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Dome-shaped breakwater in Wakkanai Port

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Abstract

Wakkanai Port is located in the northern end of Japan. Since the early 1920s till 1945 this port had been acting as a foothold for trading with and physical distribution to and from Sakhalin that had been a Japanese territory till then, and recently has been prospering in fishery. Wakkanai Port has a breakwater with dome-shaped roof that has no parallel in the world.

This breakwater dome having unique appearance reminds us of an ancient Roman galleria is not only fulfilling its function as a port also at present, but also playing an important role in historical retrospection and local sightseeing.

1 Introduction

Wakkanai Port is located at the northernmost of Japan, namely in the northern end of Bay of Soya surrounded by Cape Soya-misaki and Cape Noshappu-misaki (Fig. 1). Since southern part of Sakhalin came under the dominance of Japan in 1905 as a result of Japan-Russia War, Wakkanai Port formerly constructed as a fishery harbor had come to draw attention as a foothold for trading with and physical distribution to and from Sakhalin. With an aim to open sea-lane between Wakkanai and Sakhalin, construction of North Breakwater started in 1920 and completed in 1936. Since then till 1945 Wakkanai Port had been carrying out transportation of goods to and from Sakhalin belonging to Japan in those days. And recently this port has been keeping on prospering as a distribution-type port for diversified cargos. In this port there exists a breakwater with dome-shaped roof that has no parallel in the world.

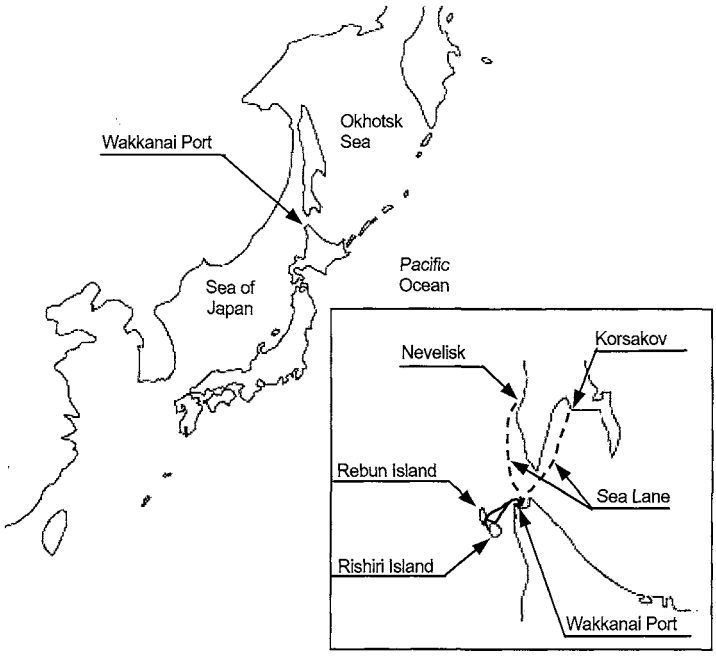

Figure 1. Location map of Wakkanai Port.

2 Construction of dome-shaped breakwater

2.1 Wakkanai Port construction plan

As southern part of Sakhalin was taken into territory of Japan in 1905 after Japan-Russia War, Wakkanai came to have an important position as a transit base for traffic to and from Sakhalin. It was an urgent need at that time to construct a railway and a seaport to transport goods to Sakhalin. Port construction plan with the aim of opening sea-lane between Wakkanai and Sakhalin had been developed since 1910 through 1919. In charge of it was a regius civil engineer Choemon Ito of the Hokkaido Development Agency. Aiming at protecting the port from sea waves caused by windstorms ranging from northwesterly to northeasterly, he developed a plan to extend 1,330 m long North Breakwater toward the east and construct sand groin 545 m long, thus wrapping the port. His further plan was to reclaim land area 270 m long x 37 m wide inside North Breakwater from the sea and there to construct a quay-wall mooring wharf with water depth of 7.5 m which must serve as a landing place for one 3,000-ton class vessel and two 2,000-ton class vessels. After revision of this plan North Breakwater was put into construction in 1920 and was completed in 1936.

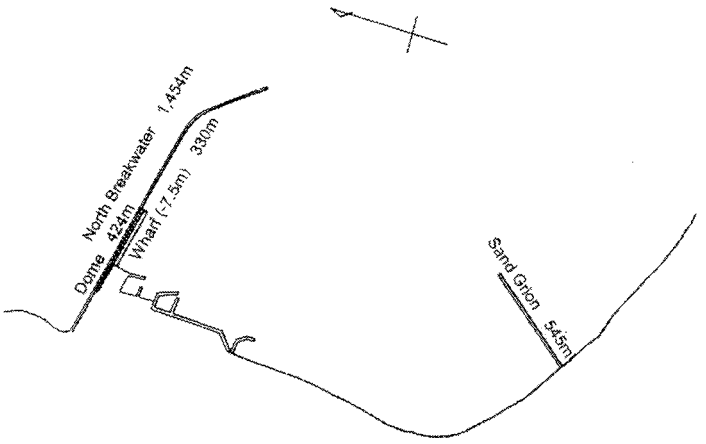

Figure 2. Plane view of port construction plan (in 1935).

2.2 Construction of North Breakwater Dome

While the quay-wall mooring wharf expected to be used as a landing place for Sakhalin sea-lane had been under construction as an annex to North Breakwater, it had often suffered from damages due to wave overtopping over North Breakwater and gales. North Breakwater was initially planned to have a parapet with crown height +5.5 m that was, however, not considered to be capable to withstand sea waves driven by gales in wintertime.

As a result of investigation of various safety measures for road, railway and cargo-handling place, a plan of seawall with dome-shaped roof was worked out. Designing of this eccentric breakwater structure with dome-shaped roof had been carried out by Mr. Minoru Tsuchiya - a 26 year old, university freshman (graduated from Department of Civil Engineering, Hokkaido Imperial University) at that time.

Structure of the dome is as shown in Fig. 3. Reinforced concrete piles were driven into ground on in-port side and on them inverse-arched concrete foundation was constructed, on which column was built up, while on the other side (seaside) the foundation was mounted on the reinforced concrete forming breakwater body. Distance between column centers was 6 m. Arched beams were installed between the both sides of columns and on them the roof was installed. Upper face of the dome was stretched out horizontally to the in-port side, on which splash-preventing wall 3 m tall was erected. Its crown height was set at 13.5 m above low water level.

Construction work started in 1931 and the Dome with total length 424 m was completed in 1936.

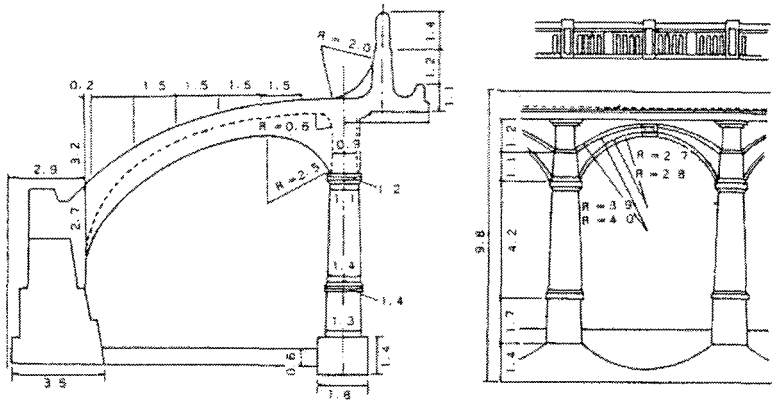

Figure 3. Drawing of dome structure of Wakkanai Breakwater.

3 Utilization of the Dome and secular change of amount of cargo handled

3.1 Utilization of the dome in prewar period

Sea-lane between Wakkanai and Korsakov was opened in 1923 and that between Wakkanai and Nevelisk in the next year of 1924. Table 1 shows secular change of number of navigation times and amount of cargo transported in Wakkanai – Korsakov sea-lane. In these data an influence of the world economic panic and outbreak of war on decreasing / increasing of amount of cargo handled are reflected. Major cargos transported from Sakhalin to Wakkanai were wood, pulp, fish and shellfish, while those from Wakkanai to Sakhalin were food articles and daily commodities. And since 1938 after completion of the Dome through 1945 many passengers had used anteroom

Table 1. Actual data of transportation in Wakkanai – Korsakov sea lane.

Year	Number of navigation times	Number of passengers	Cargo amount (t)
1923	254	69,619	6,598
1924	374	91,637	13,150
1925	513	106,396	17,252
1926	440	107,599	16,540
1927	504	113,272	24,197
1928	509	135,790	36,006
1929	511	144,877	36,338
1930	574	126,394	36,232
1931	581	98,648	27,679
1932	597	82,259	19,284
1933	600	78,866	23,871
1934	600	94,567	28,299
1935	594	106,417	29,547
1936	590	104,344	36,156
1937	606	100,336	52,897
1938	615	119,983	73,441
1939	642	173,648	96,323
1940	626	214,970	85,316
1941	628	267,398	91,821
1942	552	247,515	86,175
1943	561	257,829	116,421

in the railway station established in the Dome (Fig. 4 and Fig.5). Thus North Breakwater Dome had been not only protecting the port from sea waves and gales, but also serving as a transit point for marine transportation of cargos and passengers between Wakkanai and Sakhalin.

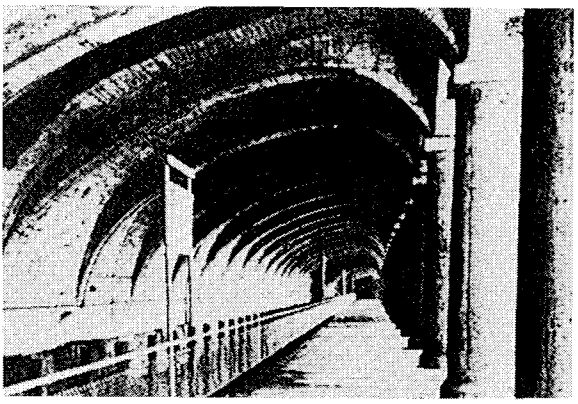

Figure 4. Railway station in the Dome.

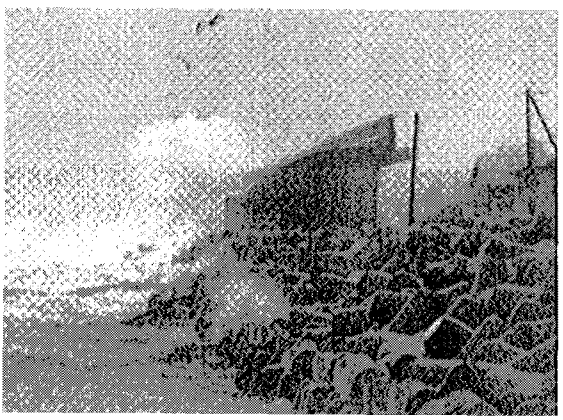

Figure 5. The Dome withstanding sea waves.

3.2 Utilization of the Dome and change of amount of cargo handled in postwar period

As the whole Sakhalin came to belong to Soviet Union after World War II, personal exchanges and physical distribution activities between Sakhalin and Wakkanai came to an end and consequentially the railway station in the Dome and Wakkanai – Korsakov sea-lane went out of use, that caused anxiety about declination of the port. However, along with growing demand for coal, Wakkanai

port came to be used as a port for shipment of coal yielded in nearby Tenpoku Coalfield and inner space of the Dome was used for coal storage (Fig. 6). Fig. 7 shows secular change of amount of cargo handled in Wakkanai Port. As seen from the figure, amount of cargo including fish and shellfish as major components has been indicating rapid growth since about 1955. Since about 1975 amount of industrial products handled in the port has been increasing and recently cargos transported by ferry have been also increasing in amount.

Landing place for former Wakkanai – Korsakov sea-lane came thereafter to be used as a ferry terminal connecting Wakkanai with Rishiri Island and Rebun Island. And since, about 1995, a regular sea-lane connecting Wakkanai with Sakhalin is also in service.

North Breakwater Dome has become famous all over the country for its unique appearance. At present the Dome is used for various events including exhibition of local products and also serves as a tourist spot where a lot of tourists visit.

Figure 6. Utilization of the Dome as coal storehouse.

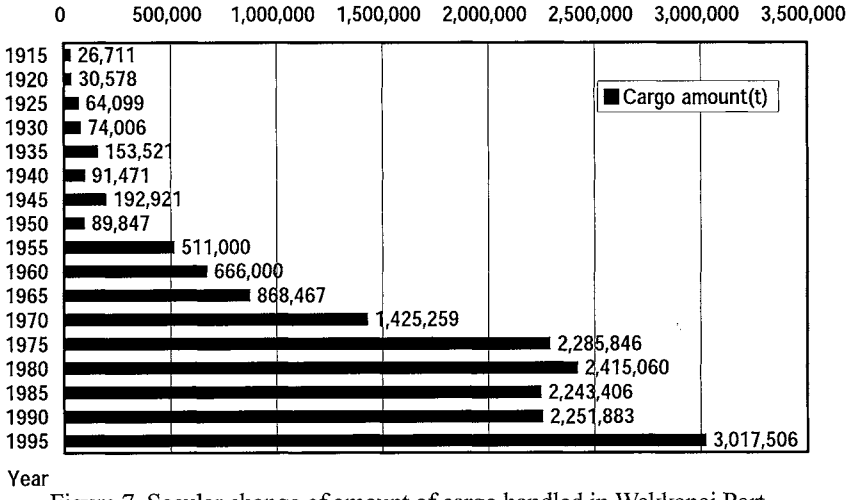

Figure 7. Secular change of amount of cargo handled in Wakkanai Port.

4 Reconstruction of the Dome

4.1 Climate in Wakkanai in winter

Average monthly ambient temperature, yearly rainfall and monthly snowfall in Wakkanai City for 5 years from 1996 through 2001 are those as shown in Figs. 8, 9 and 10 respectively. Average ambient temperature in Wakkanai goes below 0°C during the period from December through March. In winter time (December to February) average wind velocity is about 5 m/sec, maximum instantaneous wind velocity reaches up to 25 m/sec and prevailing wind direction indicates N. Under heavy weather conditions in autumn time (September to November) and winter time (December to February) sea wave crest height gets increased outside the port. Estimated data on sea waves show that frequency of appearance of wave crest height above 1 m reaches as much as 19.3% on annual average. As seen from the above data, Wakkanai Port in winter is exposed to very severe meteorological conditions and oceanographic phenomena.

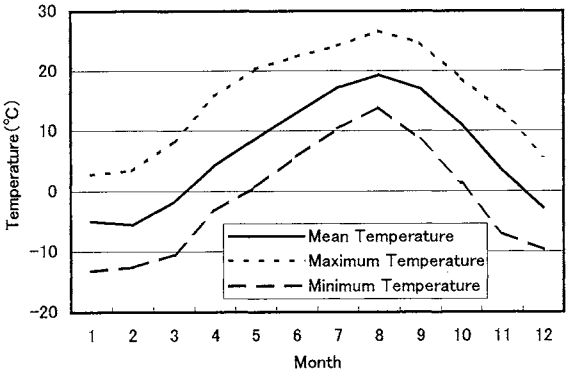

Figure 8. Ambient temperature by month in Wakkanai.

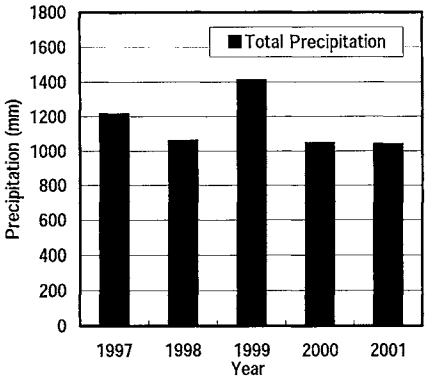

Figure 9. Rainfall by year in Wakkanai.

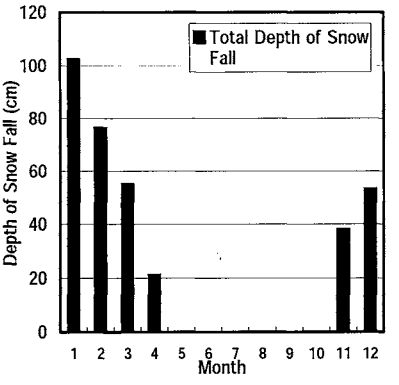

Figure 10. Snowfall by month in Wakkanai.

4.2 Dome reconstruction work

North Breakwater Dome had been enduring severe natural conditions as mentioned above for about 40 years since its completion in 1936. But since around 1965 onward concrete deterioration has been getting intensified and occasionally concrete surface has been partially peeled off, causing dangerous situation for safe utilization of the Dome. It was, therefore, needed to reconstruct it in full scale. In this case, as the Dome had been well known for its unique structure having no parallel in the world, it was decided to reconstruct and restore it to its original configuration. It was found from the investigations conducted prior to construction work that deterioration of concrete was attributable to its freezing and breaking of concrete resulting from its volume expansion due to corrosion of reinforcing steel caused by salt intrusion. The foundation remained, however, in good conditions on the whole. It was decided to use existing caissons and piles for the foundation and restore the dome part to its original configuration. Reconstruction work started in 1978 and was completed in 1981. Now the reconstructed Dome is standing as before.

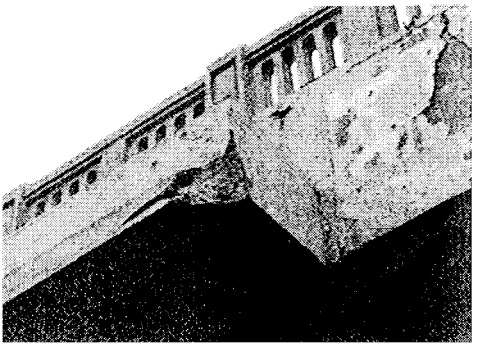

Figure 11. Aged deterioration of the Dome.

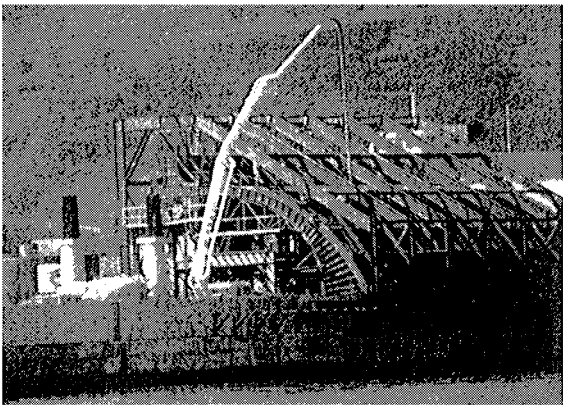

Figure 12. Dome reconstruction work.

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5 Mutual exchanges with Russia

In 1995 a regular sea-lane connecting Wakkanai with Sakhalin was opened. Secular change of number of passengers and amount of cargo transported via this lane is as shown in Fig. 13. And since 1999 a ferry sea-lane has been in service between Wakkanai and Korsakov, showing also growth of both number of passengers and cargo amount.

As regards Sakhalin Projects now being carried out for development of oil and natural gas resources in Sakhalin, Wakkanai Port appears promising as a logistic support base for providing construction materials and daily commodities by making good use of the advantage of its geographical position since the port is situated in the nearest point in Japan to Sakhalin. In this way Wakkanai Port is expected to keep on further development as a foothold for mutual exchange with Russia.

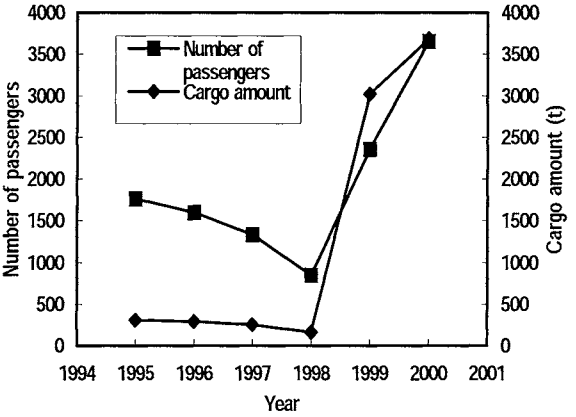

Figure 13. Secular change of number of passengers and amount of cargo transported between Wakkanai and Sakhalin.

6 Conclusions

North Breakwater Dome having unique appearance and reminding us of an ancient Roman galleria is fulfilling its seaport function also now by protecting the port from gales and waves in winter. In 2001 this dome-shaped breakwater was appointed as one of the entities of "Hokkaido Heritage". Such appellation is to be granted by Hokkaido government to the material or immaterial heritages that people wish to hand on to the next generation. Besides, North Breakwater Dome is well known for its unique appearance as a tourist spot in the northernmost city in Japan. Many tourists have been visiting the Dome year after year.

Thus, North Breakwater Dome in Wakkanai Port has been fulfilling not only function of breakwater for the port, but also function of historical sight spot, and so it has great historical value.

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