

Figure 2: Section A-A of Diaphragm Sea Wall.

System C: L-Shaped Wall with Buttresses Supported by Piles

- A type of wall, a modification of System B, that has a significant advantage over System B.
- Does not rely, or relies much less, on the gravity of the heel surcharge.
- Less susceptible to distress due to scour problem.
- Stability of the wall depends upon the pile capacity to resist uplift and the effect of horizontal load.
- Variable stiffness of the buttress T-section does not allow effective span moment redistribution, particularly when resultant of the horizontal force shifts towards the top of the wall as happens in the case of wave load or Monotube - Okabe seismic soil wedge retained by the wall.
- Price of the wall can be prohibitive.

System D: Diaphragm Wall System with Horizontally Spun Wall

A type of wall system that is easy to construct. The wall system provides a new design philosophy for Sea Wall construction. Benefits of the system include:

- Lower cost of construction and more flexibility of the system, as compared to the same features of traditional designs.
- Wall stability is not dependent on the gravity load of backfill.
- Wall stability is independent of gravity of the surcharge.
- Low effect of soil scour in front of the wall on wall system distress. Easy maintenance.

- Wall stability is dependent upon the drilled caisson capacity to resist uplift and the effect of horizontal loads.
- Lack of uplift pressure on the wall base or heel, as the Diaphragm system does not have a heel.
- Effective span moment redistribution allowed by constant stiffness of the Deep Beam Diaphragm fixed at the wall base.
- Horizontally spun continuous wall supported by Deep Beam Diaphragms. Wall Diaphragm provides support for loads applied in both directions.

System E: Soldier Pile System with Horizontally Spun Wall and Tie Back Anchors (Modified Bulkhead Approach)

A type of wall system that is also easy to construct. The front of the wall is somewhat similar to the front wall of the diaphragm system; however, design of this wall is based on a different philosophy, as the wall derives its resistance from different elements, depending on direction of load application. Benefits of this system include:

- Lower cost of construction and higher adaptability of the system, as compared to the same features of traditional designs.
- Wall stability is not dependent on the gravity load of backfill.
- Low effect of soil scour in front of the wall on wall system distress. Easy maintenance.

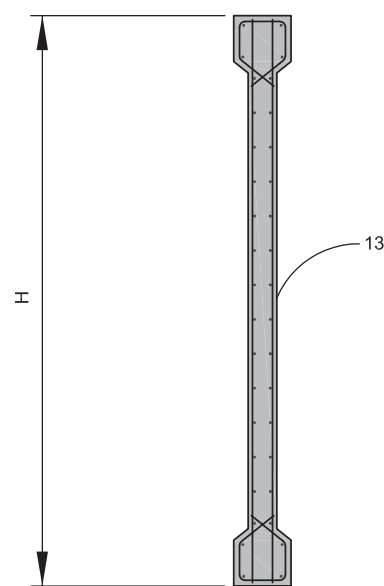


Figure 3: Section B-B of Diaphragm Sea Wall.

- Wall stability is dependent upon the drilled caisson capacity to resist the effect of horizontal load, and capacity of the soil anchors to resist the load in a seaward direction. Ability of elastic foundation (Caisson socket and granular soil backfill behind the composite width of the wall column) to resist the wave load in landward direction. Elastic foundation reaction in that case, is compared to the lateral capacity of mobilized passive

Concrete Tilt-Up Wall Panel

Armed Forces Reserve Center
Norman, Oklahoma



Designed by Scott Neuman
KPFF Consulting Engineers



Consulting Engineers

www.kpff.com

Seattle	Portland	Walnut Creek	Irvine	St. Louis
Everett	Eugene	Los Angeles	San Diego	New York
Tacoma	Sacramento	Long Beach	Boise	Amman, Jordan
Lacey	San Francisco	Pasadena	Phoenix	Abu Dhabi, UAE

ADVERTISEMENT For Advertiser Information, visit www.STRUCTUREmag.org

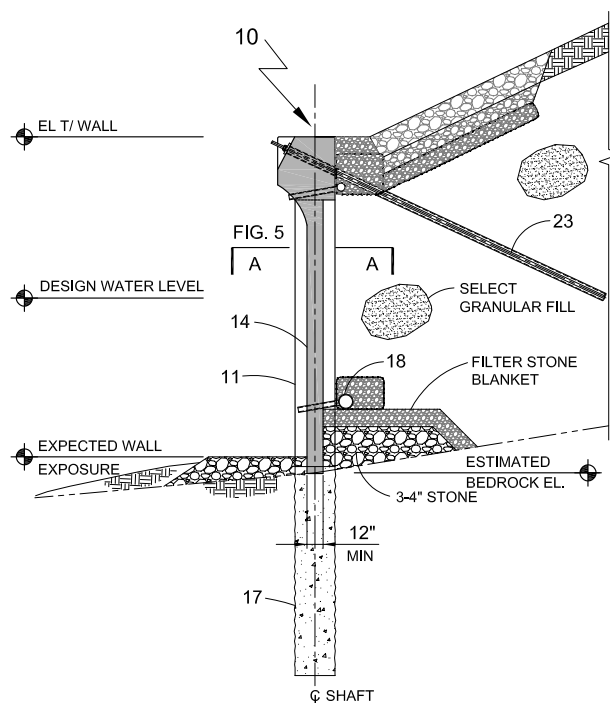


Figure 4: Soldier Pile Braced Sea Wall.

pressure. The designer must distinguish the difference between maximum possible soil passive resistance and mobilized passive pressure, as mobilized passive pressure frequently is only a fraction of maximum passive pressure resistance. Quite often, mobilized passive pressure does not exceed the pressure equivalent of the pressure exerted by the active pressure wedge.

- Lack of uplift pressure on the wall base.
- System effective span moment redistribution in both seaward and landward direction.
- Stiffness of the soil anchors and stiffness of specially modified backfill allows for the design of the retaining wall as a continuously spun horizontally slab.
- Attractive price of the wall.

Wall Systems A, B and C are well-known and well-described in many sources. A general

concept of the Diaphragm Sea Wall, Wall System D, is represented in Figures 1 (page 16), 2 (page 17) and 3 (page 17). Wall System E is shown in Figures 4 and 5.

Wall Systems D and E, however, have a common requirement for behind the wall backfill. This requirement compensates for lack of wall embedment or entrenchment into the rock or beach soil. The bottom 2-3 feet of the backfill consists of 3 to 4 inches of stone aggregate overtopped by a 2-foot thick layer of filter stone or overlaid by Geotextile filter fabric in order to prevent backfill erosion.

The final advantage of Wall System D and E is derived from the fact that erosion of the soil around the front pile can be easily remedied by the use of flowable fly ash fill that can easily restore eroded soil around the pile to a preexisting or better condition. Erosion of the soil in front of the wall itself is almost never critical and does not require urgent attention. Soil in front of the wall can be restored during normal beach nourishment operations.

Quite often, high flexural moments are exerted on the front piles of the Wall System E. Sometimes it is more economical to design front piles of that system as columns and not as beams. In that case, front pile should be designed with a post-tensioned rock anchor exerting compression force predetermined by wall designer.

The stiffness of the Deep Beam Diaphragms fixed at the base, and a very rigid spring value of such support, allows the horizontally span retaining wall (14) to be designed as a multi-span continuous horizontal slab. The Author recommends a fairly conservative three-span approach for the wall design and a five-span approach for determining the wall support reactions. To design the wall properly, the designer must check the support spring values for each set of loads in order to assure the validity of the support stiffness assumption.

Sea Wall Design Guidelines

- 1) Determine loads and load combinations affecting the Sea Wall design. The following short list of loads should be reviewed during the design process:
 - Active soil pressure wedge
 - Active soil pressure wedge + Seismic rupture wedge determined from Monotobe-Okabe equation
 - Direct Horizontal Wave load + Wave uplift pressure exerted on the heel of the wall

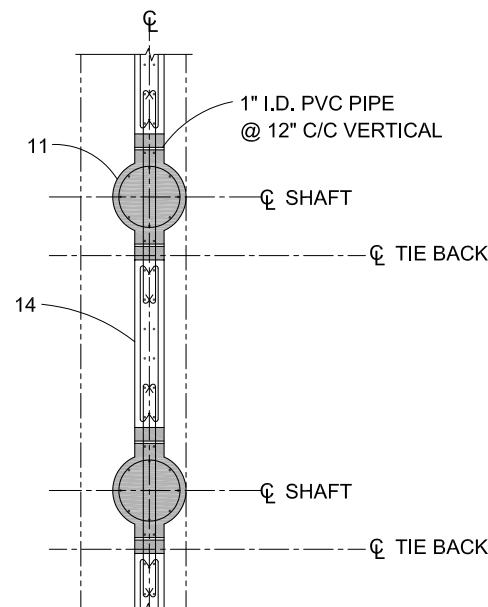


Figure 5: Section A-A.

- 2) During the wall system selection process, the Designer should understand that every flexible wall system that allows force redistribution in the horizontal direction should be designed using a set of spring values for each wall support. Each support spring value should be determined for each load combination at the level of the Horizontal Resultant force. The design should use a 3 or 5 span continuity approach, assuming pin connections at the ends of the 3 or 5 span wall. Some savings can be achieved if the designer uses spring supports only for the dynamic portion of the load. Remember that static load redistribution is a one time event causing permanent plastic deformations.
- 3) It is prudent to assume only half of the wave or seismic load in the mid span or alternate spans to verify the impact of the load on the supports differential movements.
- 4) The Designer, Owner and Contractor should collectively select the most economical Wall System. Consideration should be given to availability of materials and availability of skilled labor force. ■

Vitaly B. Feygin, P.E. is a Marine Structural Engineer. He is a Principal Structural Engineer with Marine and Industrial Consultants, Baltimore and Tampa offices. He is an author of two patents related to Sea Walls, Composite Cofferdams, Bridge Fenders and Port Structures. Mr. Feygin can be contacted at vfeygin.mic@gmail.com.

struware

Structural Engineering Software

The easiest to use software for calculating wind, seismic, snow and other loadings for IBC, ASCE7, and all state codes based on these codes (\$195.00).

Tilt-up Concrete Wall Panels (\$95.00).

Floor Vibration for Steel Beams and Joists (\$100.00).

Concrete beams with torsion (\$45.00).

Demos at: www.struware.com