

Reclaiming the Ocean The Palm Islands Dubai, United Arab Emirates

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ABSTRACT

As the human race continues to populate all reaches of our planet, the amount of land available for inhabitation becomes drastically decreased. This is particularly relevant in the case of premier property locations on the coastlines of tropical regions.

The United Arab Emirates (UAE) is a small Arab country on the Persian Gulf located approximately 24 degrees north of the equator. This country is faced with the problem of limited coastline availability for residence to live upon and have taken a future orientated approach of reclaiming the land out of the sea to solve their problem.

The three palm islands and other Dubai reclamation projects are developed by the company Nakheel and consist of the Palm Jumeirah, Palm Jebel Ali, Palm Deira, The World, The Universe, and the Dubai Waterfront. The reclamation projects on the Dubai coastline are in various stages of completion and will increase the available coastline length immensely.

In recent years the projects have faced financial difficulties as well as engineering difficulties in dealing with rising sea levels and erosive ocean activity.

This paper will focus on the history and background of the creation of the palm islands, the struggles and successes of the project, and what the future holds for other ocean reclamation projects.

1 INTRODUCTION

The United Arab Emirates (UAE) is an Arab country located on the Persian Gulf. The UAE has a population of around eight (8) million people, living in seven (7) emirates or sections, one of those being Dubai.

Dubai, a city located in the emirate of the same name is the largest metropolitan area in the UEA at a population of around two (2) million, followed by the UAE capitol of Abu Dhabi. Dubai's recent history and population increase stems from the discovery of oil, which has stimulated a rapid economic boom. The oil reserves are scheduled to run out by the year 2016 [1]. To insure that Dubai

remains a thriving city the government has since targeted an economic shift toward the mass tourism market.

Riding the wave of increased economic power in Dubai, the government and Nakheel, a local developer, have created some of the most astounding construction projects in the world.

Nakheel has a large portfolio in Dubai including the three (3) Palm Islands, The World, and planning for The Universe and Dubai Waterfront, all of which are land reclamation projects on Dubai's coastline. Along with these projects Nakheel has property throughout Dubai in the high end residential market, shopping districts, and has preliminary plans for Nakheel Tower which if constructed would surpass the recently completed worlds tallest building, the Burj Khalifa tower which is also in Dubai.

Dubai's natural coastline is less than 100 kilometres in length; this has put a prime price on every millimetre of the coastline as the population increases. With this increased interest in waterfront property, Dubai and Nakheel have chosen to solve this coastline deficiency by reclaiming land from the sea.

2 THE PROJECT

Land reclamation projects are used worldwide to increase the available land in a certain shoreline area, and have had proven success. The notable difference with the land reclamation projects in Dubai, is the size and architectural design of these reclamation projects.

The long term plan for Dubai's waterfront consists of the Palm Jumeirah, Palm Jebel Ali, The World, Palm Deira, The Universe, and Dubai Waterfront in this development sequence. The current statuses of the projects are as follows (See Figure 1.0).

- 1) Palm Jumeirah – Constructed and inhabited
- 2) Palm Jebel Ali – Constructed
- 3) The World – Constructed
- 4) The Palm Deira – Construction Started
- 5) The Universe – Planned
- 6) Dubai Waterfront – Planned



Figure 1.0 – Conceptual Map of Dubai's Waterfront

Source: <http://shoppingforarabs.com/dubai-waterfront-district-1342.html>

Strong tidal action can be detrimental to any land reclamation project. The initial study of the section of the Persian Gulf perpendicular to the city of Dubai shows that the Gulf is only 160 km wide and 30 m deep [1]. These characteristics inhibit the creation of large deep-water wave action, meaning that this would be a preferred location to reclaim land from the sea.

The Palm Jumeirah was the first project to be attempted; it is the smallest scheduled project and a good starting point to test the theories. The Palm Jumeirah was to increase the usable beachfront by 56 km. Construction began in the summer of 2001 and was estimated to be a fifteen (15) year construction project. This timeline was not sufficient for the leaders of Dubai and the UAE so it was enforced that construction would be completed in just five (5) years.

Although large deep-water waves were not going to develop in the gulf due to the lack of significant depth, there are still issues with wave action that needed to be considered. During the winter month's large shemal storms ravage the Arabian Gulf. The 1 in 100 year shemal storm can whip up the surface of the sea and create waves up to 2 m in height.

As with many large construction projects, time is of the utmost importance. As the engineers were still studying the ocean environment around the proposed site, for factors such as water circulation, the contractors were advised to move in and start the project. By starting construction before the design was complete, progress would move more quickly to completing the project on schedule.

Before construction could begin the right materials for the projects had to be found. The project was to only use natural materials in the construction of the breakwater and the palm island. Sand and blasted rocks were chosen to complete the project. Dubai is a desert country and has ample supply of sand, but this sand is much too fine for use in the ocean environment and will erode quickly. The proper sand was found on the seabed. It was coarse enough to help resist the erosive action of the ocean environment.

Van Oord a Dutch dredging company was chosen as the contractor for the project. Van Oord is a worldwide leader in dredging, offshore oil and gas, offshore wind, marine engineering, and soil improvement projects [2].

For the Palm Jumeirah project, Van Oord used three primary pieces of equipment. The trailing suction hopper dredger, the cutter suction dredger, and the side stone dumping vessel [2].

The trailing suction hopper is a marine vessel that is used to suck up material from the ocean floor, store the material on board, and then dispose of the material at the target location. The trailing suction hopper has two (2) large suction arms that are lowered just above the seabed and can be manipulated to get the correct mix of water to sand entering the vessel for the specific type of material. This material is then drained on board and stored in the vessel's storage hopper. One (1) vessel can store up to 31,000 m³ of reclaimed material on board.

This sand is then transported to the construction site and placed in the desired location. The material can be unloaded in a number of ways. The first way is to open two (2) large bay doors at the bottom of the hopper and let the material drop to the ocean floor in the correct location. It can pump the material through a temporary pipeline by injecting high-pressured water into the hopper to mix with the sand and make it a "liquid". Or it can rainrow the material using the same method as pumping except there is no use of a temporary pipeline, the material is simply ejected through a nozzle on the forward section of the ship (See Figure 2).



Figure 2 - Rainbowing

Source: <http://architectureintlprogram.wordpress.com/2011/06/13/the-dubai-palm-islands/>

The cutter suction dredger is a vessel that can be used when the ocean material that needs to be removed must be loosened prior to removal. There are large cutter heads at the end of the vacuum extraction pipes. Once the material is removed it can be pumped to another vessel for transport or to a temporary pipeline if the extraction point is near the desired deposition area.

The side stone dumping vessel is used to transport material from shore to the desired material placement location in the marine environment. Once at the deposition site large hydraulic lifts tilt the storage compartment to one side to dispose the material. These vessels can carry up to 2,000 tons of rock and deliver it to a desired location on the seabed.

The start of construction on the Palm Jumeirah began with the use of the trailing hopper dredger. The dredger would travel nine (9) kilometres offshore and suck up the seabed's sand and bring it back to the location of the breakwater. Then the vessel would open the two (2) bay doors in the bottom of the hopper and lay the sand on the seabed. This process was used to build up the bottom section of the breakwater.

The second layer of the breakwater was made up of small stones blasted from the mountains of the UAE, trucked to the dock in Dubai, and loaded onto the side stone dumping vessels. This material was steamed out to the breakwater location, and dumped. The third layer of this section of the project is the breakwaters protective layer. This layer of rip-rap is comprised of large stones that were also blasted from a quarry on land. These were loaded onto a barge and a crane picked the stones off of the barge and placed them on the breakwater.

Inside the protective breakwater, the palm shaped section of the project was created using the trailing hopper dredger. This vessel once again removed the sand from the ocean floor as in the sand for the lower layer of the breakwater. As the vessel returned to the construction location, it placed the sand strategically using the rainbowing technique. The entire palm shaped island slowly rose out of the sea to reveal the distinct final shape of the Palm Jumeirah (See Figure 3).



Figure 3 - Completion of Sand Reclamation

Source: <http://www.destination360.com/middle-east/united-arab-emirates/palm-jebel-ali>

After the breakwater and palm fronds were complete, the job was not complete. The engineers studying the development noticed that with the breakwater completed, ocean water was not circulating around the palm fronds in a quick enough manner, creating stagnant water. Stagnant water stimulates algae and other forms of ecological growths, which would not be acceptable for this high-end development.

The solution for this problem was to cut two (2) holes into the breakwater to let the water circulate at an increased rate. By strategically placing these holes, the palm now circulates new seawater to all ends of the internal waterways about every two (2) weeks [4]. This keeps the waters looking pristine and beautiful. This increase in tidal action will also increase erosive activity, but not at a rate that is too difficult to manage.

Now with phase one seemingly complete, one last obstacle had to be overcome. The sand was in place but was not ready to build large structures upon. The reclaimed sand had to be compacted. This compaction was to be completed using large vibration compactors. These compactors are suspended from a crane and a long shaft vibrates and is plunged into the sand. This vibrating compacts the sand into a denser form that can handle much larger foundation pressures. The compaction of the sand will also help defend against erosive activity from the oceans currents.

The Palm Jumeirah is now ready for development, and all of the real estate on the island was bought up and built upon (See Figure 4). The Palm Jumeirah is a relative success, with nothing but the normal complaints of any construction project. The other developments have not been as successful and it may not be the fault of Dubai.

The Palm Jebel Ali was completed in the same manner. This next palm island was significantly larger than the Palm Jumeirah, but sand reclamation was completed without many difficulties. The Palm Jumeirah is the only project that has become a success so far. The trunk of the palm has many large buildings built up on it and in use. The palm fronds have been filled with homes, and the Atlantis Resort has been built on the pinnacle of the breakwater. The Palm Jebel Ali and the World developments have been reclaimed from the sea, but have little to no development built upon their sands.



Figure 4 - The Palm Jumeirah

Source: <http://articles.adriasofthost.com/the-startling-palm-jumeirah-exciting-facts>

Since the global financial crisis began in 2008, development of the Dubai coastline has all but come to a complete halt. One article claimed that The World was in fact eroding at a rapid pace and sinking back into the ocean [3]. From an engineering analysis standpoint, a faster erosion of The World islands compared to the palm islands seems reasonable. With any type of sand in the ocean, everyone can agree that erosion will occur. Dubai and Nakheel both understand that their beloved islands will slowly deteriorate into the ocean. The difference is that with the palm shaped islands, the island itself is quite large with only a limited number of channels that will continually need to be dredged. The beachfront itself will need to be rejuvenated over the years as well, and sand replaced on areas of erosion. The design of the palm islands is such that the tidal action is enough to slowly circulate the water around the palm shape but not to rapid to erode the sand quickly.

The World development was expected to perform the same. It comes down to an issue with surface area. It is similar to how a carbon filter works. If you have a large number of small particles instead of a few large ones, there is a large surface area for things to interact with. In the case of the carbon filter chlorine and other pollutants cling to the surface of the small carbon particles. With the palm islands and The World, the small sand islands are comparable to the carbon particles of the filter. The World islands have a large surface for the ocean to erode upon. Therefore the erosion of these islands will occur at a much more rapid pace than the palm shaped islands.

Nakheel has rejected any notions that The World development is sinking [3]. The ferry contractor Dolphin Marine has made this claim towards Nakheel, but it seems that they are just not happy with the amount of usage and money that they are currently being made on this project. There is essentially no traffic on Penguins ferries due to the lack of development occurring on The World.

Although there has been a claim of increased erosion, it seems that erosive activity is not occurring at any quicker of a pace than anticipated by Nakheel.

3 CONCLUSION

The Palm Jumeirah has been completed and has succeeded in developing a pristine tourism destination (See Figure 5). Essentially the problems in Dubai's harbour are economical. The engineering and construction seems to have been executed in a world-leading manner, with erosion management always in the long-term plan for these projects. The decline of the world's economies has

indeed halted Dubai's tourism market. With oil reserves all but gone Dubai is going to need to somehow spark their coastline developments, to continue to strive to become the bustling tourism destination that they need to be.



Figure 5 - Atlantis Resort at The Palm Jumeirah

Source: <http://www.atlantisthepalm.com/photosvideos.aspx>

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