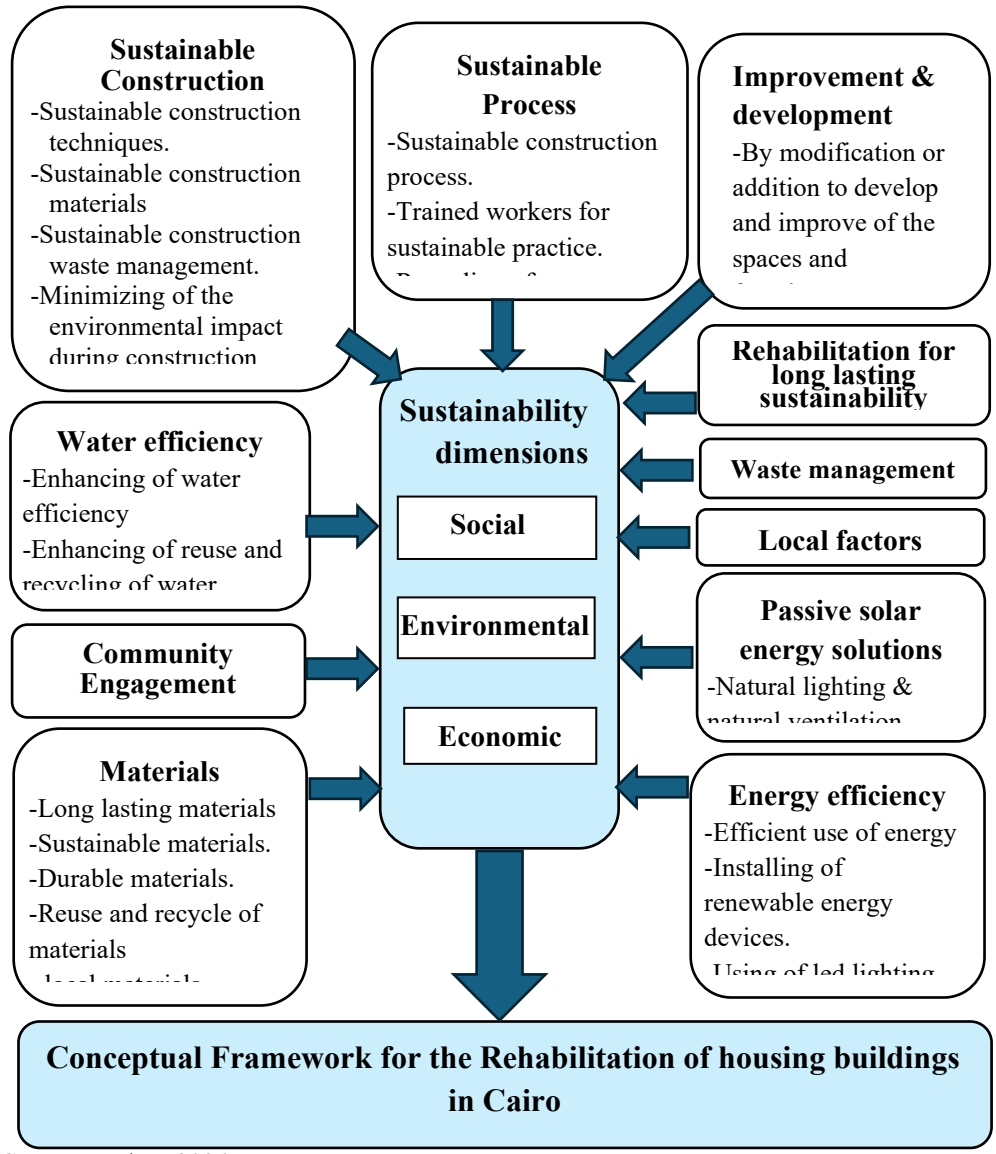
- *Materials*

  - Use of long-lasting materials.
  - Using of sustainable materials
  - Using of durable materials
  - Reusing and recycling of materials.
  - The use of local materials.

- *Passive Solar Energy Solutions*

  - Enhancement of passive solar energy techniques.
  - Enhancing natural lighting and natural ventilation.
- *Community engagement with conducting interviews with residents.*

Figure 10. *Conceptual Framework for the Rehabilitation of Housing Buildings in Cairo*



Source: Author, 2024.

Discussion

The research problem was the lack of a clear framework for the process of sustainable rehabilitation of residential buildings in Cairo, and the research aimed to create this framework. The research concluded this framework to be applicable in the city of Cairo when carrying out the sustainable rehabilitation processes.

Some previous papers studied the rehabilitation process, others studied the sustainable rehabilitation, but without applying on rehabilitation operations of

the city of Cairo, as this research concluded a theoretical framework for the sustainable rehabilitation processes in Cairo.

The research assures that rehabilitation processes, including improving and developing of internal architectural spaces, performing the required maintenance for the building, and improving internal and external finishes, can be carried out in a sustainable manner.

To determine the required elements of the concluded framework, the research analyzed the theoretical study and the case studies, and conducted interviews with experts to determine the main important elements to be included in the theoretical framework as well as to guarantee that the concluded framework for sustainable rehabilitation of housing projects is suitable to be used in Cairo city. The criteria for selecting sample members to conduct interviews were selecting professors specialized in sustainability and architecture and selecting practical engineers that have experience in construction of housing projects.

Conclusions

- The research concluded a conceptual framework for the rehabilitation of the existing housing projects for the city of Cairo.
- The research contains the analysis of some case studies which included the rehabilitation of housing projects that considered the sustainability requirements. The research also analyzed the main items in the rehabilitation practices to enhance the sustainability dimensions.
- The research provided some recent sustainable solutions in the rehabilitation process.
- he research identified the main elements that must be taken into account in rehabilitation processes with considering the sustainability requirements, which included: the sustainable construction, sustainable process, improvement & development, rehabilitation for long lasting sustainability, waste management, local factors, passive solar energy, energy efficiency, materials, water efficiency and community engagement with interviews with residents.
- The research found that rehabilitation processes can be carried out in a sustainable manner that for improving of the interior functional spaces, making the required maintenance for the building, improving of the interior and exterior finishes, engaging of passive solar energy techniques and improving of interior ventilation and natural lighting

References

Brownlee J (2016) Why Martian Concrete Might Be The Best Building Material In The Solar System Fast company. https://www.fastcompany.com/3055172/why-martian-concrete-might-be-the-best-building-material-in-the-solar-system.

Chalmers A (2023) 9 Home Renovation Projects That Are Actually Green. *Try these upgrades for a more sustainable home. The Spruce. https://www.thespruce.com/eco-friendly-home-renovation-ideas-7255083*

European Commission (2013) Brogården, Sweden: Refurbishment of social housing. *Green best practice Community. European Commission. https://greenbestpractice.jrc.ec.europa.eu/node/669.*

Hohenadel K (2022) How to Renovate with Sustainability in Mind. *The Spruce. make your best home. https://www.thespruce.com/how-to-renovate-sustainably-5524859.*

Imnovation-hub (2022) The materials of the future we are envisioning today. ACCIONA. *https://www.imnovation-hub.com/construction/materials-of-the-future-we-are-envisioning-today/?gad_source=1&gclid=CjwKCAjw9cCyBhBzEiwAJTUWNed1z-uSsbM88B0h67fsjFq4xs6TaArfE6tMYv_l0zKjWirwb3-ZVRoCIMYQAvD_BwE&_adin=11551547647#1*

Inno4sd.net (2019) Renovating public housing while increasing energy efficiency and living comfort. *Innovation of sustainable development network. https://www.inno4sd.net/renovating-public-housing-while-increasing-energy-efficiency-and-living-comfort-244*

Jorlöv M (2015) Miljonhemmet, Brogården. SKANSKA. *Sweden. https://www.skanska.se/en-us/our-offer/our-projects/57305/Miljonhemmet%2C-Brogarden*

Maffeo A (2016) Renovation of residential area in Dieselweg 3-19, Graz. *Deep retrofit with extension in Existing Buildings. https://www.politesi.polimi.it/retrieve/a81cb05c-b10c-616b-e053-1605fe0a889a/2018_04_Maffeo_03.pdf*

Rathee A et al (2014) Hydroceramics. IAAC, the Institute for Advanced Architecture of Catalonia. *https://iaac.net/project/hydroceramic/*

Urban Development Fund (2022). *Informal Settlements Development Facility. http://www.isdf.gov.eg/ProjectsListing.aspx?catid=2&state=2*

Uribe B (2016) 10 Innovative Materials That Could Revolutionize the Construction Industry. Arch Daily. *https://www.archdaily.com/800546/10-innovative-materials-that-could-revolutionize-the-construction-industry*

Sánchez L Fernández R, Giampietro M, (2022) Factors and actions for the sustainability of the residential sector. *The nexus of energy, materials, space, and time use. DOI: 10.1016/j.rser.2022.112388*

Shahi S Esnaashary Esfahani, M., Bachmann, C., & Haas, C. (2020). A definition framework for building adaptation projects. *Sustainable Cities and Society, 63, 102345. https://doi.org/10.1016/j.scs.2020.102345*

Zimmermann M et al (2011) Building Renovation Case Studies IEA ECBCS Annex 50. *Net zero energy renovation of a Swiss apartment building in Zurich. Empa. Building Science and Technology Lab. Switzerland. https://www.iea-ebc.org/Data/publications/EBC_Annex_50_Documented_CaseStudies.pdf*