Anchorage port survives nature

At the time of the March 1964 earthquake, one of the greatest in recorded history, the first element of the terminal was in service four years. The earthquake had its epicenter about 75 mi (120 km) from Anchorage and a magnitude between 8.4 and 8.6 on the Richter Scale. Parts of the city of Anchorage were destroyed. The entire zone around the marine terminal subsided about 3 ft (0.9 m) and the wharf moved about 1 ft (0.3 m) horizontally. The Port of Anchorage, the only usable marine terminal left in south-central Alaska, was back in service about 36 hours after the earthquake following emergency repairs to the electrical system, and repositioning of the cranes which had been jolted off their rails.

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THE SITING OF THE Anchorage Marine Terminal on Knik Arm, a part of Cook Inlet and the Gulf of Alaska, presented TAMS' engineers with the task of designing a pier structure in a severe earthquake zone, in an area with an extreme tidal range of 42 ft (12.8 m), and in a body of water where ice floes 4 ft (1.2 m) thick carried by strong currents would impinge against the structure. In addition the long unsupported and unbraced length of piles, the ice build-up beneath marine structures, and the poor foundation conditions combine to make the planning and design of marine terminals in Anchorage a unique engineering challenge.

Since 1955, when TAMS completed the Master Plan for the Port of Anchorage, the firm has been employed in the engineering of the staged development of the port. The terminal currently includes 2,000 ft (610 m) of wharf, six dockside cranes, facilities for the handling of bulk petroleum products, connections for rail and truck services, and other elements associated with a marine terminal. It now handles primarily containers and roll-on/roll-off trailers.

Although TAMS investigations and preliminary engineering studies (see sidebar: Beginning expansion) had developed a great deal of useful information, particularly for determining the size of ice floes and the paths of ice movements in Knik Arm, more data was needed on the effects of the severe ice conditions on the proposed wharf. TAMS engineers needed to know how it behaved at the dock and why, how much ice there was and how heavy it was.

In the winter of 1957-1958, one of TAMS intrepid engineers decided that the best way to get some answers was to try to unlock the secrets of survival of Ocean Dock—it had withstood the ravages of nature on wooden piles for 40 years. Tied at the end of a stout rope he dropped through a hole in Ocean Dock and descended below the dock deck. Crawling in a 2-ft (0.6-m) air space between the underside of the dock, and the top of the ice cap encasing the piles, he found the piles surrounded by giant "popsicles" bridged together by ribs of ice. He then lowered himself against the sides of these virtual manholes in the ice and chopped out ice blocks at various depths. Returning to the 10° temperature above, he took the ice blocks to the City's engineering office to determine their weight and volume.

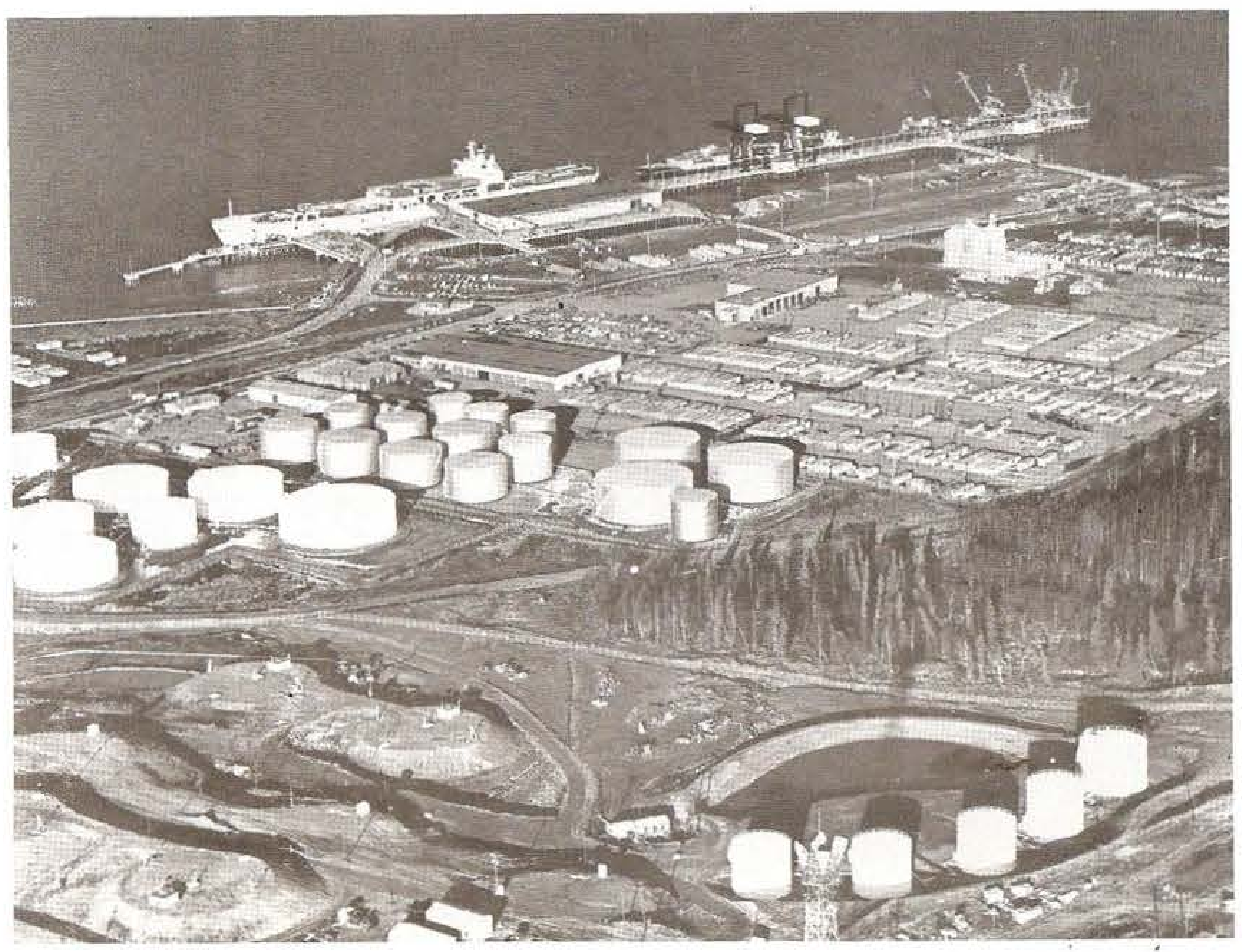
This adventure provided important data on how the ice formed on the piles; the connection of piles with ice "bridges," and the density of the ice which, because of the way it was formed and the high air entrainment, only weighed 35 to 38 lb per sq ft (171-186 kg/m²). These facts provided basic data on the ice load the piles would have to support, the hydrostatic uplift acting on 20 ft (6.1 m) of ice pack under the dock and the spacing of piles to provide for the formation of underdeck ice caps to aid in the absorption of impacts from rapidly moving floe ice impinging on the new wharf.

Resisting natural forces

The initial development phase provided for the construction of a marginal wharf with 600 ft (182.9 m) of berthing space and a 53,000-sq ft (4,924 m²) shed. The pier structure as designed has withstood well the severe winter ice conditions and it was one of the few structures in south-central Alaska to survive the 1964 earthquake.

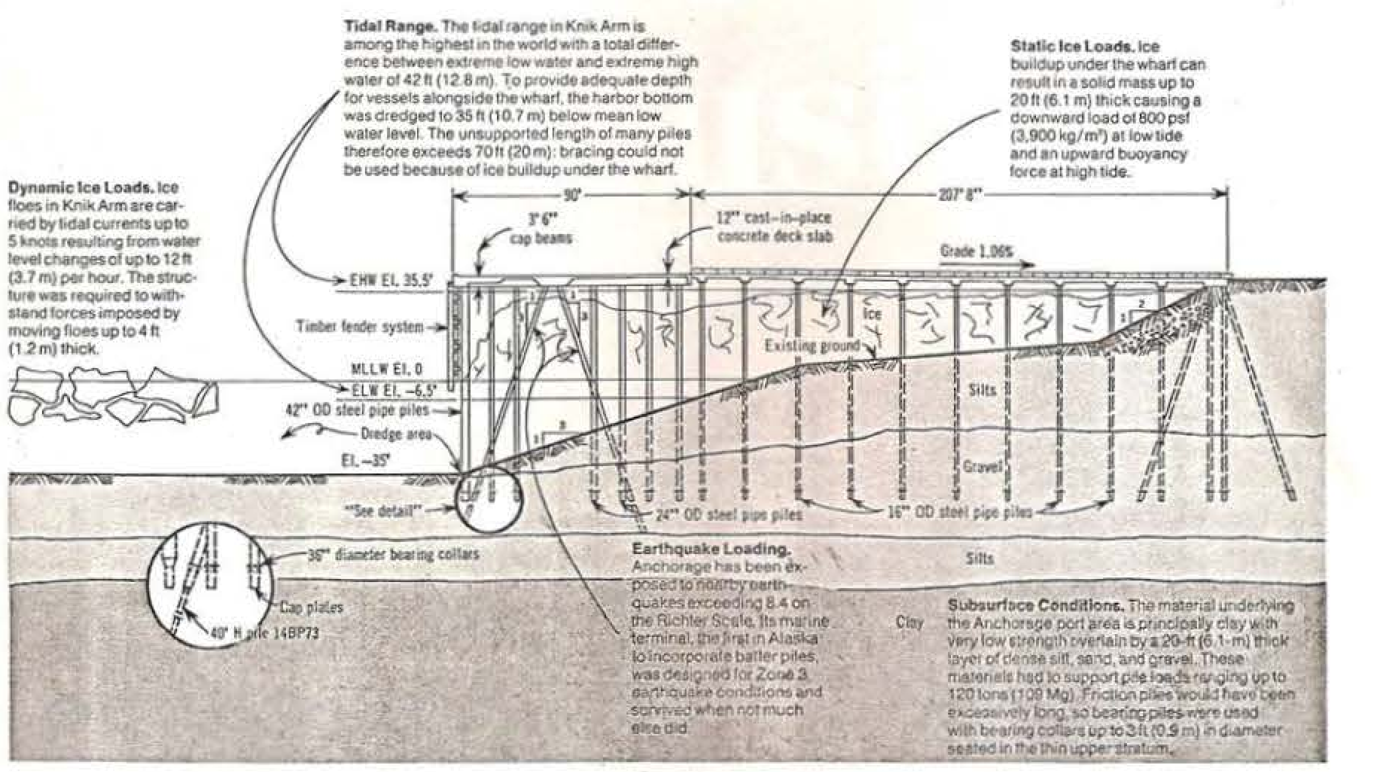
The substructure design for the first wharf segment consisted of a reinforced concrete deck supported on steel pipe piles varying in diameter from 16 in. (406 mm) at the landside of the wharf to 20 and 24 in. (508 and 610 mm) near the waterside of the wharf. The outboard row of piles, however, are made of 42-in. (1,067-mm) diameter concrete filled pipe in order to absorb ice floe forces. These front caissons also serve as beams to withstand the docking forces of the vessels. The piles are spaced approximately 10 ft (3 m) apart in bents at 13.3 ft (4.06 m) on centers. All other pipe piles were filled with sand. The pile heads are embedded in 4-ft (1.2-m) wide cap beams 3.5 ft (1.07 m) deep. The apron deck slab is 12 in. (305 mm) thick.

Extra thick metal was used for these pipe piles to allow for corrosion losses. With a splash zone of nearly 50 ft (15 m), corrosion had to be considered even though the typical rate of metal loss in the cold northern ocean waters is quite low. The large splash zone militated against use of cathodic protection; however, it can be added in the future if needed for retarding corrosion of the submerged portion of the piles. Coatings were not considered because the ice forces would peel or chip them off. There has been no need for additional sheathing or other remedial measures to date.



The Port of Anchorage stands on a unique pile support system. Successive stages of development have resulted in the construction of a petroleum terminal and three container/general cargo berths. Port capabilities are supported by seven access roadways and 31 acres of back-up yards.

Floe ice 4 ft (1.2 m) thick carried by some of the strongest tidal currents in the world striking the pipe piles was just one of the unique conditions faced by TAMS designers. Another was the 20-ft (6.1-m) thick ice buildup under the wharf adding to the weight and uplift applied to piles with 70-ft (20-m) unsupported lengths.



Support of the piles, many of which sustain 120-ton (109 Mg) loads, in the soils at the site posed unusual problems. The port site is a tidal flat consisting mainly of dark estuarine silt 20 to 70 ft (6-20 m) thick underlain by a very thick, light gray, stiff-to-very-stiff clay. In order to develop a pile design load of 120 tons (109 Mg), high-capacity friction piles would have to be deeply embedded in this relatively low-strength material, resulting in excessively long piles which would be expensive and difficult to handle. However, the major part of the terminal was located over a dense sand and gravel stratum approximately 20 to 30 ft (6.1-9.1 m) thick overlying the clay. The solution lay in supporting the vertical piles entirely in the dense materials overlying the clay stratum. However, this upper composite stratum, already relatively thin in its natural state, would be reduced to as little as 20 ft (6.1 m) in thickness as a result of dredging. Thus, to found the piles in the dense materials of the thin upper strata, end plates and bearing shoes up to 3 ft (0.9 m) in diameter were attached near the bottom of the piles. These bearing piles, which were as much as 80 ft (24.4 m) shorter than the friction piles, resulted in considerable savings in costs. The batter piles having to resist tensile forces were driven deeper into the silty materials.

Pile driving was controlled such that the tips of the vertical bearing piles stayed in the gravel high enough for the influence cone of earth to be broadened and loadings thereby reduced before reaching the compressible materials. The bearing collars were placed a few feet above the tip to aid this load spreading effect. The driving of each pile had to be carefully monitored so that it did not go too deep and to gauge adjustments needed in the desired depth for subsequent adjacent piles. Load tests proved the bearing capacity at three

Beginning expansion

Port operations in Anchorage date back to 1918 when the U.S. Department of the Interior built the timber-piled Ocean Dock to bring in materials for the construction of the Alaska Railroad. Apart from several minor bulkhead areas used for berthing barges, Ocean Dock remained, until the 1950's, the pincipal link for water transport serving Anchorage. By the mid 1950's, the rapid growth of the Anchorage area had created a need for a larger and more modern port. In February 1951 the U.S. Army Corps of Engineers asked TAMS to do a feasibility study for building a berthing facility in Knik Arm, about where the present port was subsequently constructed.

One of the first tasks was the implanting of flag markers out on the floe ice in the Arm so that the movement of the ice could be measured. Shore observation stations were set up to record the movement. Studies were also made of the ice pile-up on the shore caused by tides ranging from 35-42 ft (10.7-12.8 m). Preliminary soil investigations were conducted. Practical information on the behaviour of the ice, tides and currents obtained from those who lived in the area proved most useful. There was also the Ocean Dock, a wood-pile structure which had survived the inhospitable environment for 35 years, encouraging TAMS designers to consider a pile foundation for the proposed new wharf.

In substance, the report stated that although the construction of a major dock facility at the site was feasible, serious problems brought about by the floe ice, the extreme tidal range, poor soil conditions and an earthquake force high on the Richter Scale had to be resolved first. TAMS report also included several preliminary designs for a cellular island docking structure. In 1955 the City of Anchorage retained TAMS to continue investigations and draw up a master plan for the development of a general cargo port.

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