ARMORFORM®
Fabric Formed Hard Armoring

Fine Aggregate Concrete

Fine aggregate concrete consists of a mixture of Portland cement, fine aggregate (sand) and water, so proportioned and mixed as to provide a pumpable fine aggregate concrete.

The water/cement ratio of the fine aggregate concrete shall be determined by the ready-mix manufacturer, but generally should be on the order of 0.65 to 0.75. The pumping of fine aggregate concrete into the fabric forms causes a reduction in the water content by filtering excess mixing water through the permeable fabric. The reduction of mixing water substantially improves the water/cement ratio of the in-place fine aggregate concrete thereby increasing its strength and durability. With a typical loss of approximately 15% of the total mixing water, 27 ft^3 of pumpable fine aggregate concrete will reduce to approximately 25 ft^3 of hardened concrete.

The consistency of the fine aggregate concrete delivered to the concrete pump should be proportioned and mixed as to have a flow time of 9-12 seconds when passed through the ¾-inch orifice of the standard flow cone that is described in ASTM C6449 (Figure 1). The water/cement ratio varies with the exact granulometry of the fine aggregate (sand) and should be determined by the ready-mix manufacturer using the above referenced flow cone.

The required minimum 28-day compressive strength (f'c) must be 3,500 psi when specimens are made and tested in accordance with ASTM C 109 Standard, Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-inch or (50 mm) Cube Specimens). If specimens do not test to the strengths above, drilled cores may be obtained and tested in accordance with ASTM C42. The range of fine aggregate concrete mix proportions provided in Table 1.0 has been developed under a variety of field conditions.

Figure 1

Table 1.0 Typical Range of Mix Proportions		
Material	**Mix Proportions lb./yd^3**	**After Placement Mix Proportions lb./yd^3**
Cement	750-850	810-920
Sand	2030-2120	2195-2290
Water	485-555	360-430
Air	As Required	As Required

Portland Cement

Portland cement should conform to ASTM C150, Type I, II or V. Pozzolan grade fly ash may be substituted for up to 25% of the cement as an aid to pumpability. (The pumpability of fine aggregate concrete mixes containing coarse sand is improved by the addition of fly ash.) Pozzolan, if used, should conform to ASTM C 618, Class C, F or N.

Fine Aggregate (Sand)

Fine aggregate should consist of suitable clean, hard, strong, and durable natural or manufactured sand. All fine aggregates should conform to ASTM C33. Aggregate gradation should follow Table 2.0 below, should be reasonably consistent, and not exceed 3/8 inches in size.

Table 2.0 Fine Aggregate (Percent Passing by Weight)		
Sieve Size (In)	**Min**	**Max**
3/8	100	-
#4	95	100
#8	80	100
#16	50	85
#30	25	60
#50	5	30
#100	0	10
#200	0	3

Fine aggregate failing to meet these grading requirements can be utilized provided that the supplier can demonstrate to the specifier that fine aggregate concrete of the class specified, made with fine aggregate under consideration, will have relevant properties at least equal to those of fine aggregate concrete made with same ingredients, with the exception that the referenced fine aggregate will be selected from a source having an acceptable performance record in similar fine aggregate construction.

Water

Water used for mixing and curing should be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials, or other substances that may be deleterious to concrete.

Plasticizing and Air Entraining Admixtures

Grout fluidifier, water reducing or set time controlling agents may be used as recommended by their manufacturers to improve the pumpability and set time of the fine aggregate concrete.

Any air entraining agent or any other admixture may be used, as approved, by the Engineer-in-charge to increase workability, to make concrete impervious and more durable. Air entraining admixture should conform to ASTM C494 and ASTM C260, respectively. Mixes designed with 5% to 8% air content will improve the pumpability of the fine aggregate concrete, freeze-thaw, and sulfate resistance of the hardened concrete.

Placement Of Fine Aggregate Concrete

1. Following the placement of the fabric forms over the geotextile filter fabric, fine aggregate concrete shall be pumped between the top and bottom layers of the fabric form through small slits to be cut in the top layer of the fabric form or manufacturer supplied valves. The slits shall be of the minimum length to allow proper insertion of a filling pipe inserted at the end of a 2-inch I.D. concrete pump hose. Fine aggregate concrete shall be pumped between the top and bottom layers of fabric, filling the forms to the recommended thickness and configuration.

2. Beginning at the designated staring point, check and adjust the fabric form panel's seams to assure that they are perpendicular to the longitudinal alignment line. Care should be exercised in the alignment and securing of the first fabric form panel. This will ensure the aesthetics of the concrete lining or mat and will also hasten the installation of subsequent panels. Fabric should be placed loosely at the connection or anchor to allow for contraction in both directions during filling.

3. A tight seal will be made by wrapping a piece of nonwoven fabric around the pipe. When the pipe is withdrawn, the nonwoven fabric will be stuffed into the hole to provide a temporary closure. When the concrete has stiffened and is no longer fluid, the fabric must be removed, and the concrete surface smoothed by hand.

4. Fine aggregate concrete shall be pumped in such a manner that excessive pressure on the fabric forms is avoided. Baffles shall be installed by the Manufacturer to facilitate the pumping process by providing a termination point at pre-determined locations within a single fabric formed panel. Cold joints shall be avoided. A cold joint is defined as one in which the pumping of the fine aggregate concrete into a given section of form is discontinued or interrupted for an interval of forty-five (45) or more minutes.

5. The sequence of fine aggregate concrete shall be such as to ensure complete filling of the fabric formed concrete lining to the thickness specified by the Engineer. The flow of the fine aggregate concrete shall first be directed into the lower edge of the fabric form and working back up the slope, followed by redirecting the flow into the anchor trench.

6. Prior to removing the filling pipe from the current concrete lining section and proceeding to the fine aggregate concrete filling of the adjacent lining section, the thickness of the current lining section shall be measured by inserting a length of stiff wire through the lining at several locations from the crest to the toe of the slope. The average of all thickness measurements shall be not less than the specified average thickness of the concrete lining. Should the measurements not meet the specified average thickness, pumping shall continue until the specified average thickness has been attained.

7. Excessive fine aggregate concrete that has inadvertently spilled on the concrete lining surface shall be removed. The use of a high-pressure water hose to remove spilled fine aggregate concrete from the surface of the freshly pumped concrete lining shall not be permitted.

8. Foot traffic will not be permitted on the freshly pumped concrete lining when such traffic will cause permanent indentations in the lining surface. Walking boards shall be used where necessary.

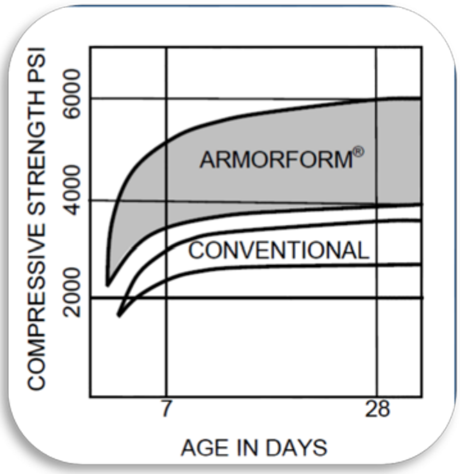
9. After the fine aggregate concrete has set, all anchor, flank and toe trenches shall be backfilled and compacted flush with the top of the concrete lining. The integrity of the trench backfill must be maintained to ensure a surface that is flush with the top surface of the concrete lining for its entire service life. Toe trenches shall be backfilled as shown on the Contract Drawings. Backfilling and compaction of trenches shall be completed in a timely fashion to protect the completed concrete lining.

Pumpability

The fine aggregate concrete mix which is used to fill fabric forms is very fluid compared to a conventional mix (see Table 1.0). A conventional concrete mix has a 4-to-6-inch (100 to 150 mm) slump. However, as the fabric form is filled the excess mixing water in the pumped mix is rapidly expelled through the water-permeable fabric form, resulting in the pumped mix ratio of approximately 0.7 being reduced to a more typical ratio of 0.5. Within thirty minutes after placement, the consistency of the fine aggregate concrete within the fabric forms is that of a very low slump concrete.

Strength and Durability

Fabric formed fine aggregate concrete possesses superior physical properties. The compressive strength of fine aggregate concrete pumped into fabric forms is typically 1.5 to 1.75 times greater than companion samples taken from conventual concrete test cylinders. In addition, the fine aggregate concrete has less than 5% water absorption. This combined with a “case hardening” effect produces a concrete that is abrasion resistant, durable under freeze thaw action, resistant to “break up” caused by thermal cracking, highly impermeable, and resistant to acid, alkali, salt, organic solvents, biological organ- isms and petrochemicals. It is equivalent to a rich conventional concrete mix placed at an extremely low water/cement ratio. The “case hardening” effect is a result of a higher percentage of the cement in the cement-rich, fine aggregate concrete mix being drawn to the sur- face of the fabric forms by the expelled excess mixing water.



The higher compressive strength and "case hardening" achieved by the fine aggregate concrete permits concrete linings, mats, and armor units to be constructed without reinforcement steel.

Environmental Compatibility

When fine aggregate concrete is pumped into the fabric forms, an average of 0.25% of the cement content (with a maximum of 0.5%) is lost through the fabric forms, or the equivalent of approximately 1000 g of cement to a cubic yard of concrete pumped. The addition of 40 g of cement to a cubic yard of water will raise the pH value of water approximately 1.0. This should fall well within the nominal pH range (7.0 to 9.5) of potable water.

The following procedures, should assure that the rise in pH during fine aggregate concrete pumping of fabric formed linings, mats or armor units will not exceed 1.0:

- In ***stagnant water***, the total volume of water must be at least 50 times the volume of fine aggregate concrete pumped.

$$\text{Water Volume} \geq 50 \times \text{Pumped Concrete}$$

- In ***flowing water***, the rate of water flow in cubic yards per minute must exceed the rate of fine aggregate concrete pumped in cubic yards per hour.

$$\text{Water Flow (CY/MIN)} > \text{Pumping Rate (CY/HR)}$$