Overseas Report

Seawater Purification System Utilizing the Tidal Range Fluctuation: A Unique Engineering Challenge at the Jakarta Fishing Port

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The Outline of the Jakarta Fishing Port

Indonesia is the world's third largest maritime nation after the USA and Australia, possessing 5.41 million km^2, i.e. 200 nautical miles of Exclusive Economic Zone (EEZ). In 2000, it became the world's 6^{th} nation in fisheries sector, producing approximately 4.93 million tons of fish. Of the total fish production, 4.14 million tons or approximately 84% depends on the marine fisheries. However, due to the insufficiency of the fisheries infrastructure development and modernization of the fishing boats, a sustainable marine fish resources management system has not yet been established. Under such circumstances, in 1999, President Abdurrahman Wahid reorganized the Directorate General of Fisheries that had been under the Ministry of Agriculture into the Ministry of Marine Affairs and Fisheries in order to place emphasis on the sustainable development of the marine fishery resources.

In 1973 the Government of the Republic of Indonesia requested the Japanese Government to conduct a feasibility study for the development of a fishing port/market in Jakarta to upgrade its fishing industry. The Overseas Technical Cooperation Agency (OTCA: presently Japan International Cooperation Agency (JICA)) responded and conducted a feasibility study for the construction of a new Jakarta Fishing Port/Market. That is when the history of the Jakarta Fishing Port (JFP) (Photo-1) began. JFP was completed in 1984 with yen-loans from Japanese

Photo 1: Jakarta Fishing Port

Overseas Economic Cooperation Fund (OECF: the predecessor of the present Japan Bank for International Cooperation) and started its service as the largest fishing port in Indonesia. The author has been involved in this project since 1978 and is still working as the chief consultant. In Phase I: Port Facilities Construction works, locally traditional bamboo piles and bamboo mats were used to build the foundation of 4,000 m long coastal revetment and breakwater in order to cope with the soft seabed condition (JSCE Journal; March 1986.)

The original plan for JFP was to integrate small-scale fish landing places around Jakarta and to make JFP the fishery center in the Java Sea. However, trawl fishing in the Java Sea was completely banned in the beginning of 1980, and the fishing ground was expanded as far off as the Madura Island, the Natuna

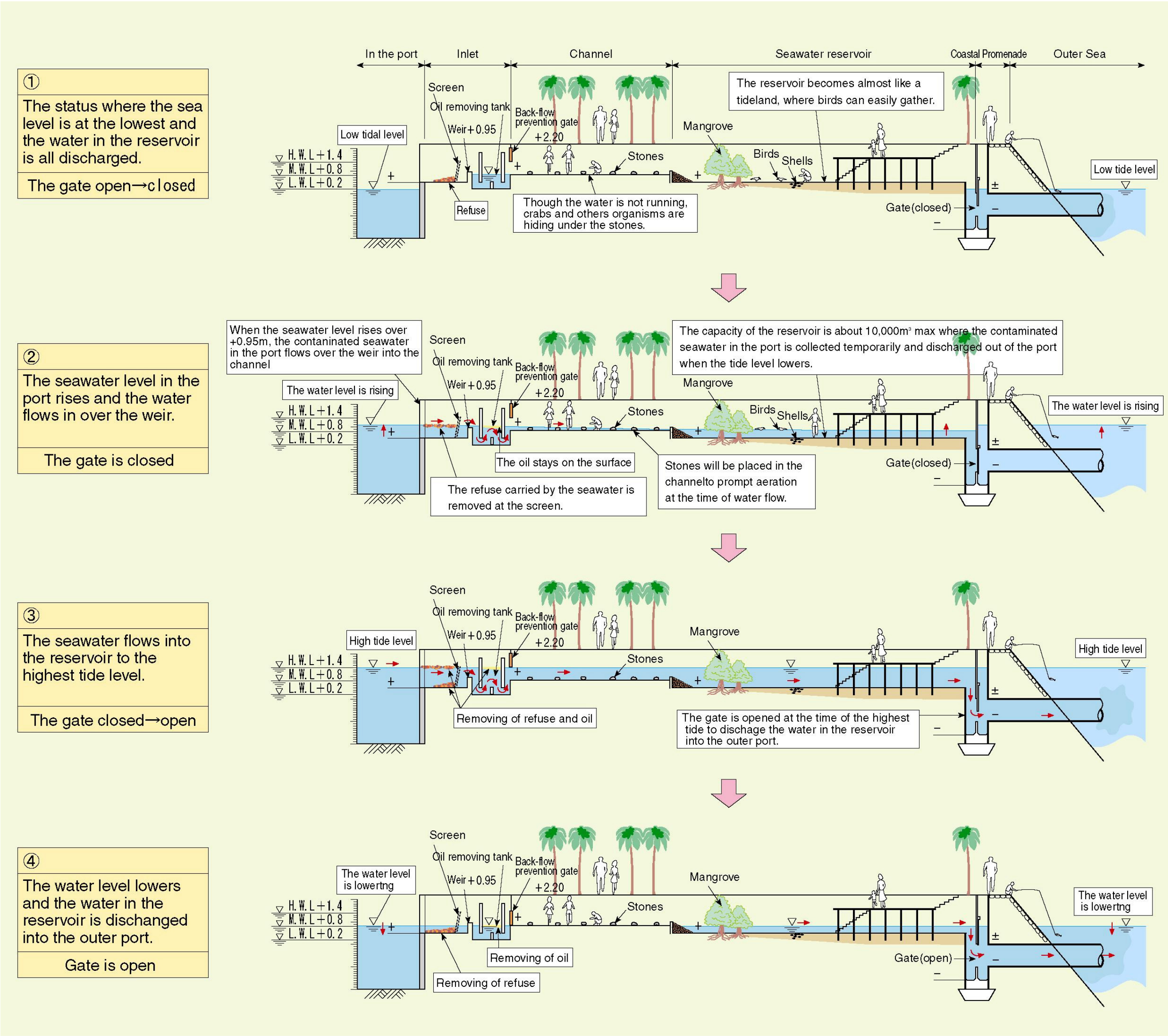

Figure 1: The outline of the Seawater Purification System

Sea area and the Indian Ocean off Sumatra.

During the latter half of 1980, in addition to its function as the supply base for marine products to Jakarta citizens, JFP became known as the base for fresh tuna landing from the Indian Ocean and the daily airfreight exportation for the sashimi market. This business became very active partly because of the strong yen and the increasing number of airline flights to Japan from Jakarta. At present, about 20% of the fresh tuna airlifted to Japan from overseas is from Indonesia. Fishery products transported from various places nationwide are traded during nighttime at the Jakarta Fish Wholesale Market located inside JFP complex where more than 10,000 people in the fishery business related work carry out their transactions. More than 80 companies engaged in fish processing activities have been operating their factories in JFP covering about 30ha of land area of JFP with more than 10,000 employees. JFP is now the processing center of shrimp and fish, contributing to the export of fishery products in Indonesia as well as local market. At present, the JFP has grown to be a fishing town where almost 30,000 people are working everyday from early morning to midnight. The value of fish transaction amounts to approximately 100 million yen on-site every day.

The JFP provides three functions: A fishing port, a fish distribution center and fish-processing center. Moreover, in the Phase IV project, a “1,500 meter-long coastal promenade along the east coast” and a “unique mangrove revetment on the west coast” have been constructed, providing beach recreation spots for citizens who enjoy fishing and strolling along the waterfront. The JFP has been specially noted by the Japanese government for the following reasons: 1) It is one of the typical and pioneer Japanese ODA projects based on the “technical cooperation by JICA” and the “JBIC’s yen loan”; 2) The redevelopment projects considering the environment are continuously implemented, and 3) It is well popularized in the district and used by the local fishermen and citizens. With the above reasons, together with the fact that it is well placed in the city of Jakarta, the JFP has been attracting to private investors and a lot of visitors from both within the nation and abroad coming to JFP.

The Present State of the Sea Area of the Fishing Port

As the JFP was constructed in the Jakarta Bay, with a shoal extending for a considerable distance from the shore (the seabed grade of 1 in 300), the port is surrounded by the breakwaters (occupying about 40 ha, of sea area having average water depth of about 5 m) is exclusive. The tidal range fluctuation is usually only about 60 cm and the natural exchange of the seawater in the port cannot be expected much. Moreover, around 300 ships are using the quaywall for mooring frequently with more than 3,000 fishermen are living on board the ships. Since wastewater from the fishing vessels are disposed directly in the basin including waste oil by leakage coming from the vessels, the pollution of the water in the port basin is becoming worse and worse. During the Phase IV engineering stage, it was decided by the author and his colleagues to construct a device for seawater exchange / purification system in order to overcome the water pollution in the port basin that will be applicable in relation to tidal fluctuation, site condition and environmental aspects point of view.

Engineering Conception of the Seawater Purification System in the Port Basin

The seawater purification system was required to meet the following criteria and conditions:

(1) To accelerate the exchange of about 2 million m^3 seawater in the port.
(2) To be able to remove floating garbage and waste oil during seawater exchange process.
(3) Easy operation and less maintenance cost.
(4) To clean the polluted seawater as much as possible before discharging outside the port basin.
(5) To enlighten and educate the citizens about the seawater pollution issue.
(6) To beautify the environment as part of the fishing port complex

It is a common idea in Japan to discharge the seawater using a large pump and floating garbage by a refuse collecting ship. However, in a developing country like Indonesia, and in a fishing port, which generate small profit, the possibilities of using machine type system will be difficult and expensive to operate and maintain. For several years, the author has been searching for a device that would fulfill the criteria and conditions as mentioned above.

While taking a bath at home, the author observed the grimes being washed away as the hot water in the bathtub overflowed. Observing this phenomenon, the author came to a revelation that it might be possible to recreate this phenomenon using the daily rise and fall of the tide. Having arrived at this idea, the author has assembled the prerequisites that must be met to realize this idea as follows:

(1) A system that naturally overflows the seawater.
(2) In order for the seawater to overflow, the place must be a lower place than the sea surface.

(3) A reservoir that is large enough to temporarily collect the overflowed water from the port.

(4) To be able to maintain the condition of temporary emptiness of the reservoir.

In order to meet the above conditions, the author and his colleagues have decided to construct as large a reservoir as possible. The conceptual plan of the water purification system of the port was created as shown in Fig.1. The outline of the system is as follows:

(1) Construct a reservoir, which is large enough (approx.10, 000 m^2), and make its basin as low as possible. (Photo-2) in order to make the capacity as large as possible (max. 10,000 m^3 at the time of spring tide, average 4,000 m^3).

(2) Install a gate to discharge the reservoir water out of the port, so as not to let the outer seawater in by opening/closing the gate. To install a screen in front of the gate to prevent the refuse from the reservoir from flowing out of the port.

(3) Install a device to take in the seawater in the port ("inlet" hereunder) at the innermost area of the port. (Fig.2, Photo-3)

(4) Construct a weir in the inlet in order for the seawater in the port to overflow into the empty reservoir when the tidal level rises over the weir height. (Fig.-3)

(5) Install a screen in the inlet in order to prevent the

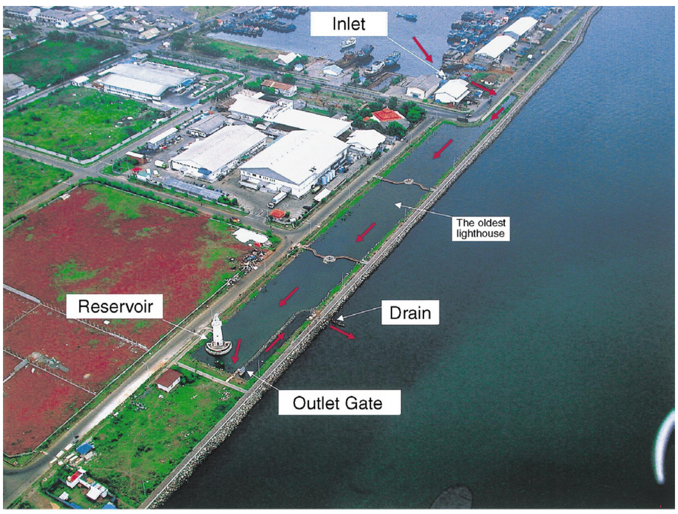

Photo 2: Port Seawater Exchange Reservoir

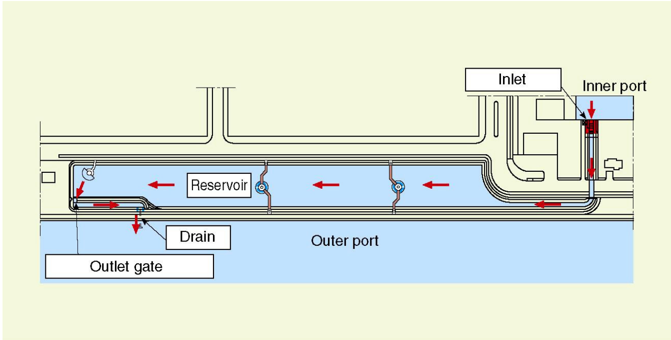

Figure 2: The outline of the water purification system

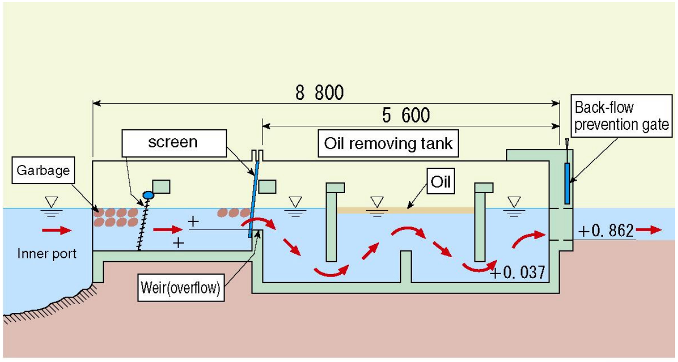

Figure 3: Sectional plan of the inlet

floating refuse/garbage in the port from flowing into the reservoir. (Photo-4)

(6) Since the oil easily floats on the inlet water, an oil-removing tank should be installed to prevent the oil from flowing into the reservoir.

(7) Install a gate at the inlet in order to prevent the seawater that had flowed into the reservoir from going back to the port during ebb tides.

(8) Create a channel made of natural stones extending from the inlet to the reservoir to prompt aeration at the time of the seawater inflow and create an environment in which sea habitats such as fishes, crabs and others organisms can thrive. (Photo-5)

(9) Plant mangroves in the reservoir to create a seawater purification system by zooplankton and phytoplankton mechanism of mangrove characteristics. (Photo-6)

(10) Create a tideland in the reservoir in order to prompt purification functions by shells.

(11) Plant enough vegetation around the channel and the reservoir to create a beautiful

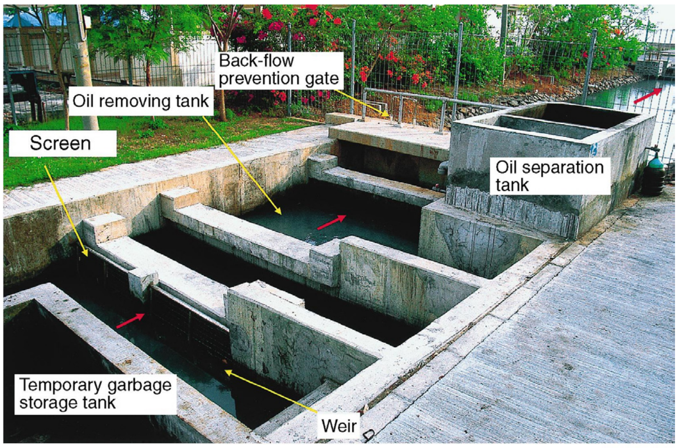

Photo 3: Inlet

landscape (Photo-6). Also, build wooden bridges and terraces as resting spots for people.

Conclusion

The construction works have been completed and the testing of the seawater purification system has been carried out. As a result, the following points have been found out.

(1) The seawater in the port is overflowed over the weir at the flux time as had been expected. Although the inflow amount differs depending on the tidal level of the day, the maximum is 10,000 m^3/day and the average is 4,000 m^3/day. Since the water amount in the port is approx. 2 million m^3, about 0.2% of the water in the port is discharged every day.

(2) It was confirmed that the floating refuse such as plastic bottles, plastic bags and wooden pieces could be completely removed when the seawater in the port flowed over the weir and through the screen. This has proved that the inlet had a better refuse collection function than had been expected. If the refuse caught at the screen fails to be removed, the screen promptly gets blocked up with the refuse and the seawater's overflowing power at the weir deteriorates. It is important that the people in charge continuously remove the refuse at the time of the seawater overflow.

(3) The oil and other matters floating in the port flows into the inlet, as are clearly recognized in Photo-l. The oil floats in the oil-removing tank and can be easily disposed of.

(4) The seawater from which the refuse and oil were removed is more transparent than expected.

(5) The revetments of the channel and the reservoir made of natural stones are environments where algae grow easily and fish and other organisms can breed, providing a good fishing spot. Also, they create a pleasant space in a fishing port, abundant in greenery.

(6) Mangroves are in midst of their growth.

(7) The oldest lighthouse in Indonesia was maintained in the reservoir, which provides a landscape that is in harmony with the historical heritage.

Thus this “seawater purification system” has proved to fully function as designed. However, since the timely opening/closing of the gate according to the tidal level and removing of the refuse and the oil have to be executed by man, whether this system will perform according to the designed functions continuously totally depends on the operator's will and passion.

At the time this article was written, as part of the industrial wastewater was still flowing into the reservoir, the degree of purity of the seawater in the port was not measured quantitatively. It is our future


Photo 4: The refuse is removed at the screen


Photo 6: Mangroves


Photo 5: Channel from the inlet to the reservoir

goal to measure the water quality periodically (levels of COD, nitrogen, phosphate, etc.) and assess the effects of the system quantitatively.

Lastly, in introducing this system, I would like to express my sincere gratitude to Mr. Sadayuki Oka, Fisheries Agency (JICA Fishery Expert at that time), who gave me precious advices; to Mr. Nobuo Hazeyama, Chief Representative of JBIC Jakarta at that time; to Mr. Hideki Wakabayashi at the Japanese Embassy; and to Mr. Toshiro Matsushima at Rinkai Corporation, who has been involved in this construction project.

Following is the URL of the Jakarta Fishing Port for further information: http://www. jakartafishport.com