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Design practice for a prefabricated resort hotel in Hendurabi Island

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Abstract: Small islands in humid and hot climates have received less attention development due to lack of resources and difficulties for in-situ construction. This paper addresses this problem by presenting a modular system for sustainable construction of a resort hotel in accordance with the international tourism standards, in addition to, minimizing undesirable effects on nature. This has been achieved by review of literature in the scope of off-site construction and identification of the natural geographical features of Herndurabi Island. According to the information acquired, a feasibility study and design practice have been conducted to achieve a reasonable solution to equip Hendurabi Island as a sample with a self-sufficient prefabricate resort hotel. Findings indicate that the volumetric prefabricated modules would be a solution to devising a framework for design and construction in remote regions.

Key words: sustainable off-site construction, prefabricated construction, shipping container architecture, resort hotel buildings

1. INTRODUCTION

Since Iran was located on the way of ancient caravans, caravanserais or the ancient resorts constitute a great proportion of Iranian architecture [15].

In May 2014, Presidential Adviser and Secretary of the Coordination Council of Free Zones insisted that: development of these Islands with the aim of attracting tourists and boom of Halal tourism should be taken seriously by the organization. Unfortunately, there are many fundamental troubles lay ahead for Hendorabi Island, even though the governors placed great emphasis on the development of the tourism industry on this Island.

Since establishing the basic infrastructure for a tourist island is immensely time and cost consuming, policies in the meantime are to exploit the tourism benefits of the Island in the near future. Therefore, it seems essential to study feasibility and practically design a prefabricated resort that could be substituted for the existing low-level accommodations (Fig.1) cover all the tourist requirements and supply all international tourism quality standards.

It would be necessary to apply the prefabricated construction techniques to maximize the speed of construction and minimize the undesirable effects on nature on Hendurabi Island. Our objectives for designing the prefabricated resort in the Hendurabi Island is to cover all the tourist requirements and to respond to all international tourism quality standards.

Hendurabi Island is an Iranian island in the Persian Gulf which has recently attracted the attention of the government as an international tourist island based on its natural potential. The total population of

the Island is about 80 people who live in a small village carrying the same name as the Island. Accordingly, there are no infrastructure in order to construct and operate of a large-scale building on the Island, therefore, off-site construction is an inevitable and reasonable method and construction technology in this case. Prefabricated construction, replacing traditional methods of construction, has drawn international attention over the past twenty years. This interest can be explained by the substantial advantages of the technology, including, construction waste reduction, [4][21][22], improved quality control [10], noise and dust reduction [19], higher standards for health and safety [14][19], time and cost savings [6][9], reduced labour demand [16], and low resource depletion [1][23].

Fig. 1. Existing accommodations

2. RESEARCH METHOD

The study is based on a case study analysis from a hot and humid climate in the Persian Gulf. The observational data and the quantitative data were used for designing modular buildings for the same context. Several alternative strategies and conceptual designs were initially developed. Expert opinions were received on the alternatives in the workshops during the design process, and the conceptual design was finished. For example, several prefabrication strategies were evaluated but the shipping container architecture were used because of availability of a substantial number of used shipping container in nearby harbors. In the context of architecture in hot and humid climate, the vernacular architecture of Laft Harbor has been studied. Its most prominent features were recognized and cutting-edge construction technologies that match the hot and humid climate were identified and applied in the architectural design.

According to the explanation of design process of this project, the main concept and how it formed will be described initially, the site of the construction will then be analysed and the building performances will be overviewed. Design of building envelope details and the insulation of spatial units will be considered along with the physical necessities. Finally, energy supply methods and topics for mechanical and electrical installations will be mentioned.

3. MAIN CONCEPT AND PRIMARY GENERATORS

The designer's role and responsibilities are a prescriptive model rather than a descriptive one. Unlike scientists who describe how the world is, designers try to show how the world could be. Accordingly, designers are also futurists. The essence of their job is creating the future or some aspects of it [13].

Passer-by (Fig.4), Way (Fig.2) and Node (Fig.3) are key factors for the design concept of this project. The different ways to supply common needs of passers-by cross each other at a specific point and form a node. Ways as the linear elements, Passers-by as the point elements and the conceptual factor of the node as the three-dimensional volumetric elements applied for the form production.

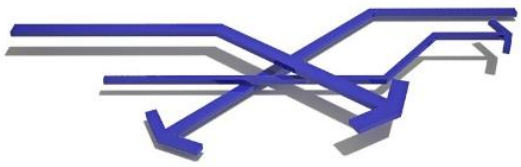

Fig. 2. Design concept diagram, Way

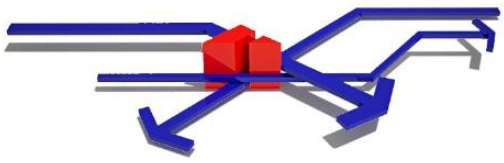

Fig. 3. Design concept diagram, Node

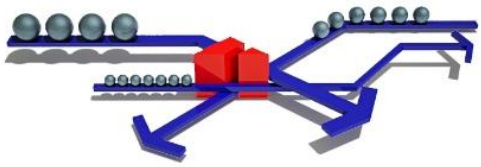

Fig. 4. Design concept diagram passerby

Primary generators are criteria that draw the attention of designers to themselves at the earlier stage of the design process and move towards some ideas of a solution and lead to narrow domain possible solutions [13].

Five primary generators have been applied in the design process of this project, namely:

1-Prefabrication: Since Hendurabi Island lacks any infrastructures to facilitate construction and operation of a large-scale building, application of off-site and prefabricated construction methods are reasonable and inevitable. Accordingly, due to structural considerations in addition to limitations and possibilities for transportation, a triangular concrete slab as the basic module of the roof structure and the steel frame structure have been considered as the structural system of the building (Fig.5).

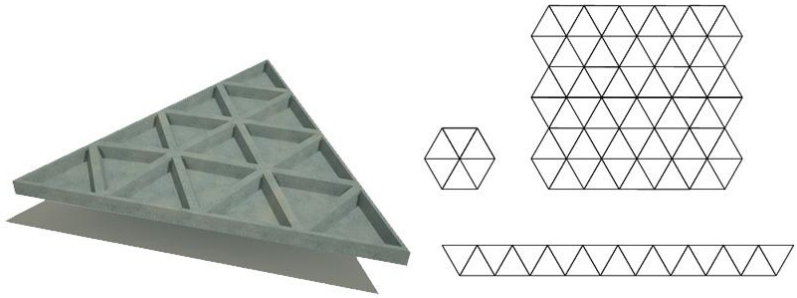

Fig. 5. Triangular concrete slab

2- Application of geometric shape of the equilateral triangle: the triangle is the only geometric shape that has a different upward direction from its downward direction and direction would change the meaning of the shape. Since WAY is one of the key factors to produce the form of the building, the triangle with its special quality underpinned the production of a basic module that led to the design of the entire project.

3-Shipping Container as a portable and replaceable spatial unit: The shipping container as an expandable architectural entity which could be attached to the main structure has been contemplated as the passerby key factor of the design process. According to the subject of prefabrication, shipping containers will be equipped and prefabricated as the hotel rooms in remote factories and will be shipped to the construction site. Furthermore, by the consideration of required stable quality and construction standards, overused containers could be removed and replaced by new ones.

4-Traditional architecture of Laft historic Harbor: Laft is the most prominent coastal village of Qeshm Island in the Persian Gulf. Traditional buildings, stable social living, increasing development and development perspectives are the reasons that led to choosing Laft Harbor as the inspiring resource. Since the indigenous architecture of Hendurabi Island is confined to the very small Hendurabi village and due to close resemblance between the architecture of Iranian islands in the Persian Gulf, iconic patterns of the traditional architecture of this region were studied and adapted for this project. Following are the most significant patterns of traditional architecture of Laft Harbor which were determined as the inspirational elements:

- Deep porches (Fig.6)
- Short and wide four-sided traditional ventilators (Fig.7)
- Rooftop as a living space
- Strait stairs that connect yard with roof (Fig.8)
- Application of perforated panels as the exterior sun shades [2] (Fig.9).

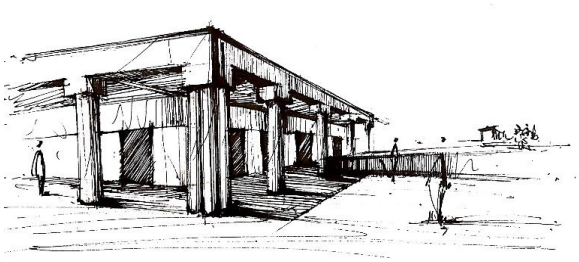

Fig. 6. Deep porches in Laft Harbor

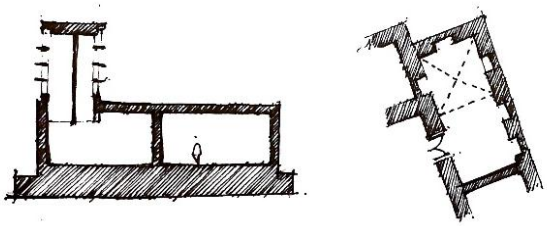

Fig. 7. Traditional ventilator

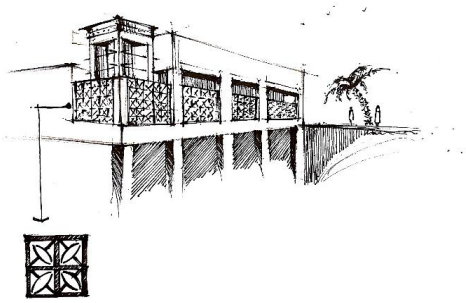

Fig. 9. Traditional perforated panels

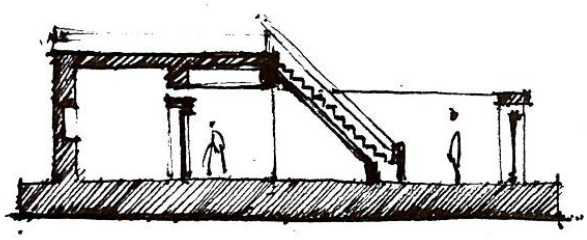

Fig. 8. Strait stairs that connect yard with roof

5-Traditional ventilators: Studying traditional architecture and urban texture of southern and central cities of Iran indicates that the warm and dry or warm-humid climates in addition to strong seasonal winds have a significant effect on the construction and application of traditional ventilators [8]. As mentioned earlier, the traditional ventilator is an iconic architectural pattern indigenous to architecture of Laft Harbor (Fig.10) and it is considered one of the main signs and symbols of Persian architecture. Accordingly, formal and functional application of this outstanding pattern as one of the primary generators has been considered in the design process (Fig.11).

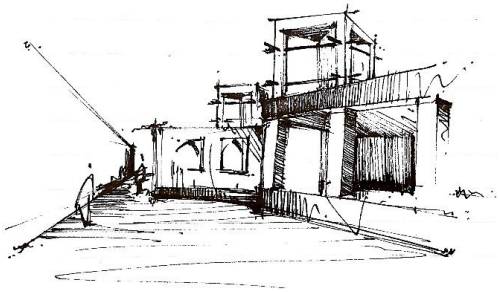

Fig.10. Short and wide four-sided traditional ventilators

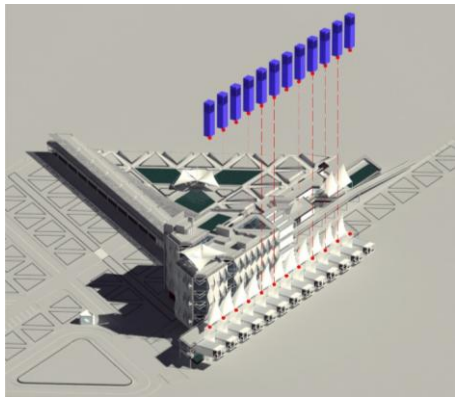

Fig.11. Updated Windcatchers

4. SITE ANALYSIS

The site is located on Hendurabi Island at a distance of 325km distance far from the state capital city. Hendurabi Island has an area of 22.8km^2 and is located between the Lavan and Kish islands which are more developed areas. There are currently 20 households on the Island and their occupation is fishing

and diving which are not skilled construction labors. There are no industrial activities, mining, exploitation of underground resources, or even handicrafts on the Island. Freshwater supplies are limited and water is provided through wells and reservoirs (ponds). Hendurabi Island is a quiet and tranquil place, uncrowded with beautiful sandy beaches and a dreamlike place for relaxation, recreation, swimming, strolling along the beach and sunbathing [3].

Based on the climatic classification of Iran, Hendurabi Island is located in the desert climate zone, but on the local scale, the desert climate of the island is different from the internal regions of Iran, which is mainly due to the high relative humidity.

Unfortunately, there is no accurate available information about the climate of Hendourabi Island but it could be perceived from the climate of two neighbouring islands which are situated about 30km distance from this island (Table 1).

Table 1. Weather stations statistics of Hormozgan province (2016) [11]

	Rainfall (mm)	Temperature (°C)					Humidity (RH)			Sunny hours	Max. wind speed (km/h)
		Average	Max. Average	absolute maximum temperature	Min. Average	absolute minimum temperature	Average	Max.	Min.		
Kish Island	29.9	28.3	32.2	44.4	24.4	12.8	62	83	41	3267.4	24
Lavan Island	68.9	27.9	31.9	44.5	24	9	61	79	42	3401.7	23

The Island's prevailing wind blows from west to east which causes wavy sea and a rocky coast at the western side of the Island. On the contrary, there is clear sea and a sandy coast on the eastern and northern shorelines [18] (Fig.12). It is clear that the building will be safe at this side of the Island from the strong humid winds that would cause the rapid erosion of the structure. According to the abovementioned considerations, the construction site was chosen at the east end of the Island with 125 meters distance from the shoreline based on the regulations (Fig.13). The chosen site has an uninterrupted view of the sea from the north and east direction and almost no slope. To take the advantage of the lookout, the form of the building has been stretched to the west and north direction.

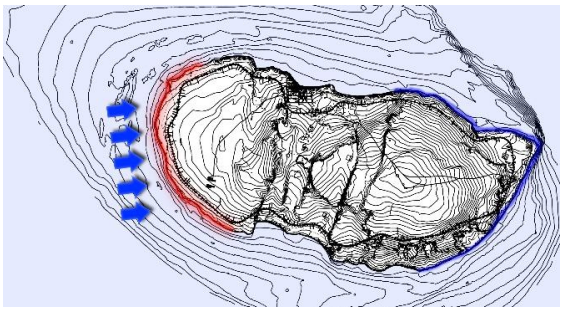

Fig.12. prevailing wind direction

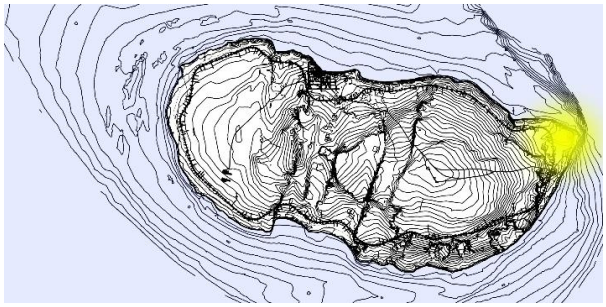

Fig.13. Site location

5. FUNCTIONAL REVIEW

Function analysis started with the investigation of possible solutions, predicated upon three steps. At the earlier stage, a list of criteria was set to formulate a framework for the form studies of the project, namely:

1. Flexibility of spaces
2. Architectural legibility
3. Indigenous architectural identity

4. High availability of installations
5. Equal separate recreational facilities for both genders
6. Sea view from main spaces
7. Public semi-open spaces

The framework was applied to devise a functional analysis in order to find an optimal location for the main spaces.

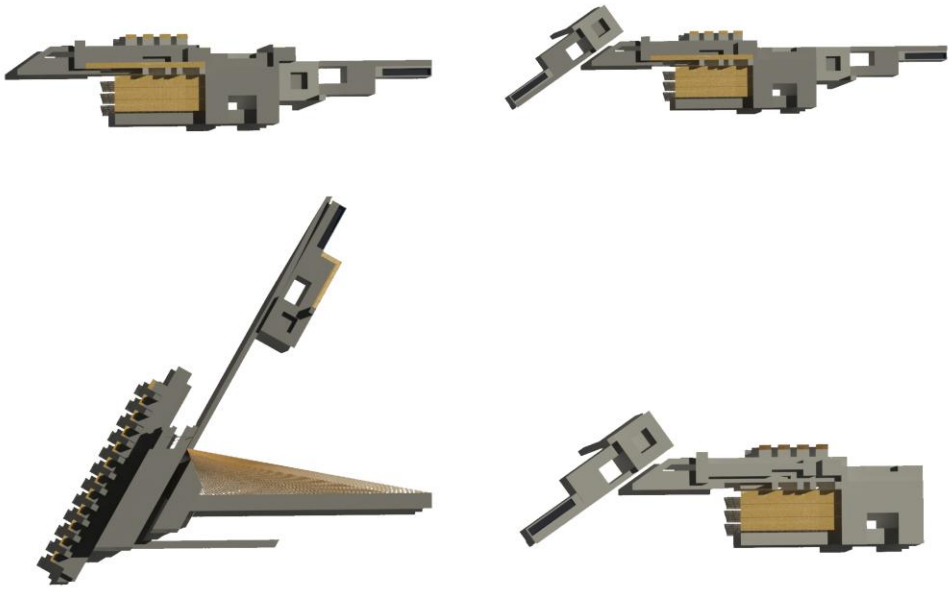

Fig. 14. Feasible solutions

In the second step, using triangular concrete slabs and about 200 cargo containers, numerous empirical practices were carried out in 4 months and five feasible solutions (Fig.14) obtained which satisfy all the pre-set constraints and criteria. At the final stage, in a bilateral interactive process on the basis of the main concept, one of the possible solutions was selected (Fig.15), and accordingly, an optimal layout and composition of spaces was attained (Table 2).

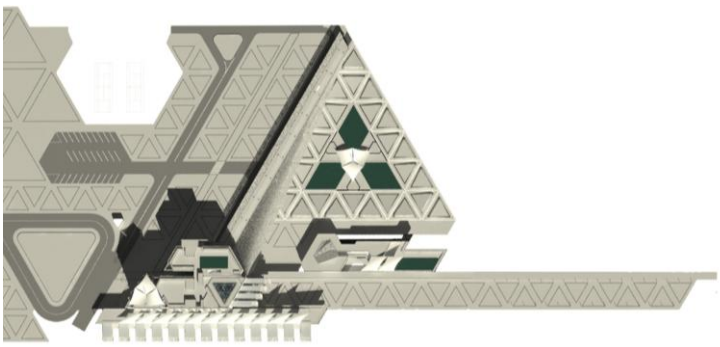

Fig. 15. Selected feasible solution

The architectural form of the building encompasses a number of main spaces including, served and servant, accommodation and recreational spaces in addition to mechanical shafts and the engine room as well as proper circulation as the main constituents of form.

Based on the High-Tech Architecture principles “served and servant” spaces are distinguished. Accordingly mechanical considerations such as stairwells and pipes apart from the served spaces which lead to facilitate maintenance of the building. Furthermore, servant spaces that have a shorter lifetime are going to operate separately [7]. The western block will perform as the servant part in this project (Fig.16).

Table 2. Function analysis

Items	Optimal location	Reasons and advantages
Served and servant spaces	• Western Block (servant) • Basement floor (servant) • Eastern Block (served) • Two Wings (served) • Peripheral Building Block (served)	Flexibility of spaces Easy maintenance Categorizing sections by their lifespan
Accommodation spaces	• Eastern Wing • Western Wing • North side of the main block	Categorizing types of rooms by their dimensions and equipment Sea view from every room Possibility to categorizing rooms by the types of gusts
Recreational spaces	• Rooftop • Peripheral Building Block	Outdoor swimming pool for both genders regarding Islamic context Equal recreational facilities for both genders
Vertical circulation	• Two pairs of elevators at the central sector at the leftmost and rightmost edge of the building • A service elevator at the mid-point between two pairs of elevators	Architectural legibility Easy access to all spaces Controllable access to special spaces
Mechanical shafts	• Two pairs of wide vertical shafts adjacent to the elevators	High availability of installations Easy maintenance

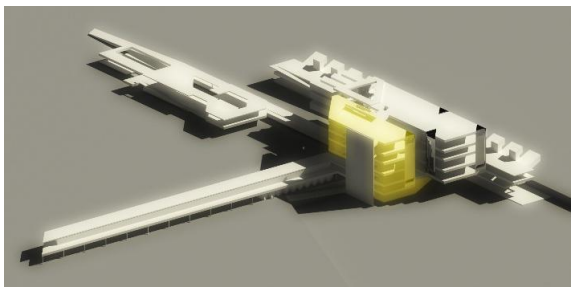

Fig.16. Servant places block

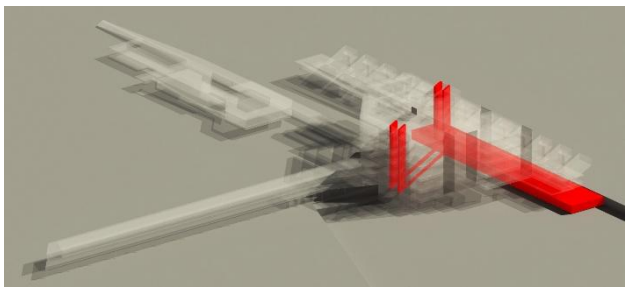

Fig.17. Wide vertical shafts and Engine room

In order to facilitate maintenance of mechanical and electrical installations, two pairs of wide vertical shafts (Fig.17) have been provided on two sides of the building in a way that makes them easily accessible in all floors. They would be connected to the engine room directly.

Using shipping containers, as volumetric prefabricated modules, four room types (Fig.20) have been manufactured which are located in three sections of the building (Fig.18) on the basis of their facilities and dimensions.

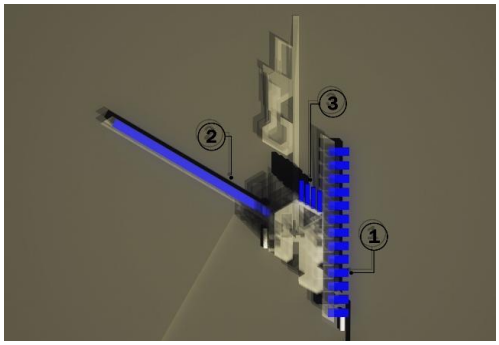

Fig.18. Accommodation sections

6. BUILDING ELEMENTS AND DETAILS

6.1. Double-skin facade (DSF)

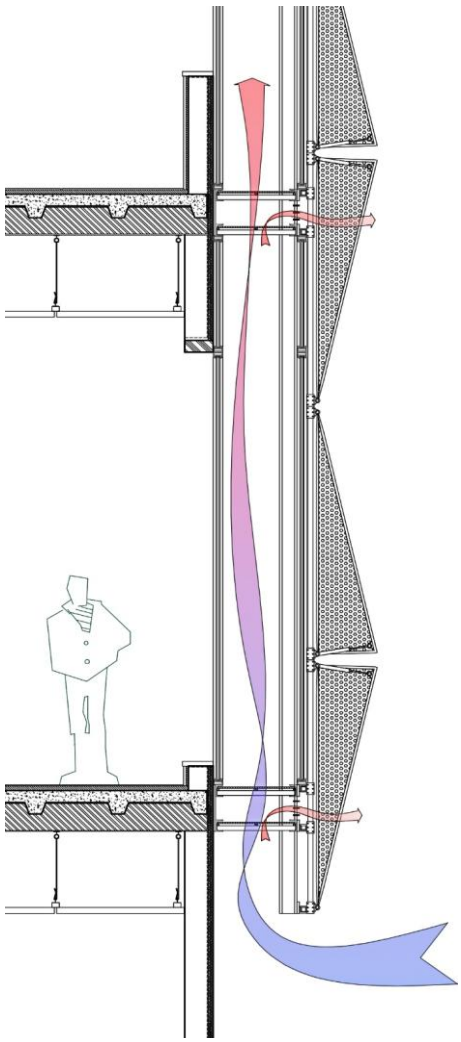

Fig.19- Double skin facade detail

"Conventional building skin facades are known to have numerous problems such as thermal comfort, natural ventilation and glare especially in buildings with high glazing skin, which are located in hot temperature regions" [20]. Double skin facade (DSF) is a solution to the thermal operation enhancement of buildings albeit, its good reputation is in relation to the reduction of radiation energy transfer in buildings.

DSF consists of three layers: an external layer, an inner layer and a hollow layer between them. Usually, the external layer is a single glazed translucent façade and the inner layer can be a regular building façade but The airspace in between, called the channel, is rather important (up to 0.8–1.0 m) [20].

DSF has been developed for buildings in cold climates. Accordingly a very small number of studies have been done on the application of DSF in hot and humid climates. He G, et al 2011 studied the DSF in the hot and humid regions of China and the results indicated that a double skin façade with a proper ventilation that well-controlled the amount of direct sunlight by means of sunshades could be applied with high performance [10].

In this case, the inner layer is a double glazed facade with UPVC framing. The external layer is a double glazed façade with reflex glass with aluminium framing placed at a distance of 60cm from the inner facade. There are perforated steel sheets in the level of each floor for maintenance and another perforated steel sheet is placed under the other one to provide space for electrical installation and electric motors of sunshades. Furthermore, there are several openings between the two perforated sheets to boost the natural ventilation performance.

In order to prevent the greenhouse effect in the channel, several dynamic triangular sunshades would be mounted on the external façade. Triangular sunshades with two hinge joints and the third one which is connected to an electric motor are able to rotate around a fixed axis and control the percentage of the energy radiated by the sun reaches the building.

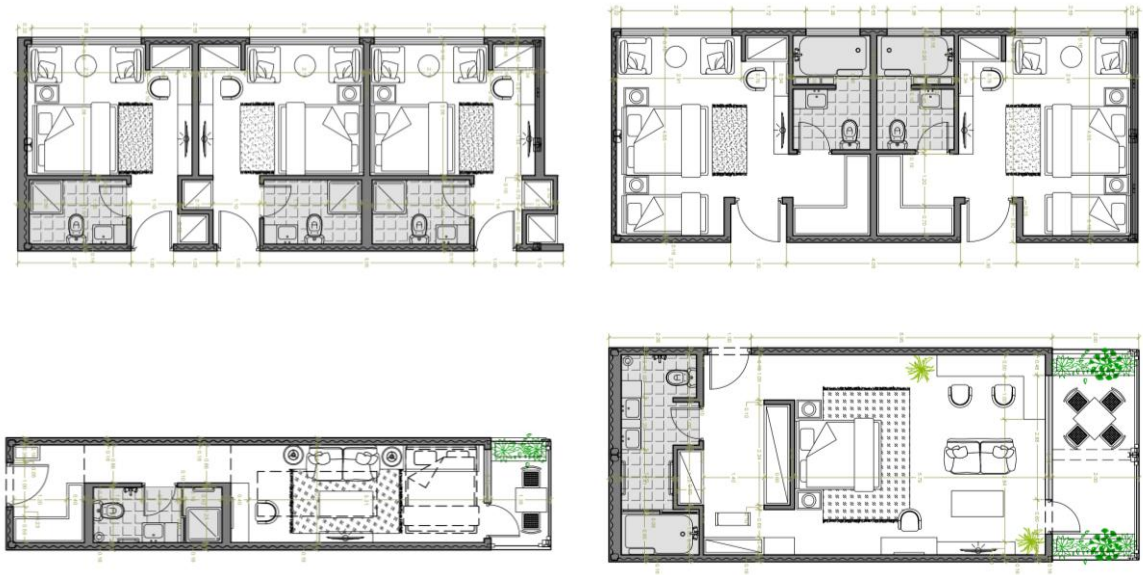

Fig.20. Room types using 40ft cargo containers

6.2. Shipping container

Since shipping containers (SC) are entirely made of steel, thermal insulation and control of the inner temperature especially in hot and humid climates, is dramatically important.

Regarding studies, the most efficient insulation method is to spray a layer of 5cm to 7cm polyurethane foam on the inner side of the SC which would be covered by two layers of gypsum panels and the external side of the containers would be covered by Nano-ceramic thermal insulation coating. Nano-ceramic thermal insulation is a water-borne insulating coating that is specifically designed to block heat-load, moisture-penetration, and air-infiltration on virtually any type of surface [5].

7. MECHANICAL AND ELECTRICAL INSTALLATIONS

'Iran's total area is around 1,600,000 km^2 or 1.6×10^{12} m^2 with about 300 clear sunny days in a year and an average 2200 kW-h solar radiation per square meter'. Consequently, in the field of solar energy production this country is one of the most capable countries in the world [17].

More than 1000 square meters have been allocated to the solar energy plant which could be equipped with more than 200 photovoltaic panels. A significant portion of the energy requirement of the building would be supplied by the photovoltaic system.

7.1. Recycling air conditioning water Condensation

Regarding the high relative humidity rate on Hendurabi Island, the amount of condensate produced by an air conditioner would be noticeable. Due to the shortage of fresh water on the Island, without any water treatment operations, this water could be used for Irrigation of green spaces and filling the tank of toilets or on the condition of filtration and refinement, it could be applied for laundering and bathing.

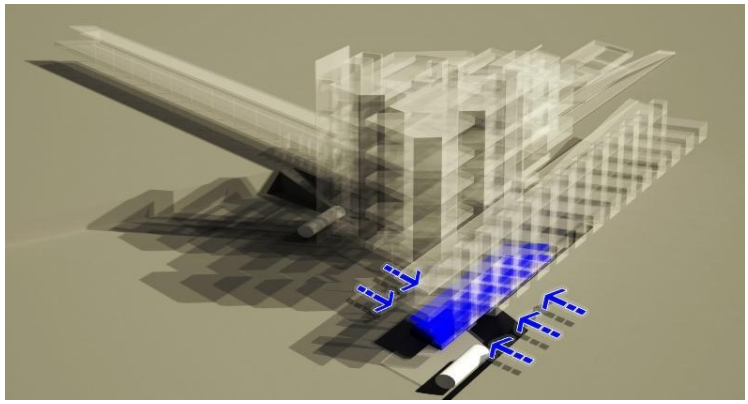

Fig.21. Pond of recycled produced water

8. Conclusion

Significant research efforts have been carried out on the scope of construction methods in hot and humid climates. Furthermore, studies that are separately associated with this subject are abundant but, the empirical experiences that applied practical attainments of these studies are not considered noticeably. In this case, it was attempt to design a resort hotel on an ad-hoc and practical basis, by the application of cutting-edge construction technologies and previous research achievements. Accordingly, barrier factors and potential solutions for the design and construction of a hotel on Hendurabi Island have been overviewed. Regarding the current situation and lack of any infrastructures in order to construct and operate a large-scale building, the project is supposed to be self-sufficient in energy supply and sewerage. Moreover, the freshwater which is produced by an air conditioner could be reused. Regarding the religious context of Iran, recreational and tourist facilities were designed and considered in special regulations. This study indicates that the volumetric prefabricated modules would be a solution for devising a framework for design and construction in remote regions. A combination of modern technology and vernacular architecture could be considered as the optimal and best possible solution to the architectural design which would satisfy all the pre-set constraints and criteria. Future research directions can be derived based on religious restrictions of architectural design for Islamic countries in the Middle-East.

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