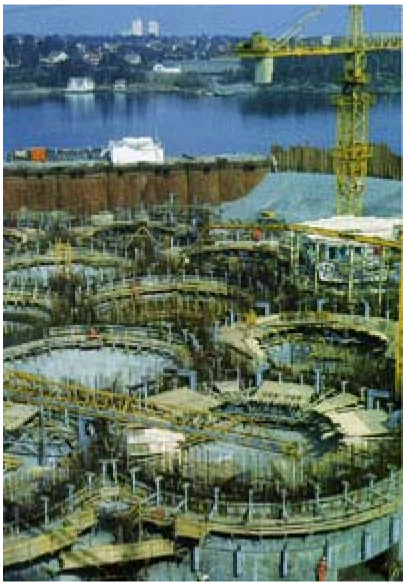
Since 1973 there have been s 20 offshore concrete platforms/structures installed in the North Sea, with four more platforms currently under design/construction: Draugen, Sleipner, Troll East, and the Heidrun Tension Leg Platform. Also, another concrete floating platform, Troll West, will soon be under contract. Such platforms are constructed inshore, in dry-docks and fjords, over a period of 2 to 4 years, and are towed to site and installed in a nearly completed state. The total cost of a completed platform can exceed $1.5 billion US-dollars. The Gullfaks C represents the largest mass of any structure ever moved by man. The platform installation water-depths have been progressively increasing, and when installed in 1995 Troll East will be the world's tallest Gravity Base Structure, GBS, standing in over 300 m of water. Floating concrete platforms such as Heidrun and Troll West will allow for operation in virtually unlimited water-depths.

Troll GBS.



Troll GBS under Construction in dry-dock

Besides increasing operational water-depth, other trends in the North Sea have been:

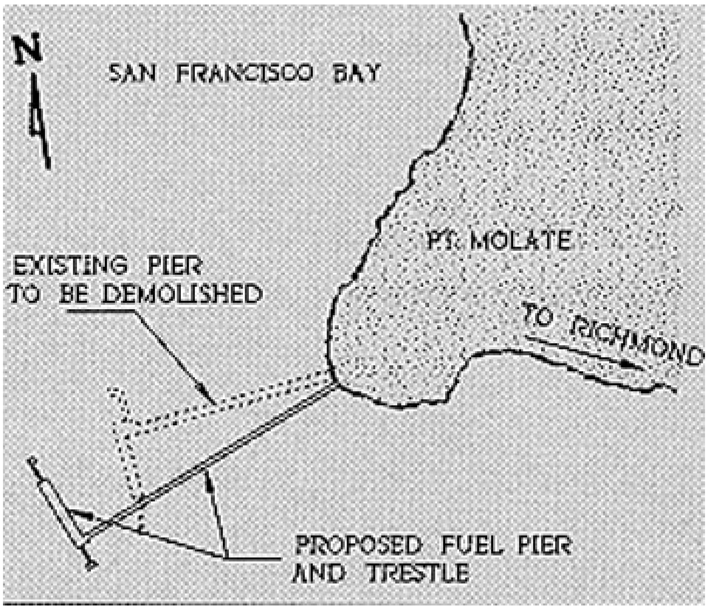
- Increasing specified concrete strengths, currently up to C75 (75 MPa).
- Increasing steel reinforcing densities, locally to 800 kg/cu.m., or more.
- Increasingly varied, flexible, and efficient designs.

During 1991 and 1992 Ben C. Gerwick, Inc. has had a number of engineers working on platforms, currently under contract to Dr. Techn. Olav Olsen a.s., and Norwegian Contractors. Work assignments that Ben C. Gerwick, Inc. personnel have been engaged in have been varied including:

- Reduced stiffness analysis of cracked tricell walls.
- Compression-induced splitting-tensile effects near prestressing ducts and pipes embedded within the concrete.
- Shear compatibility between pipe protection beams and the structure.
- Evaluation of increased sectional forces in lower domes, ring beams, cell walls, upper domes, and shafts due to increased wall thickness.
- Evaluation of non-linear strain distributions near thick elements and discontinuities.
- Evaluation of dropped objects and lightweight aggregate concrete protection.
- Calculation of selected member capacities and member deformations.
- Global and local finite element modeling, verification and analysis.
- Crack analysis, and calculation of potential oil leakage rates.
- Design checking work.

Dale E Berner and Thomas Dahlgren

Ben C. Gerwick, Inc. is assisting Parsons Brinckerhoff Quade & Douglas, Inc. in the design of a new fuel pier to be constructed at the Naval Fuel Depot at Point Molate, which is located a few miles northeast of San Francisco. The work is being performed for the Western Division, Naval Facilities Engineering Command, headquartered at San Bruno, California.



Location plan.

The proposed new fuel pier is to replace the existing antiquated pier which was originally constructed in 1941. The new pier is being designed to accommodate modern naval vessels which are too large to be served at the existing pier.

The new pier will consist of an access trestle approximately 37 feet wide by 2,000 feet long and a main pier structure 50 feet wide by 450 feet long. Two mooring dolphins, with connecting walkways, will be located at each end of the main pier. A resilient fender system will be provided on each side of the main pier.

The all-concrete structure will consist of vertical prestressed concrete cylinder piles with outside diameters of 36 and 54 inches, supporting a precast and cast-in-place concrete deck structure.

Depressed concrete trenches will provide liquid-tight containment for the fuel lines and utilities.

Geotechnical engineering services are being provided by Woodward-Clyde Consultants. The earthquake engineering analysis includes an evaluation of the potential rock motions at the site during major earthquakes on the nearby Hayward and San Andreas Faults.

The seismic design of the structure is based on the AASHTO Guide Specifications for Seismic Design of Bridges" (1 983) and is being checked by calculating peak modal responses using the site-specific response spectrum curve developed for this project.

Point Molate existing Fuel Pier near Richmond-San Rafael Bridge.

We assisted in developing the structural system used for the trestle and the main pier and are taking the lead in designing the mooring dolphins, walkways and resilient fender systems. We are also preparing the construction cost estimate for the structural part of the project and the overall construction schedule.

C. R. Firth and George C. Fotinos

The City of San Diego, California discharges its treated sewage effluent through a 10 foot diameter outfall sewer extending 17,000 feet to deep water in the Pacific Ocean. Construction of a 13,000 feet long extension to 300 feet water depth is currently starting.

First replacement concrete pipe section during lowering with "horse" at Point Loma.

An unusual storm, on February 2, 1992 with extremely long period swells (about 2022 seconds) on which local wind waves were superimposed caused a breakage in the existing line near the shore where the water depth was only 35 feet. Eight sections of concrete pipe were tossed aside by the waves. The effluent was discharging in an environmentally vulnerable area, causing shutdown of many miles of beaches during the tourist season as well as prohibition of commercial and sports fishing in the area.

An emergency engineering design contract was entered into by Engineering Science, Inc. who had just completed the design of the seaward extension of this outfall. An emergency construction contract was let to a joint venture of Morrison-Knudsen Co. and Manson Construction Co. who not only did a highly creditable job in the reconstruction but were successful bidders on the extension when it was bid a month later.

The most difficult part of the reconstruction was the closure which had to connect the replacement section to the existing line. Engineering Sciences, Inc. assisted by Dr. William Buehring and Ben C. Gerwick, Inc. as subconsultants, devised a telescoping double sleeve of steel, which was slipped over the existing line and filled with a special concrete mix.

Ben C. Gerwick, Jr.

0n April 13,1992, the basements of many of the skyscrapers in downtown Chicago began to flood from an unknown source and, within hours, water was 40 feet deep. The source was identified by a whirlpool vortex in the Chicago River, which was discharging into an abandoned freight tunnel. The tunnel apparently had been holed by the driving of timber piles for a dolphin in the river: They had penetrated to the unreinforced concrete tunnel roof and broken it.

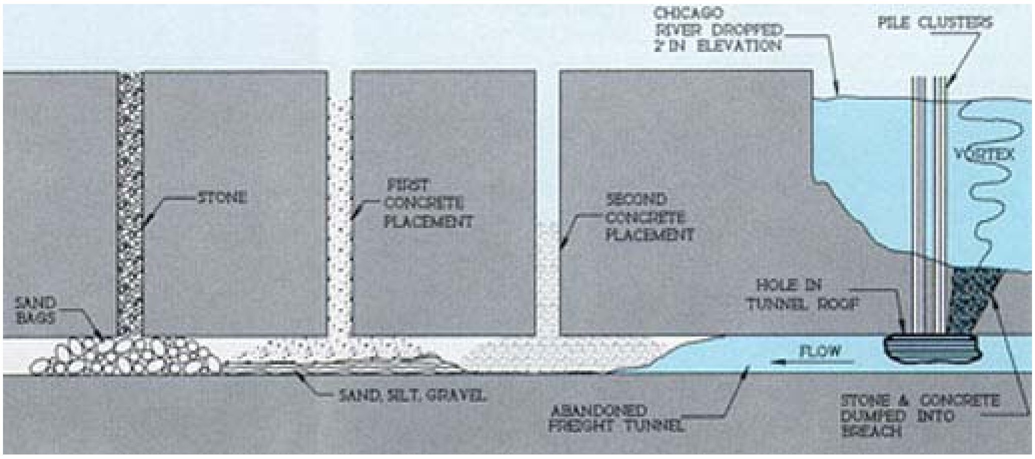


Diagram of flood source and efforts to stop flow of water from Chicago River.

Emergency measures were undertaken by the City to plug the leaks. Later, the Corps of Engineers was called in by FEMA, the Federal Emergency Management Administration. After locating the three landward extensions of the tunnel, which bifurcated at the riverbank, 60 inch holes were drilled, carefully located to thread their way through a maze of gas, power and other utility lines.

Upon drilling through the tunnel roof, initial attempts were made to stop the flow with sandbags, but the swift current swept them away. The flow was finally stopped by dumping rock. Then attempts were made to plug the tunnels with tremie concrete. The initial plugs were placed under emergency conditions and tended to flow over the sand and gravel rather than sealing it.

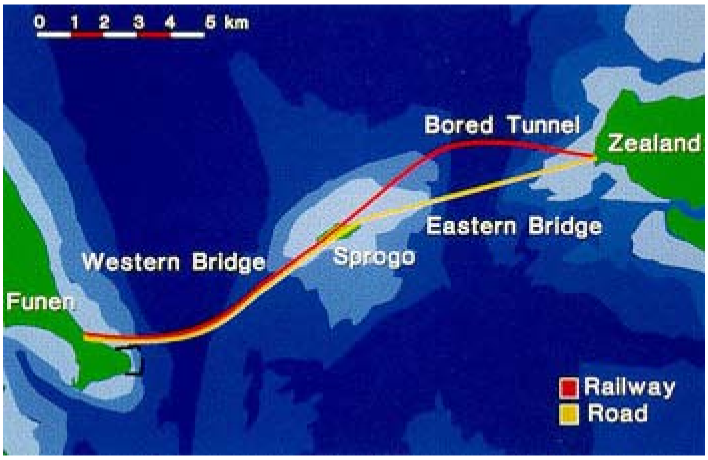
When the Corps of Engineers took charge, they proceeded in a thorough and methodical manner to ensure complete cleaning and proper concreting procedures.

Additional plugs completely sealed the tunnels and the long task of dewatering began.

Work was carried on 24 hours a day since the flooding had rendered much of downtown Chicago unusable. Estimated costs of this disaster run from $1 to $2 billion. As the dewatering took hold and lowered the water, the hydrostatic head on the plugs increased, so as soon as access was feasible, permanent concrete plugs were placed in the dry.

Ben C. Gerwick, Inc. was one of the many specialists called in by the Corps to assist in this task. Our role was in regard to the concrete mixes and placement procedures for the underwater plugs.

An important step to improve the northern European transportation network is the present construction of the USD 4 billion Great Belt fixed link in Denmark. The 18 km wide Great Belt is divided into two channels, east and west, by the island of Sprogo. The link consists of three major structures: A bored railway tunnel and a high level motorway bridge across the east channel, and a low-level, dualmode bridge for rail and motorway across the west channel. The high level Eastern Bridge has attracted considerable attention, because it spans the international shipping route between the Baltic and the North Sea with a suspension main span of 1624 m. The design is developed by the CBR joint venture of COWIconsult, B. Hojlund Rasmussen and Ramboll & Hannemann, with support from Ben C. Gerwick, Inc. for constructibility for deep water foundations.



Rising 254 m above sea level, both pylons of the suspension bridge will be located in water depth of 20 m. After excavation of a 1 0 m deep layer of soft till, a trimmed bed of 5 m crushed stone will be placed and compacted. Initial investigations had revealed very dense glacial till at depths of 2 to 3 meters below the seabed. However, the alignment was shifted slightly after the contracting procedure was in progress and new borings revealed underlying weak strata at -8 meters. It is hypothesized that these are the relics of thawed ice lenses left after the glacial epoch. To meet this change, the decision was made to dredge out below the weak zones and backfill with compacted stone.

Drydock for construction of anchor block caissons

Cellular 78 x 35 m caissons, 20 m high, and weighing 30,000 tones, are now being cast in a dry dock 20 km from the bridge site. The caisson is equipped with 0.5 m high skirts which will penetrate into the stone bed. Full contact between the stone bed and the caisson will be secured by grouting. The corners of the rectangular caissons are rounded to minimize water drag and to reduce the effects of ship impact.

Pylon caisson with rounded shape.

The foundation works prior to placing the caissons will comprise:

- Dredging with a bucket dredger to minimize disturbance of boulder clay.
- A dumping vessel with suction equipment will clear away siltation left from the excavation.
- A side dumping vessel will place the crushed stone material in layers.

Vibration for compaction will be performed from a floating barge, equipped with a crane and very heavy and powerful plate vibration units.

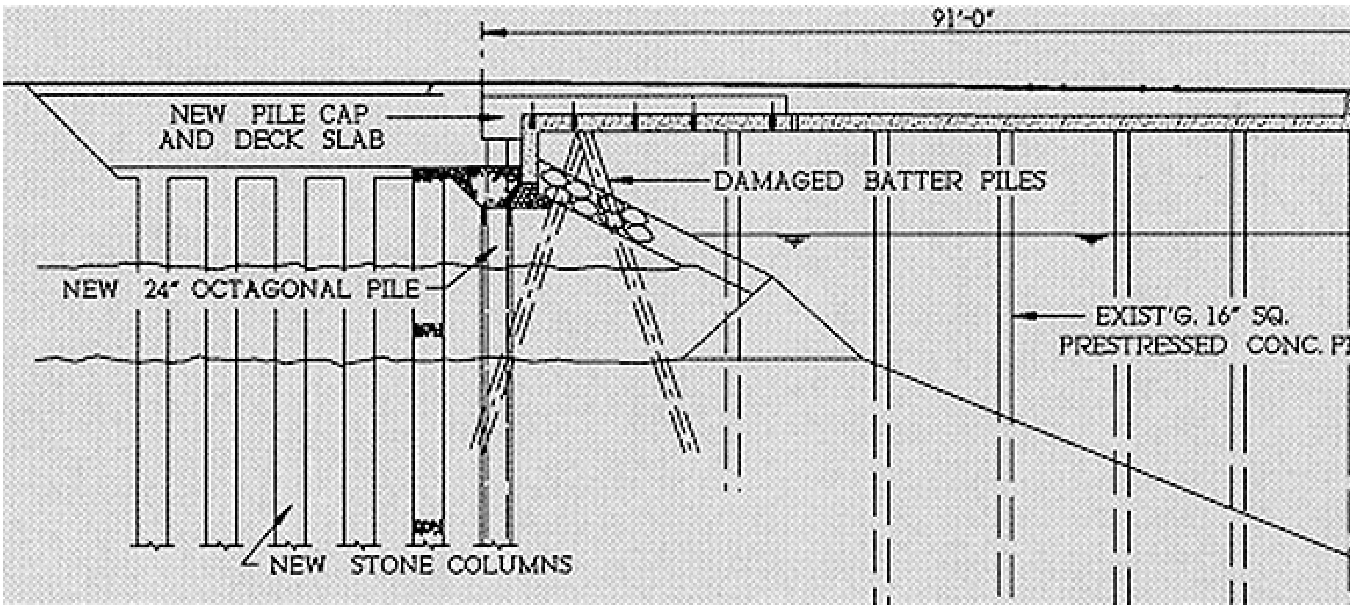
The foundation top layer will be screeded for levelling to 50 mm tolerance.

The two massive anchor block structures are located at a water depth of 1 0 m, and will resist inclined cable forces of 60,000 t. Excavation down to 25 m below sea level is planned for construction of a wedge shaped foundation base to provide shear resistance to the large horizontal loading. Each anchor block caisson covers an area of 6,100 m2 and will weigh 36,000 tones in the transport stage. It will contain 96 cells which will be ballasted with sand and olivine. Later artificial islands will be constructed around the anchor blocks in order to ease the waterflow around the large structures and to provide protection against ship impact.

Ben C. Gerwick, Jr. and Paul E. Bach

The October 17,1989 earthquake in San Francisco shut down several container terminals at the Port of Oakland.

Ben C. Gerwick, Inc. designed the repair and upgrading work for many of these, applying the latest seismic criteria which require the facility to remain operational following a moderate earthquake. After a significant major earthquake, the facility should be readily repairable and should not collapse or need time-consuming repairs that might potentially displace shipping companies.



Batter piles failed in shear

One of the container terminals, Berth 40, was converted to a public park and tugboat dock. In consultation with the Port of Oakland, the seismic criteria were developed to meet the usual life safety standards of the 1991 Uniform

Building Code, but did not have to meet the additional container terminal standards.

The existing concrete wharf at Berth 40 had battered prestressed concrete piles that failed in shear during the Loma Prieta Earthquake

The repair design added a new row of piled along the landside edge of the deck and also a new concrete deck poured on top of the existing deck. -The new deck, 35 feet wide, was designed to span the distance from the new piles, over the broken battered piles and onto the existing vertical piles that were undamaged.

The new concrete deck and piles were designed as a Moment Resisting Frame with special attention to ductility in the detailing of the new prestressed and reinforced concrete members.

Section of upgraded Berth 40

Significant construction cost savings were achieved by pouring the new deck directly on top of the existing deck and designing only for an operating level earthquake.

George C. Fotinos and Stephen P. Hardy

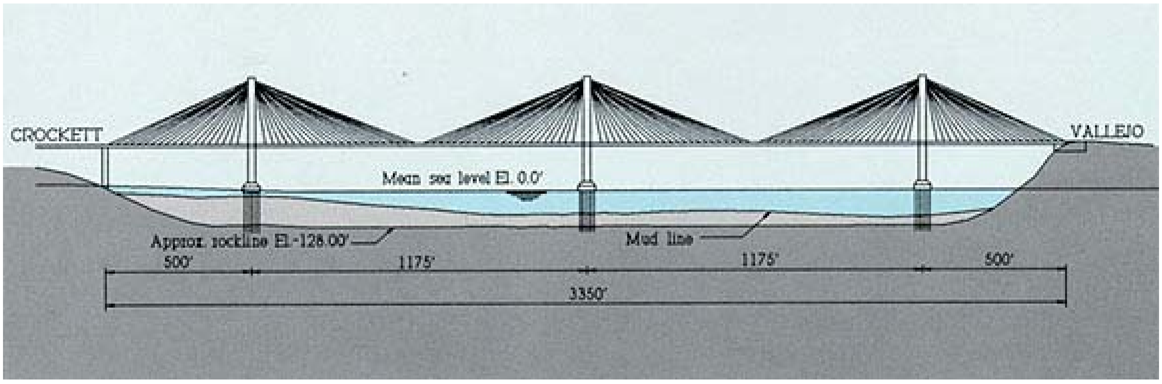
Three new parallel crossings of the San Francisco Bay area adjacent to existing bridges are planned by Caltrans to relieve congestion for commuter traffic within the next five years.

Existing Carquinez Bridge.

In the northern part of the Bay, two new high level crossings like the existing bridges are planned at the Carquinez Strait and at Benicia-Martinez. The existing bridges comprise cantilever steel trusses and steel trusses with concrete decks built in the 1920's and 1960's. The bridges are located in high seismic zones and are founded through deep soft soils underlain by firm rock. The new bridge at Carquinez is planned as a cantilever steel truss, which Caltrans will study in-house, and an alternate as a cable stayed structure with two spans of 1175' to coincide with the spans of the existing bridge while crossing the heavy trafficked ship channel. The new bridge at Benicia-Martinez has seven spans of 528'and is again planned as a steel truss bridge with concrete deck to be developed to final PS&E in-house by Caltrans and an alternate segmental concrete box girder-in lightweight aggregate concrete to reduce the seismic loads on the foundations.

Caltrans has selected two major consulting organizations to develop the alternate study and design, for both of which Ben C. Gerwick, Inc. has been selected to undertake the foundation study and design.

The initial considerations on foundation concepts include multiple, large dia. (10'-12') thick walled steel cylinders, filled with concrete. A temporary casing will be drilled to just above the rock line. Cylinder piles will be set through the casing and socketed into rock. Composite action will be attained by studs welded to the inside of the pile, over the regions of high moment and shear.



Proposed cable-stayed alternate for new Carquinez Bridge

The pier caps just above water level, will be massive cast-in-place concrete caps, with their soffits at mean tide level enabling construction in the dry. Precast concrete skirts will be hung and incorporated in the pier caps so as to prevent debris and small boats from entry at low tide. We will carry out further studies to include consideration of incorporating precast concrete soffit forms of normal-weight concrete with the massive fill of lightweight concrete, which will reduce the dead weight while still maintaining high durability around all surfaces.

In the southern part of the Bay, Caltrans is planning a widening of the existing 4.5 mile long San Mateo-Hayward

Bridge trestle section to allow for upgrading of this bridge to freeway standard and possible addition of bike/pedestrian lane and rail transit.

Ben C. Gerwick, Inc. has been selected by Caltrans to carry out the Preliminary Engineering including design alternatives with and without allowance for construction dredging.

Extensive use of precasting of piling and superstructure is foreseen to ensure a speedy construction program and a durable structure. Emphasis will be placed on developing ductile cast-in-place joints with seismic redundancy.

The work also entails development of construction costs for a 30' wide section added to the existing high level structure for rail transit.

George C. Fotinos and Paul E Bach