Best Practices Manual

Precast Concrete On-site Wastewater Tanks

Dedicated to expanding the use of qualty precast concrete

Second Edition
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NPCA
Precast...The Concrete Solution

Precast ... The Concrete Solution
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NOTES

1. This manual does not claim or imply that it addresses all safety-related issues, if any, associated with its use. Manufacture of concrete products may involve the use of hazardous materials, operations and equipment. It is the user's responsibility to determine appropriate safety, health and environmental practices and applicable regulatory requirements associated with the use of this manual and the manufacture of concrete products.

2. Use of this manual does not guarantee the proper function or performance of any product manufactured in accordance with the requirements contained in the manual. Routine conformance to the requirements of this manual should result in products of an acceptable quality according to current industry standards.

INTRODUCTION

This manual provides guidance on material selection, manufacturing techniques, testing and installation to attain structurally sound, watertight precast concrete septic tanks and related components for on-site wastewater treatment systems. It is not intended for use as a regulatory code or minimum design standard, but rather as an aid to manufacturers, engineers, contractors and owners.

This manual will be most effective when used in conjunction with a complete review of local codes and design considerations before designing or manufacturing any on-site wastewater treatment tank or system.

It is impossible for a manual of this type to be all inclusive, and the recommendations are not intended to exclude any materials or techniques that will help achieve the goal of producing structurally sound and watertight precast concrete tanks. Attention to detail, appropriate materials, proper training of workers and quality control throughout a repeatable process will ensure that the concrete tanks meet the needs of specifiers, contractors and owners while protecting the environment.

The on-site wastewater treatment industry is rapidly evolving, with greater demand for product quality and performance. In the past, on-site wastewater systems often were considered temporary structures with limited performance expectations, because, as a community matured, centralized collection and treatment systems replaced the on-site systems that helped to develop the area. However, this is no longer the trend.

Today, on-site wastewater treatment and disposal systems have become the first choice of developers and public health officials in many parts of North America. The growing dependence on these systems places a greater emphasis on system performance and component structural integrity. As such, protection from water infiltration and exfiltration is a critical element in the design of tanks used in on-site systems. Regulatory codes and project specifications requiring structurally sound and watertight tanks are becoming the rule rather than the exception, as they should be.

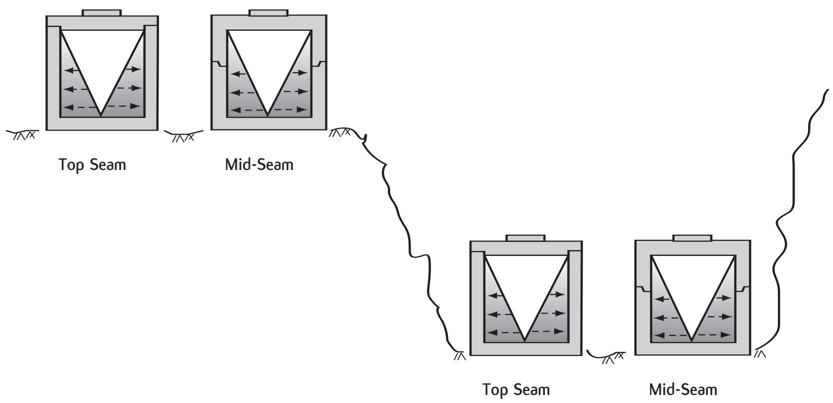
Precast concrete on-site wastewater treatment systems, when manufactured and installed properly, will outperform and outlast systems consisting of competing materials. With the increasing regulatory demands for structurally sound and watertight tanks, it is critical for precast manufacturers to continually raise the bar on quality. It is with this in mind that many industry specialists have come together to create this manual.

STRUCTURAL DESIGN

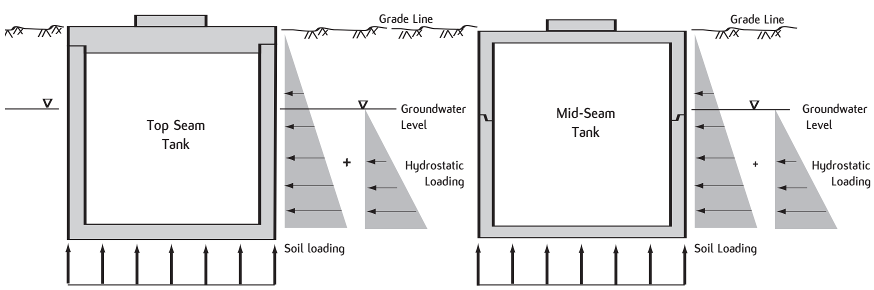
Loading Conditions

A properly designed precast concrete on-site wastewater treatment tank must be able to withstand a variety of loading conditions, which vary during manufacture, installation, testing and service. Tanks must be designed to withstand these loading conditions with rational mathematical design calculations performed by a qualified professional engineer or by proof load testing in accordance with ASTM C1227 "Standard Specification for Precast Concrete Septic Tanks."

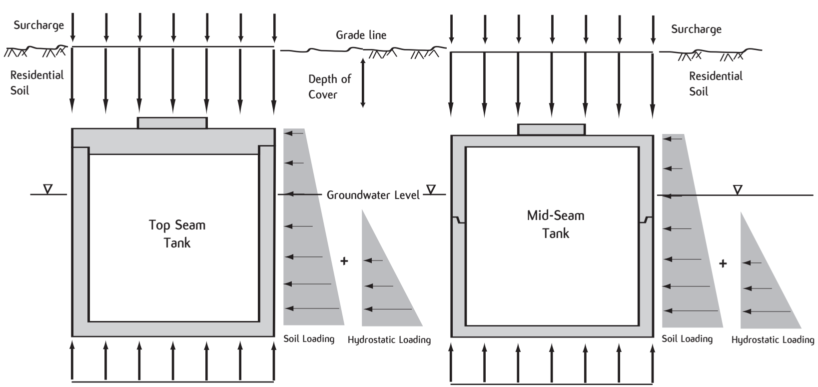
Internal Hydrostaic Loading – Tank Full (on grade or without backfill)



External Soil and Water Loading: Tank Empty



Optional Loading Where Appropriate
*Manufacturer to specify the maximum depth of cover



Consider the following in the design:

- Surface surcharge
- Concentrated wheel loads
- Lateral loads
- Presumptive soil bearing capacity
- Buoyant forces
- Connections and penetrations
- Point loads

Design precast concrete tanks for on-site applications in accordance with one or more of the following applicable industry codes and standards or as required by the authority or authorities having jurisdiction:

- ASTM C890, "Standard Practice for Minimum Structural Design Loading for Monolithic or Sectional Precast Concrete Water and Wastewater Structures"
- ASTM C1227, "Standard Specification for Precast Concrete Septic Tanks"
- IAPMO/ANSI
- CSA B66

The loading conditions illustrated in the these diagrams should be analyzed and considered in the design of an on-site wastewater tank.

The following design characteristics have a critical impact on the performance of on-site wastewater tanks.

Concrete Thickness

The concrete thickness must be sufficient to meet minimum reinforcement cover requirements and withstand design loading conditions.

Concrete Mix Design

Concrete must have a minimum compressive strength of 4,000 psi at 28 days. Consider methods to reduce permeability, improve durability and increase strength. Maintaining a low water-cementitious ratio is one way to achieve this and must not exceed 0.45.

Reinforcement

Proper reinforcement is critical to withstand the loads applied to an on-site wastewater tank. Reinforcement must be sufficient to provide adequate strength during early-age handling, installation and service, including temperature and shrinkage effects. All reinforcement must meet applicable ASTM International specifications.

MATERIALS

The primary constituents of precast concrete are cement, fine and coarse aggregates, water and admixtures. The following discussion covers relevant factors in the selection and use of these fundamental materials.

Cement

The majority of cement used in the manufactured concrete products industry is governed by ASTM C 150, "Standard Specification for Portland Cement."

The five primary types of ASTM C 150 cement are:

Type I	Normal
Type II	Moderate Sulfate Resistance
Type III	High Early Strength
Type IV	Low Heat of Hydration
Type V	High Sulfate Resistance

Select the cement type based on project specifications or individual characteristics which best fit the operation and regional conditions of each manufacturer. Note that certain types of cement may not be readily available in certain regions.

Store cement in a manner that will prevent exposure to moisture or other contamination. Bulk cement should be stored in watertight bins or silos. If different types of cement are used at a facility, store each type in a separate bin or silo. Clearly identify delivery locations.

Design and maintain bin and silo compartments to discharge freely and independently into the weighing hopper. Cement in storage should be drawn down frequently to prevent undesirable caking.

Stack bagged cement on pallets to permit proper circulation of air and avoid exposure to undesirable moisture or condensation. On a short-term basis (less than 90 days), stack the bags no more than 14 high. For long-term storage, do not exceed seven bags in height (or per manufacturer's recommendations).

Use the oldest stock first. Discard any cement with lumps that cannot be reduced by finger pressure.

Aggregates

Ensure aggregates conform to the requirements of ASTM C33, "Standard Specification for Concrete Aggregates." Evaluate the aggregates and maintain documention at the plant for potential deleterious expansion due to alkali reactivity, unless the aggregates come from a state department of transportation-approved source. The maximum size of coarse aggregate should be as large as practical, but should not exceed 20 percent of the minimum thickness of the precast concrete tank or 75 percent of the clear cover between reinforcement and the surface of the tank. Larger maximum sizes of aggregate may be used if evidence shows that satisfactory concrete products can be produced.

Quality of Aggregates

Concrete is exposed to continuous moist and corrosive conditions in wastewater applications. It is important to specify a well-graded, sound, nonporous aggregate in accordance with ASTM C33 "Standard Specification for Concrete Aggregates."

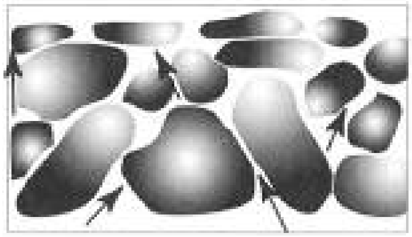
Gradation of Aggregates

Aggregate gradation influences both the economy and strength of a finished on-site wastewater tank. The purpose of proper gradation is to produce concrete with a maximum density along with good workability to achieve sufficient strength.

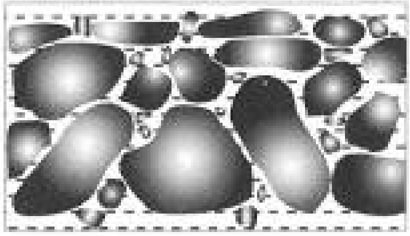
Well-graded aggregates help improve workability, durability and strength of the concrete. Poorly graded or gap-graded aggregates rely on the use of excess mortar to fill voids between course aggregates, leading to potential durability problems. Concrete mixes containing rounded coarse aggregates tend to be easier to place and consolidate. However, crushed aggregates clearly are acceptable. The use of elongated, flat and flaky aggregates is discouraged. Gap-graded aggregates lacking intermediate sizes are also discouraged.

Experience has shown either very fine or very coarse sand or aggregate having a large deficiency or excess of any size is undesirable. Sand gradation should be uniform and have a fineness modulus of not less than 2.3 nor more than 3.1. A variation in base fineness modulus greater than 0.2 may call for an adjustment to the mix design as suggested in ASTM C 33, "Standard Specification for Concrete Aggregates."

Figure 2 — Poorly graded mix vs. Well-graded mix design



Porous concrete resulting from absence of fine materials. Arrows indicate water infiltration.



Inclusion of fine materials provides filling for spaces between coarse aggregates.

Aggregate Deleterious Substances

Ensure all aggregates are free of deleterious substances. Deleterious substances include:

- Substances that cause an adverse chemical reaction in fresh or hardened concrete
- Clay, dust and other surface-coating contaminants
- Structurally soft or weak particles

For good bond development, ensure aggregate surfaces are clean and free from excessive dust or clay particles. Excessive dust or clay particles typically are defined as material passing a #200 sieve, the limit of which is no more than 3 percent. Friable aggregates may fracture in the mixing and placement process, compromising the integrity of the hardened concrete product.

Moisture Content of Aggregate

The measurement of aggregate moisture content is important in the control of concrete workability, strength and quality. Aggregates, particularly fine aggregates (sands), can collect considerable amounts of moisture on their surfaces. Fine aggregates can hold up to 10 percent moisture by weight; coarse aggregates can hold up to 3 percent.

Water on the surface of an aggregate that is not accounted in the mixture proportions will increase the water-cementitious ratio. The moisture content of aggregates will vary throughout a stockpile and will be affected by changes in weather conditions. Therefore, adjust mixture proportions as necessary throughout the production day to compensate for moisture content changes in the aggregate.

The following methods will increase the likelihood of uniform moisture content:

- Enclose storage of daily production quantities
- Store aggregates in horizontal layers
- Have at least two stockpiles
- Allow aggregate piles to drain before use
- Avoid the use of the bottom 12 inches of a stockpile
- Continuously sprinkle aggregate stock piles (climate dependent)
- Store entire stockpile indoors or under cover

Careful monitoring of aggregate moisture content during batching will reduce the necessity of using additional cement to offset excess water. This will maintain high-quality standards and save on expensive raw materials. The plant should have a program in place that manages surface moisture content or accounts for moisture variation during batching.

Handling and Storage of Aggregate

Handle and store aggregates in a way that prevents contamination and minimizes segregation and degradation.

Aggregate handling is an important operation. Accurately graded coarse aggregate can segregate during a single improper stockpiling operation, so minimize handling to reduce the risk of particle size segregation. Also minimize the number of handling operations and material drop heights to avoid breakage.

The following methods can prevent segregation:

- Store aggregates on a clean, hard, well-drained base to prevent contamination. Bin separation walls should extend high enough to prevent overlapping and cross-contamination of different-sized aggregates.

- Avoid steep slopes in fine aggregate stockpiles. Fine aggregate stockpiles should not have slopes greater than the sand's angle of repose (i.e., natural slope, typically 1:1.5) to prevent unwanted segregation.
- Remove aggregates from a stockpile by working horizontally across the face of the pile. If possible, avoid taking aggregate from the exact same location each time.

Water

Water used in mixing concrete should meet the requirements of ASTM C 1602, "Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete." Avoid water containing deleterious amounts of oils, acids, alkalis, salts, organic material or other substances that may aversely affect the properties of fresh or hardened concrete.

Chemical Admixtures

Commonly used chemical admixtures in precast manufacturing include:

- Accelerating admixtures (ASTM C494, "Specification for Chemical Admixtures for Concrete")
- Air entrainment admixtures (ASTM C260, "Specification for Air-Entraining Admixtures for Concrete")
- Water reducing admixtures (ASTM C494, "Specification for Chemical Admixtures for Concrete")
- High-range water-reducing admixtures or superplasticizers (ASTM C1017, "Chemical Admixtures for Use in Producing Flowing Concrete")

Store admixtures in a manner that avoids contamination, evaporation and damage. Protect liquid admixtures from freezing and extreme temperature changes, which could adversely affect their performance. It is also important to protect admixture batching components from dust and temperature extremes; ensure they are accessible for visual observation and periodic maintenance. Perform periodic recalibration of the batching system as recommended by the manufacturer or as required by local regulations.

Chemical admixture performance can vary; exercise caution, especially when using new products. Test some trial batches and document the results before using a new admixture for production. Follow manufacturers' recommendations exactly. Carefully check admixtures for compatibility with the cement and any other admixtures used. Do not mix similar admixtures from different manufacturers without the manufacturer's agreement or testing to verify compatibility.

Additional guidelines for the use of admixtures are included in ACI 212.3, "Guide for Use of Admixtures in Concrete."

Avoid accelerating admixtures that contain chlorides in order to prevent possible corrosion of reinforcing steel elements and other embedded metal objects.

Supplementary Cementitious Materials (SCMs)

SCMs have three classifications:

1. Cementitious materials – blast furnace slag (ASTM C595, "Standard Specification for Blended Cements")
2. Pozzolanic materials – fly ash, silica fume, metakaolin (ASTM C618, "Standard Specification for Coal Fly Ash, and Raw or Calcined Natural Pozzolan for Use in Concrete")
3. Pozzolanic and cementitious materials – Class C fly ashes (ASTM C618)

SCMs have a varying impact on the amount of water and air entrainment admixture required. Some SCMs, particularly fly ash, silica fume and blast furnace slag, could lead to significant improvements in permeability and resistance to sulfate attack, which are important considerations in on-site wastewater tank design and performance.

Ready-Mixed Concrete

Verify that the ready-mixed concrete supplier is operating in accordance with ASTM C94, "Standard Specification for Ready-Mixed Concrete."

Perform plastic concrete tests (slump, temperature, air content and density) at the plant prior to casting products. Record any added water on the delivery batch ticket for each truck and keep it on file.

CONCRETE MIXTURE PROPORTIONING

The design of concrete mixtures is a broad and extensive subject, one that is specific to concrete in general but not necessarily to on-site wastewater tanks. This discussion will focus only on critical factors that pertain to these products.

Mix designs are selected based upon several necessary factors including permeability, consistency, workability, strength and durability. The elements necessary to achieve high-quality watertight precast concrete include:

- Low water-cementitious ratio (less than 0.45)
- Minimum compressive strength of 4,000 psi at 28 days
- Use of good quality and properly graded aggregate
- Proper concrete consistency (concrete that can be placed readily by traditional methods.

For concrete to be watertight, water must not be able to flow through its hardened pore structure. Low water-cementitious ratios are critical for increased concrete strength, watertightness and decreased permeability.

High water-cementitious ratios yield undesirable increased capillary porosity within the concrete. Capillary pores are voids resulting from the consumption and evaporation of water during the hydration or curing process. Enlarged and interconnected capillary voids serve as pathways that allow water and other contaminants to either infiltrate or exfiltrate through the concrete. Lower water-cementitious ratios result in smaller and fewer pores, reducing the permeability of the concrete. ACI 350, "Code Requirements for Environmental Engineering Concrete Structures," recommends a maximum water-cementitious ratio of 0.45.

Proper consistency of fresh concrete is a critical element in producing high-quality, watertight concrete. Fresh concrete must be sufficiently plastic (flowable or deformable) to be properly placed, consolidated and finished. The size, shape and grading of aggregates, cement content, water-cementitious ratio and admixtures affect the workability of a mix.

Water-reducing admixtures and superplasticizers can greatly increase the workability of fresh concrete without changing the water-cementitious ratio. Experience has shown that concrete with low water-cementitious ratios (less than 0.45), can be properly placed and consolidated with the aid and proper use of admixtures. Concrete should be air-entrained in accordance with ACI 318. Their use is particularly important, since most on-site wastewater tanks are relatively thin-walled and require special attention to ensure full concrete consolidation during casting. In certain circumstances, and where local regulations allow it, a properly designed and tested self-consolidating concrete (SCC) mix can reduce the necessary effort to achieve proper consolidation of the concrete.

Air-entraining admixtures are designed to disperse microscopic air bubbles throughout the concrete's matrix to function as small "shock absorbers" during freeze-thaw cycles. The required air content for frost-resistant concrete is determined by the maximum aggregate size and severity of in-service exposure conditions (ACI 318). In addition, air entrainment improves workability and reduces bleeding and segregation of fresh concrete while greatly improving the durability and permeability of hardened concrete.

LIFTING INSERTS

LIFTING INSERTS:

Commercially manufactured lifting devices come furnished with documented and tested load ratings. Use the devices as prescribed by the manufacturer's specification sheets.

If lifting devices are homemade, have them load tested or evaluated by a professional engineer. Note that ASTM C1227, "Standard Specification for Precast Concrete Septic Tanks," calls for the following:

> *6.1.6 Inserts embedded in the concrete shall be designed for an ultimate load that is four times the working load (Factor of Safety = 4).*

COATINGS

COATINGS:

Good concrete (water-cementitious ratio less than 0.45 and compressive strength greater than 4,000 psi) is sufficiently watertight for on-site wastewater tanks. Under normal in-service conditions, there is no need for additional applications of asphalt, bituminous, epoxy or cementitious coatings. Coatings serve only to add cost but offer no benefit to concrete tanks that are already watertight. Additionally, coatings can be difficult to apply properly and may peel away from the concrete surface. Dislodged particles of coatings will move through the septic system and may clog the drain field. However, a protective exterior coating may be specified when a soil analysis indicates a potential for chemical attack.

PRODUCTION PRACTICES

Quality Control

All plants must have a quality control program and manual, including but not limited to the following:

- Documented mix designs
- Pre-pour inspection reports
- Form maintenance logs
- Post-pour inspection reports
- Performance and documentation of structural and watertightness testing discussed in this manual
- Plant qualty control procedures
- Raw materials
- Production practices
- Concrete mixes
- Reinforcement fabrication and placement
- Concrete testing
- Storage and handling

Records of the above listed items should be available for review by appropriate agencies upon request.

Participation in the NPCA Plant Certification Program and future programs is recommended as an excellent way to ensure product quality. Use the NPCA "Quality Control Manual for Precast Concrete Plants" as the basis for developing a strong quality control program.

Forms

Forms must be in good condition. Frequent inspection intervals and regular maintenance ensure that forms are free of any damage that could cause concrete placement difficulties or dimensional problems with the finished product. Uniform concrete surfaces are less permeable and consequently enhance the watertightness of completed tanks.

Use forms that prevent leakage of cement paste and are sufficiently rigid to withstand the vibrations encountered in the production process. Maintain forms properly, including cleaning after each use and inspection prior to each use, to ensure uniform concrete surfaces. Ensure forms are level and on a solid base.

Apply form release agents in a thin, uniform layer on clean forms. Do not apply form release agents to reinforcing steel or other embedded items, as it can compromise the bond between the steel and the concrete. Do not allow the form release agent to puddle in the bottom of forms. Remove excess form release agent prior to casting.

Forms must be designed to meet individual product specifications. Select forming materials, configuration, hardware and accessories that help the stripping process and minimize stripping damage. Inspect and maintain joint areas to ensure proper tolerances on concrete joints and keyways.

REINFORCEMENT

Fabrication drawings must be a part of every QC program. Fabrication drawings should detail the reinforcement requirements and all necessary information pertaining to the product prior to casting.

Conventional Reinforcement

Fabricate reinforcing steel cages by tying or welding the bars, wires or welded wire reinforcement into rigid structures. The reinforcing steel cages should conform to the tolerances defined on the fabrication drawings. If not stated, minimum bend diameters on reinforcement should meet the requirements set forth in ACI 318, as defined in Table 1. Make all bends while the reinforcement is cold. The minimum bend diameter for concrete reinforcing welded wire reinforcement is $4d_b$.

Table 1: Concrete Reinforcing Steel

ASTM A615 and A706 Inch-Pound Bar Sizes	Minimum Bend Diameter	ASTM A615 and A706 Soft Metric Bar Sizes
# 3 through # 8	$6d_b$	# 10 through # 25
# 9, # 10 and # 11	$8d_b$	# 29, # 32 and # 36
# 14 and # 18	$10d_b$	# 43 and # 57

d_b = nominal diameter (inch or mm) of bar

Weld reinforcement (including tack welding) in accordance with AWS D1.4, "Structural Welding Code, Reinforcing Steel." This code requires either special preheat requirements (when required) or weldable grade reinforcement according as defined by ASTM A706, "Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement," for any welding of reinforcing steel, including tack welds. Take special care to avoid undercutting or burning through the reinforcing steel.

Conventional reinforcement (ASTM A615, "Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement") is produced from recycled metals that have higher carbon contents and are likely to become brittle if improperly welded. A brittle weld is a weak link, which can compromise the structural integrity of the finished product. ASTM A615/615M states: "Welding of material in this specification should be approached with caution since no specific provisions have been included to enhance the weldability. When the reinforcing steel is to be welded, a welding procedure suitable for the chemical composition and intended use or service should be used."

Ensure lap splices for steel reinforcement (rebar and welded-wire reinforcement) meet the requirements of ACI 318. Adequate development length is required to develop the design strength of the reinforcement at a critical section. A qualified engineer should determine development length and clearly indicate it on shop drawings.

Reinforcement steel should be free of loose rust, dirt and form release agent. Cut, bend and splice reinforcing steel in accordance with fabrication drawings and applicable industry standards. Inspect reinforcing cages for size, spacing, proper bends and length. Secure the reinforcing cage in the form so that shifting will not occur during casting. Use only chairs, wheels and spacers made of noncorrosive materials.

It is important to place and hold reinforcement in position as shown in the fabrication drawings. Due to the relatively thin walls of some on-site wastewater tanks, a maximum recommended placement tolerance for the depth of reinforcement is $+\frac{1}{4}$ inch (ACI 318). As a general rule, the variation in spacing between bars should not exceed 1 inch, except where inserts may require some shifting of bars.

The recommended minimum cover is 1 inch (ASTM C1227, "Standard Specification for Precast Concrete Septic Tanks."

Fiber Reinforcement

Data must be available to show conclusively that the type, brand, quality and quantity of fibers to be included in the concrete mix are not detrimental to the concrete or to the precast concrete product.

Fiber reinforced concrete must conform to ASTM C1116, "Standard Specification for Fiber-Reinforced Concrete and Shotcrete" (Type I or Type III).

The two most popular types of fibers are synthetic and steel fibers. Steel fibers must conform to ASTM A820, "Specification for Steel Fibers for Fiber-Reinforced Concrete." Do not use fibers as a replacement for primary structural reinforcing steel. In general, fibers will not increase the compressive or flexural strength of concrete.

Synthetic microfibers in concrete typically reduce plastic shrinkage cracks and improve impact resistance. They can help reduce chipping when products are stripped. Typical dosage rates will vary from 0.5 to 2.0 lbs/yd^3. Synthetic macrofibers and steel fibers may replace secondary reinforcement to provide equivalent bending stress and strength when compared with welded wire reinforcement and light-gauge steel reinforcement. Typical dosage rates for synthetic macrofibers vary from 3.0 to 20 lbs/yd^3. Steel fiber dosage rates may vary from 20 to 60 lbs/yd^3. Fibers must be approved by a regulatory agency or specifying engineer prior to concrete placement.

Design the concrete mix so that the mix is workable and the fibers are evenly distributed. Chemical admixtures or adjustments to the concrete mixture design may be necessary to achieve proper consolidation and workability. It is important to adhere to the manufacturer's safety precautions and to follow instructions when introducing the fibers into the mix.

Embedded Items

Embedded items such as plates, inserts, connectors and cast-in seals must be held rigidly in place during casting.

Pre-Pour Inspection

A typical pre-pour checklist, as illustrated on the next page, provides a means of documenting the required quality checks. A qualified individual should make inspections prior to each pour. Correct any deviations prior to the start of placement activities.

Pre-Pour Operations Include:

- Preparing and setting forms
- Positioning steel reinforcement according to structural design
- Placing blockouts
- Positioning embedded items

PRE-POUR CHECKLIST

PRODUCT: ____ Job No. _____________

Casting Date	Sun	Mon	Tues	Wed	Thurs	Fri	Sat
Form Condition							
Form Cleanliness							
Form Joints							
Release Agent/Retarder							
Design Length (ft/in)							
Set-Up Length (ft/in)							
Design Width (ft/in)							
Set-Up Width (ft/in)							
Design Depth (ft/in)							
Set-Up Depth (ft/in)							
Blockouts							
Squareness							
End and Edge Details							
Reinforcing Steel							
Size of Reinforcement							
Spacing							
Rustification							
Plates and Inserts							
Lifting Devices							
Top Finish (wet)							

REMARKS: ____

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____

QC Supervisor __________________ Date ________ Inspector _________________ _________________

CASTING CONCRETE

Transporting Concrete

When transporting concrete from mixer to form, use any method that does not contaminate the concrete, cause delay in placing, or segregation. Concrete can be discharged directly from the mixer into the forms - ACI 304, "Guide for Measuring, Mixing, Transporting and Placing," is a valuable reference.

Placing Concrete

Conventional Concrete

Keep the free fall of the concrete to a minimum and deposit as near to its final location as possible. Do not use vibration equipment to move fresh concrete laterally in the forms.

Fiber Reinforced Concrete (FRC)

Follow the same practices as described for conventional concrete, but note that the workability of the FRC may be slightly reduced.

Self-Consolidating Concrete (SCC)

Place self-consolidating concrete into itself at a constant pressure head from one end of the form, allowing air to escape as the concrete flows into and around steel reinforcement. Avoid placement practices that add additional energy to the mix and cause unwanted segregation, such as excessive vibration, increased pour heights or increased discharge rates.

Consolidating Concrete

SCC generally requires minimal consolidation efforts. However, when using conventional concrete, consolidation operations are required to minimize segregation and honeycombing. Consolidation can be improved on particular molds by using vibrators with variable frequency and amplitude.

Three types of vibration are prevalent in the precast industry:

Internal – stick vibrator
External – vibrator mounted on forms or set on a vibrating table
Surface – vibrator can be moved across the surface

Lower internal vibrators vertically and systematically into the concrete without force until the tip of the vibrator reaches the bottom of the form. When using internal vibrators, concrete should be placed in wall sections using lifts not exceeding 2 feet. Do not drag internal vibrators horizontally. Once consolidation is complete in one area, remove the vibrator vertically and move the vibrator to the next area. Regardless of the vibration method, insure that the field of vibration overlaps with another insertion to best consolidate the concrete and minimize defects. Some external vibrators are mounted on a piece of steel attached to the form. Position them to allow for overlap of vibration areas.

Continue the vibration process until the product is completely consolidated. Vibration is considered complete when large bubbles (3/8" diameter or greater) no longer appear at the surface.

Also take care to not overvibrate, because segregation of the aggregate from the cement paste can result lowering concrete quality and strength.

Finishing Unformed Surfaces

Each product is to be finished according to its individual specifications. If finishing techniques are not specified, take care to avoid floating either too early or for too long. Premature finishing can trap bleed water below the finished surface, creating a weak layer of concrete susceptible to freeze-thaw cycles and chemical attack. Finishing with a wood or magnesium float is recommended.

CURING PROCEDURES

Two critical elements in curing concrete are maintaining correct moisture content and maintaining correct concrete temperature. Proper curing is important in developing watertightness, chemical resistance, and strength and durability, all important considerations in on-site wastewater tank construction.

Note: Concrete temperature discussed in this manual refers to the temperature of the concrete itself, not the ambient temperature.

The nature of precast operations poses unique challenges to proper curing. To ensure cost-effective use of forms, precasters often strip the forms at the beginning of the next workday. That is an acceptable standard, according to ACI 308, "Standard Practice for Curing Concrete." The time necessary to develop enough strength to strip the forms is highly dependent on ambient temperature in the casting area.

The Portland Concrete Association (PCA) lists three methods of curing:

1. Maintaining water moisture by wetting (fogging, spraying, wet coverings, etc.)
2. Preventing the loss of water by sealing (plastic coverings or applying curing compounds)
3. Applying heat (often in conjunction with moisture, with heaters or live steam)

Choose the method(s) that best suit the particular production operation. All three are permissible, but preventing the loss of water (method 2) may be the simplest choice for on-site wastewater tanks. Maintaining moisture requires constant wetting, which is manpower-intensive. Alternate wetting and drying can lead to problems with cracking. Steam curing can also be effective. Concrete temperatures should never exceed 150 F. Both of these techniques are described in ACI 308, "Standard Practice for Curing Concrete," and the PCA publication "Design and Control of Concrete Mixtures."

Plastic coverings or membrane-forming curing compounds require less manpower and allow form stripping the next work day. There are some special considerations for both:

1. Plastic sheeting must comply with ASTM C171, "Standard Specification for Sheet Materials for Curing Concrete," which specifies a minimum thickness of 4 mm and be either white or opaque in color. PCA states that other colors can be used depending on sun conditions and temperature. When using multiple sheets, overlap them by approximately 18 inches to prevent moisture loss.

2. Curing compounds can be applied when bleed water is no longer present on the surface. As with plastic, white-colored compounds might reflect sunlight better and limit temperature gain. Follow the manufacturer's recommendations.

Cold and Hot Weather Concreting

In hot and cold weather, special precautions are necessary.

Cold Weather – Hydration rates are slower during cold weather. Concrete temperatures below 50 F are considered unfavorable for pouring due to the extended time required for strength gain and the possibility of freezing. However, once concrete reaches a minimum strength of 500 psi (usually within 24 hours) freezing has a limited impact. Ideally, precast concrete operations should be performed in heated enclosures that will provide uniform heat to the products until they reach 500 psi. If necessary, heating the mixing water and/or aggregates can increase the concrete temperature. Do not heat water above 140 F, and do not use clumps of frozen aggregate and ice. ACI 306, "Cold Weather Concreting," contains further recommendations on cold-weather concreting.

Hot Weather – High temperatures accelerate hydration. Do not allow fresh concrete temperature to exceed 90 F at time of placement. Keep the temperature of the concrete mix as low as possible using a variety of means, including:

- Shading the aggregate piles
- Wetting the aggregates (mix design must be adjusted to account for the additional water)
- Using chilled water

Note: During the curing process, ensure that the concrete temperature does not exceed 150 F. In all cases, protect freshly cast products from direct sunlight and drying wind. ACI 305, "Hot Weather Concreting," contains further recommendations on hot-weather concreting.

POST-POUR OPERATIONS

Handling Equipment

Cranes, forklifts, hoists, chains, slings and other lifting equipment must be able to handle the weight of the product with ease and comply with federal and local safety requirements.

Routine inspections of all handling equipment are necessary. Qualified personnel should make periodic maintenance and repairs as warranted. Tag all chains and slings with individual load capacity ratings. For U.S. plants, refer to the specific requirements of the Occupational Safety and Health Administration (OSHA). For Canadian plants, refer to the specific requirements of the Canadian Centre for Occupational Health and Safety (CCOHS).

Stripping and Handling Products

Minimum Strength Requirement – Concrete must gain sufficient strength before stripping it from the forms. Due to the nature of the precast business, the American Concrete Institute recognizes that forms will usually be stripped the next workday. Under normal conditions (concrete temperature greater than 50° F), properly designed concrete can reach the minimum compressive strength for stripping within this time period. Periodic compressive strength testing of one-day or stripping strength cylinders is recommended to confirm that proper concrete strength is attained.

Handle recently poured and stripped products with care. Perform lifting and handling carefully and slowly to ensure that dynamic loads do not damage the tank. Always follow recognized safety guidelines.

Product Damage During Stripping – Inspect the tank immediately after stripping to check for damage.

Post-Pour Inspections

A post-pour inspection checklist, as illustrated on the following page, provides a method of identifying and communicating quality problems as they occur and to identify any trends. After stripping a tank from its form, inspect the tank for conformance with the fabrication drawings. Clearly label all products with the date of manufacturing and mark these in accordance with ASTM C1227, "Standard Specification for Precast Concrete Septic Tanks."

POST-POUR CHECKLIST

PRODUCT: ____ Job No. _____________

Casting Date:__________	Sun	Mon	Tues	Wed	Thurs	Fri	Sat
Inspection Date:______							
Mark Number							
Stripping Strength							
Top Finish							
Bottom Finish							
Surface Texture							
As Cast Length (ft/in)							
As Cast Width (ft/in)							
As Cast Depth (ft/in)							
Cracks or Spalls							
Squareness							
Chamfers							
Honeycomb / Grout Leak							
Bowing							
Exposed Reinforcement							
Exposed Chairs							
Plates and Inserts							
Chamfer & Radius Quality							
Openings / Blockouts							
Lifting Devices							

REMARKS: ____
____
____
____
____
____

QC Supervisor __________________ Date ________ Inspector _________________ _________________

FINISHING AND REPAIRING CONCRETE

Finished Formed Surfaces – Formed surfaces must be relatively smooth and free of significant honeycombed areas, air voids and "bugholes."

Repairing Minor Defects – Defects that do not impair the use or life of the product are considered minor or cosmetic and may be repaired in any manner that does not impair the product.

Repairing Honeycombed Areas – Remove all loose material from the damaged area. Cut back the damaged zone in horizontal or vertical planes deep enough to remove the damaged concrete. Coarse aggregate particles should break rather than merely dislodge when chipped. Use only materials that are specifically developed for concrete repair, and make repairs according to the manufacturers' specifications.

Repairing Major Defects – Major defects are defined as those that impair the intended use or structural integrity of the product. If possible, repair products with major defects by using established repair and curing procedures only after a qualified person evaluates the feasibility of the repair.

Secondary Pours

For products that require secondary pours, establish procedures to assure that the new concrete bonds adequately to the product and becomes an integral part of it.

The surfaces of the product against which the secondary pour is to be made should be free of laitance, dirt, dust, grease or any other material that will tend to weaken the bond between the original and new concretes. If the surface is very smooth, roughen it to help promote a good bond. As a minimum, use a high-quality water stop, keyway and continuation of reinforcing between pours to ensure a watertight joint.

Cold Joints

Cold joints require special care and, as a minimum, should include a high-quality water stop, bonding agent and continuation of reinforcing between pours.

Storage of Products

Storage areas must be flat and strong enough to support the product without causing damage. Store the product in a manner that will not damage it in any way while stacking, moving or handling and in a manner that will facilitate rotation of inventory.

Marking of Products

Unless otherwise specified by project specifications or authority having jurisdiction, mark tanks and tank lids in accordance with ASTM C1227, "Standard Specification for Precast Concrete Septic Tanks."

Final Product Inspection

Check the tanks visually at the plant prior to shipping, preferably after being loaded and secured on the delivery vehicle.

Product Shipment

All vehicles used to transport products must be in good condition and capable of handling the product without causing damage. Allow tanks to adequately cure prior to shipment to a job site or distant storage areas. Secure all products properly with appropriate blockage and either nylon straps or chains with guards in order to avoid product damage during shipment. NPCA's publication "Cargo Securement for the Precast Concrete Industry" outlines proper methods for securing product. The final inspection should include a check of these items.

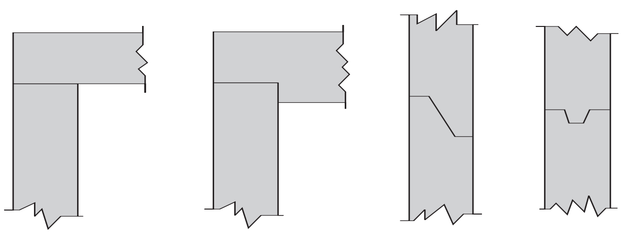
SEALS, FITTINGS AND JOINTS

Joint details, sealing materials and pipe connectors are important to the watertight integrity of on-site wastewater tanks. Systems to be installed in areas with high water tables require special consideration for joint and connection seal designs.

Joint Designs

To ensure structurally sound mid-seam tank with watertight joints, use only interlocking joints. Interlocking joints have the effect of increasing the overall structural strength of mid-seam tanks. The most common types of interlocking joints used in tank construction are tongue-and-groove and lap joints. Non-interlocking joints are acceptable on top-seam tanks provided that the top piece (lid) is properly secured to the structure with appropriate sealing materials.

Examples of tank joints are illustrated in the following diagrams.



Sealing Materials

Use high-quality, preformed, flexible joint sealants to achieve a watertight seal in multiple-piece tanks. Characteristics of high-quality joint sealants include:

- Compressibility in ambient temperatures below 40 F
- Adhesion to clean, dry surfaces
- Resistance to degradation caused by aging (shrinkage, hardening or oxidizing)
- Resistance to degradation caused by exposure to sewage materials

Sealants conforming to ASTM C990 typically meet the criteria listed above.

Sealant Size

A critical factor when evaluating the sealing potential of a sealant is cross-sectional area. Cross-sectional area is defined as the geometric shape of the sealant (i.e., 0.75 inches high by 1.0 inches wide). Industry experience has shown that a sealant's cross-sectional height must be compressed a minimum of 30 percent to create a good seal; 50 percent compression is desirable.

Apply sealants to form a continuous length of seal. Properly splice the sealant by one of the following methods:

- Overlap splice – Place one piece on top of the other and carefully mold together
- Side-by-side – Place ends in a parallel position and carefully mold the two pieces together

Pipe to Tank Seals

The connection between the pipe and tank must be accomplished with a watertight, resilient connector. This connector must be the sole means of sealing between the pipe and tank and cannot permit the infiltration of fluids or loss of vacuum around installed pipes (or pipe stubs) when tested in accordance with the requirements of this specification. Connectors conforming to ASTM C923 fulfill the requirement of this section. In the event that an ASTM International specification for pipe-to-tank connectors becomes available, connectors in accordance with this new specification are also acceptable for use in this application.

Access Risers and Manholes

All access risers and manholes must be structurally sound and watertight.

TANK INSTALLATION

Proper installation of the tank is absolutely critical for maintaining structural integrity and watertightness. Many of the problems experienced with leakage can be attributed to incorrect installation procedures. In addition to damage to the tank, improper installation techniques could be a safety hazard.

Site Conditions

The installation site must be accessible to large, heavy trucks weighing up to 80,000 pounds. The construction area should be free of trees, branches, overhead wires or parts of buildings that could interfere with the delivery and installation of the on-site wastewater tank. Most trucks will need to get within 3 to 8 feet of the excavation to be unloaded.

Excavation

Prior to excavation, identify and locate all buried utilities. Follow OSHA regulations governing excavation work at all times. Excavations should be sloped to comply with all construction safety requirements.

Bedding

Proper use of bedding material is important to ensure a long service life of an on-site wastewater treatment system. Use imported bedding material as necessary to provide a uniform bearing surface. A good base should ensure that the tank would not be subjected to adverse settlement. Use a minimum of 4 inches thickness of sand or granular bed overlying a firm and uniform base unless otherwise specified. Tanks should not bear on large boulders or rock edges.

Sites with silty soils, high water tables or other “poor” bearing characteristics must have specially designed bedding and bearing surfaces. In the presence of high water tables, structures should be properly designed to resist floatation.

Proper compaction of the underlying soils and bedding material is critical to eliminate later settlement, which can ultimately occur in all tank installations regardless of the tank material. Potential tank settlement is measurable, predictable and preventable. Proper evaluation of the original soil, bedding materials, water table, backfill materials and potential soil bearing stresses reduces the likelihood of later tank settlement. Set the tanks level to provide the proper elevation drop from the inlet to the outlet.

Worker safety is of primary importance. If it is necessary to have a worker enter the excavation to check elevation or compact bedding materials, use proper excavation methods that will prevent the sidewalls from collapsing. Alternatively, trench boxes may also be used if necessary.

Tank Placement

Prior to placement in the excavation, confirm the tank’s orientation. Check the bedding material and ensure that inlet penetrations face the residence. After placement, check that the tank is level. The slope of the sewer line and tank elevation should meet local plumbing and building codes.

Lifting Devices

Verify lifting apparatus such as slings, lift bars, chains and hooks for capacity, and ensure an adequate safety factor for lifting and handling products. The capacity of commercial lifting devices must be marked on the devices.

All lifting devices and apparatus should meet OSHA requirements documented in “Code of Federal Regulations” Title 29 Part 1926. Other applicable codes and standards are ANSI A10.9 and ASTM C857, C890 and C913.

A factor of safety of at least 4 is recommended for lifting devices. Manufacturers of standard lifting devices should provide test data to allow selection of appropriate loading.

Because of their brittle nature, do not use reinforcing bars as lifting devices. Use smooth bars made of steel conforming to ASTM A36 instead.

A factor of safety of at least 5 is recommended for lifting apparatus, such as chains, slings, spreader beams, hooks and shackles.

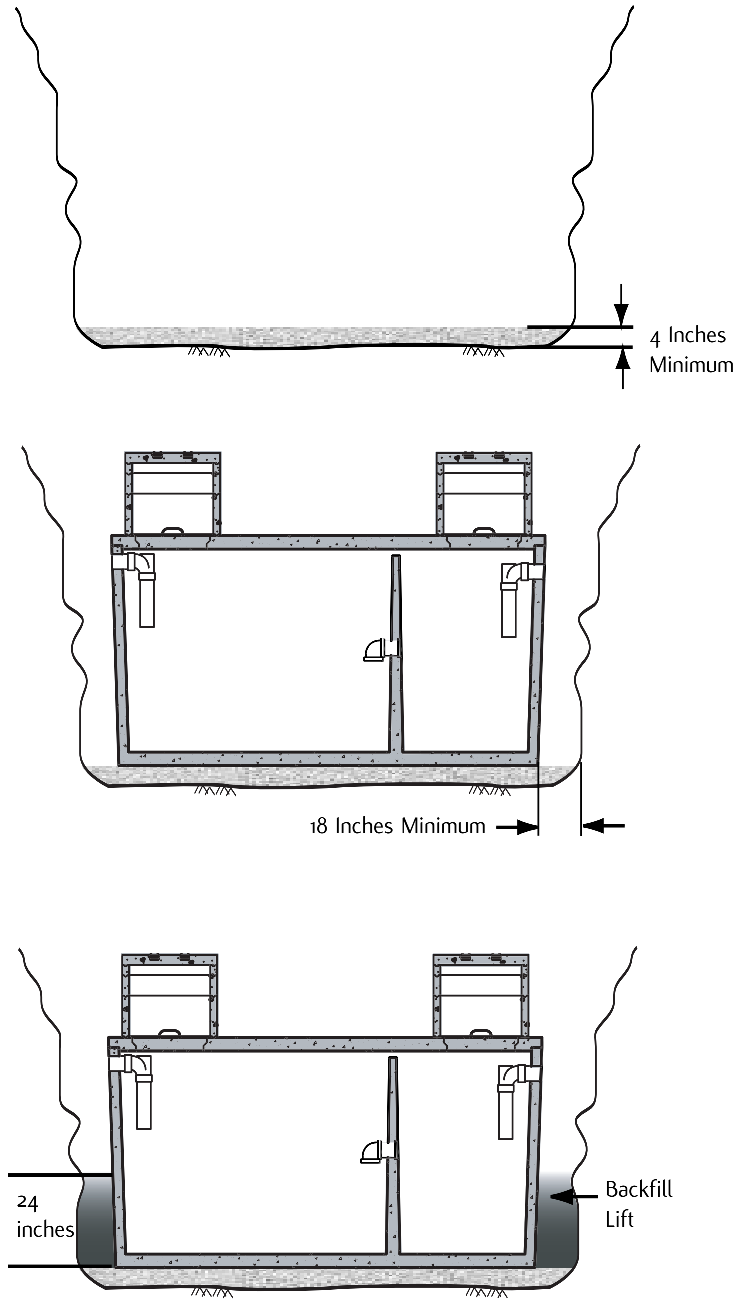
Joint Seals

For two-piece tanks, use high-quality preformed joint seals. Surfaces should be clean. Ensure seals meet minimum compression and other installation requirements as prescribed by the seal manufacturer and detailed herein. During the time of installation, ambient temperatures below 50 F sometimes affect the compressibility of the sealant. Care must be taken to determine that tank sections installed on site have been properly sealed. Inspecting the joint area to determine that the tank sections have been properly seated helps prevent soil materials from entering the joint area during backfilling operation. Properly seal manholes and risers to prevent infiltration.

Backfilling

Place backfill in uniform layers less than 24 inches thick. Backfill should be free of any large stones (greater than 3 inches in diameter) or other debris.

Figure 3 — Basic principles of bedding, tank placement and backfilling



TESTING

Stripping Strength Testing
Perform periodic compressive strength testing at one day, or test stripping strength cylinders. The frequency is at the judgment of the precaster and based on the plant's quality control manual. Cure these cylinders in a similar manner as the finished product.

Tank Testing
Each plant must develop a quality control program that includes testing. Define the test procedures clearly prior to tank fabrication and installation. Consider whether tests will be conducted in the plant or on the job site (prior to or after backfilling). Use one of the following two primary testing methods:

Vacuum Testing
The recommended procedure is to introduce a minimum vacuum of 4 inches of mercury and hold this pressure for five minutes.

Depending upon the tank configuration, it may take some time to stabilize the vacuum level due to various factors (compression of sealant, temperature variations, etc.). It is permissible to apply vacuum until the vacuum level stabilizes at 4 inches. Once vacuum is stabilized, remove the vacuum source and hold the vacuum for 5 minutes. If the tank fails the test, it may be repaired and retested. The suggested range of the gauge is 0-10 inches of mercury (maximum).

WARNING: Testing with negative pressure involves potentially hazardous conditions. It is recommended that the negative air pressure testing of concrete tanks not exceed 7 inches of mercury, which is the recognized maximum requirement for structural strength proof testing. Take precautions to minimize potential risks by incorporating safety devices that will prevent excessive vacuum levels (safety release valves, etc).

Water Testing
Fill the tank with water to 2 inches above the top of the cover inside the riser and allow it to stand for 24 hours. If there is visible leakage (water flowing or dripping in a steady stream), repair the tank, refill it and allow it to stand for one hour. No visible leakage is allowed. Do not reject the tanks for damp spots on the exterior. If water is dripping or flowing in a steady stream, repair the tank and retest. Condensation on the exterior of the tank due to temperature variation is not considered a failure.

Select the method and location of testing in order to ensure watertightness and to ensure that the actual test load condition does not exceed engineered design.

Frequency of Testing
Perform testing on one tank per form per year at a minimum or every 250 tanks per form, whichever is greater. Forms producing tanks that fail this test must undergo additional testing commencing with the next production of tanks from the form and continuing until 10 consecutive tanks pass the test.

REFERENCES

Specifications

American Concrete Institute (ACI)

ACI 116R, "Cement and Concrete Terminology"

ACI 211.1, "Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete"

ACI 211.3, "Standard Practice for Selecting Proportions for No-Slump Concrete"

ACI 212.3, "Chemical Admixtures for Concrete"

ACI 304R, "Guide for Measuring, Mixing, Transporting and Placing Concrete"

ACI 305R, "Guide for Hot Weather Concreting"

ACI 306R, "Guide for Cold Weather Concreting"

ACI 308R, "Guide to Curing Concrete"

ACI 318, "Building Code Requirements for Structural Concrete and Commentary"

ACI 350R, "Code Requirements for Environmental Engineering Concrete Structures and Commentary"

ACI 544, "State-of-the-Art Report on Fiber Reinforced Concrete"

ASTM International

ASTM A185, "Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete Reinforcement"

ASTM A496, "Standard Specification for Steel Wire, Deformed for Concrete Reinforcement"

ASTM A497, "Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete Reinforcement"

ASTM A615, "Standard Specification for Deformed and Plain Carbon Steel Bars for Concrete Reinforcement"

ASTM A706, "Standard Specification for Low Alloy Steel Deformed Bars and Plain for Concrete Reinforcement"

ASTM A820, "Specification for Steel Fibers for Reinforced Concrete"

ASTM C33, "Standard Specification for Concrete Aggregates"

ASTM C125, "Standard Terminology Relating to Concrete and Concrete Aggregates"

ASTM C150, "Standard Specification for Portland Cement"

ASTM C260, "Standard Specification for Air-Entraining Admixtures for Concrete"

ASTM C494, "Standard Specification for Chemical Admixtures for Concrete"

ASTM C595, "Standard Specification for Blended Hydraulic Cements"

ASTM C618, "Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete"

ASTM C890, "Standard Practice for Minimum Structural Design Loading for Monolithic or Sectional Precast Concrete Water and Wastewater Structures."

ASTM C913, "Standard Specification for Precast Concrete Water and Wastewater Structures"

ASTM C1017, "Chemical Admixtures for Use in Producing Flowing Concrete"

ASTM C1116, "Standard Specification for Fiber Reinforced Concrete and Shotcrete"

ASTM C1227, "Standard Specifications for Precast Concrete Tanks"

ASTM C1602, "Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete "

ASTM D6, "Standard Test Method for Loss on Heating of Oil and Asphaltic Compounds"

American Welding Society (AWS)

AWS D1.4, "Structural Welding Code - Reinforcing Steel"

Occupational Safety and Health Administration (OSHA)

29 CFR 1910.184 (Slings)

29 CFR 1926.650-652 (Excavation)

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Hunter, L.E., “Concrete Waterproofing,” Pitman & Sons, London, 1947

Kosmatka, Steven H. and Panarese, William C., “Design and Control of Concrete Mixtures,” 13th edition, Portland Cement Association, Skokie, Illinois, 1988

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Mindess, Sidney and Young, Francis T., “Concrete,” Prentice Hall, Englewood Cliffs, N.J. 1981

Neville, A.M., “Properties of Concrete,” 4th edition, Wiley & Sons, New York, 1996

U.S. Department of Interior, “Concrete Manual,” 8th edition, Denver, 1981

American Concrete Institute, ACI 350-89, “Environmental Concrete Structures,” Farmington Hills, MI

Portland Cement Association, “Circular Concrete Tanks without Prestressing,” 1993, Skokie, IL

Portland Cement Association, “Design and Control of Concrete Mixtures,” Fourteenth Edition, 2002

Portland Cement Association, “Rectangular Concrete Tanks,” 1994, Skokie, IL

U.S. Department of Interior, “Concrete Manual,” 8th edition, Denver, 1981

Waddell, Joseph, “Fundamentals of Quality Precast Concrete,” National Precast Concrete Association, Indianapolis, IN

GLOSSARY

admixture – a material other than water, aggregates, cement and fiber reinforcement used as an ingredient of concrete and added to the batch immediately before or during its mixing.

admixture, accelerating – an admixture that accelerates the setting and early strength development of concrete.

admixture, air-entraining – an admixture that causes the development of a system of microscopic air bubbles in concrete, mortar or cement paste during mixing.

admixture, water-reducing – admixture that either increases the slump of freshly mixed concrete without increasing the water content or that maintains the slump with a reduced amount of water due to factors other than air entrainment.

aggregate – granular material, such as sand, gravel, crushed stone or iron blast-furnace slag used with a cement medium to form hydraulic-cement concrete or mortar.

aggregate, coarse – generally pea-sized to 2 inches; aggregate of sufficient size to be predominately retained on a No. 4 sieve (4.75 mm).

aggregate, fine – generally coarse sand to very fine; aggregate passing the 3/8 inch sieve (9.5 mm) and almost entirely passing a No. 4 sieve (4.75 mm) and predominately retained on the No. 200 sieve (0.75 mm).

air content – the volume of air voids in cement paste, mortar or concrete, exclusive of pore space in aggregate particles; usually expressed as a percentage of total volume of the paste, mortar or concrete.

ASTM – ASTM International is a not-for-profit organization that provides a forum for producers, users, ultimate consumers and those having a general interest (government and academia) to meet and write standards for materials, products, systems and services.

bedding material – gravel, soil, sand or other material that serves as a bearing surface on which a structure rests and which carries the load transmitted to it.

bleeding – the separation of mixing water or its emergence from the surface of newly placed concrete caused by the settlement of the solid materials.

bonding agent – a substance applied to a suitable substrate to create a bond between it and a succeeding layer, such as between a layer of hardened concrete and a layer of fresh concrete.

cement, hydraulic – cement that sets and hardens by chemical interaction with water and is capable of doing so under water.

cementitious material – an inorganic material or mixture of inorganic materials that set and develop strength by chemical reaction with water by formation of hydrates.

cold joint – a joint or discontinuity formed when a concrete surface hardens before the next batch is placed against it.

concrete – a composite material that consists essentially of a binding medium within which are embedded particles of aggregate fragments, usually a combination of fine aggregate and coarse aggregate; in portland cement concrete, the binder is a mixture of portland cement and water.

concrete, fresh – concrete that possesses enough of its original workability so that it can be placed and consolidated by the intended methods.

compressive strength – measured maximum resistance of a concrete or mortar specimen to axial compressive loading; expressed as a force per unit cross-sectional area; or the specified resistance used in design calculations.

consistency – the relative mobility or ability of freshly mixed concrete to flow; it is usually measured by the slump test.

consolidation – the process of inducing a closer arrangement of the solid particles in freshly mixed concrete during placement by the reduction of voids, usually accomplished by vibration, centrifugation, rodding, tamping or some combination of these actions. Consolidation facilitates the release of entrapped air; as concrete subsides, large air voids between coarse aggregate particles are filled with mortar.

curing – action taken to maintain moisture and temperature conditions in a freshly placed cementitious mixture to allow hydraulic cement hydration and, if applicable, pozzolanic reactions to occur so that the potential properties of the mixture may develop.

curing compound – a liquid that can be applied as a coating to the surface of newly placed concrete to retard the loss of water or to reflect heat in order to provide an opportunity for the concrete to develop its properties in a favorable temperature and moisture environment.

deleterious substances – materials present within or on aggregates that are harmful to fresh or hardened concrete, often in a subtle or unexpected way. More specifically, this may refer to one or more of the following: materials that may be detrimentally reactive with the alkalis in the cement (see alkali aggregate reactivity) clay lumps and friable particles, coal and lignite, etc.

dry-cast (no-slump concrete) – concrete of stiff or extremely dry consistency showing no measurable slump after removal of the slump cone.

differential settlement – the uneven sinking of material (usually gravel or sand) after placement.

elongated aggregate – a particle of aggregate where its length is significantly greater than its width.

entrained air – see air void; microscopic air bubbles intentionally incorporated into mortar or concrete during mixing, typically between 10 μm and 1,000 μm (1 mm) in diameter and spherical or nearly so.

exfiltration - to cause (as a liquid) to flow outward through something by penetrating its pores or interstices.

fiber reinforcement – discontinuous tensile filaments of steel or synthetic materials designed to provide secondary reinforcement of concrete structures and to help mitigate the formation of plastic shrinkage cracks.

float – a tool, usually of wood, aluminum or magnesium, used in finishing operations to impart a relatively even but still open texture to an unformed fresh concrete surface.

floating – the operation of finishing a fresh concrete or mortar surface by use of a float, preceding troweling when that is to be the final finish.

fly ash – the finely divided residue transported by flue gases from the combustion of ground or powdered coal; often used as a supplementary cementitious material in concrete.

forms (molds) – a structure for the support of concrete while it is setting and gaining sufficient strength to be self-supporting.

friable – easily crumbled or pulverized, as it refers to aggregates.

gap grading – aggregate graded so that certain intermediate sizes are substantially absent (i.e., aggregate containing large and small particles with medium-size particles missing).

gradation – the particle-size distribution as determined by a sieve analysis (ASTM C 136, etc.); usually expressed in terms of cumulative percentages larger or smaller than each of a series of sizes (sieve openings) or the percentages between certain ranges of sizes (sieve openings).

hydration – formation of a compound by the combining of water with some other substance; in concrete, the chemical process between hydraulic cement and water.

infiltration – to cause (as a liquid) to permeate something by penetrating its pores or interstices.

organic impurities (re: aggregate) – extraneous and unwanted organic materials (twigs, soil, leaves and other debris) that are mixed in aggregates; these materials may have detrimental effects on concrete produced from such aggregates.

OSHA – Occupational Safety and Health Administration, U.S. Department of Labor.

plastic concrete – see concrete, fresh.

portland cement – hydraulic cement produced by pulverizing portland cement clinker, usually in combination with calcium sulfate.

pozzolan – a siliceous or siliceous and aluminous material that in itself possesses little or no cementitious value but will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperatures to form compounds possessing cementitious properties.

psi – pounds per square inch

secondary pour – a situation when a succeeding layer of concrete is placed on previously placed hardened concrete.

segregation – the unintentional separation of the constituents of concrete or particles of an aggregate, resulting in nonuniform proportions in the mass.

set – the condition reached by a cement paste, mortar or concrete when it has lost plasticity to an arbitrary degree, usually measured in terms of resistance to penetration or deformation; initial set refers to first stiffening; final set refers to attainment of significant rigidity.

silica fume – very fine noncrystalline silica produced in electric arc furnaces as a byproduct of the production of elemental silicon or alloys containing silicon; also known as condensed silica fume and micro silica. It is often used as an additive to concrete and can greatly increase the strength of a concrete mix.

slump – a measurement indicative of the consistency of fresh concrete. A sample of freshly mixed concrete is placed and compacted by rodding in a mold shaped as the frustum of a cone. The mold is raised, and the concrete is allowed to subside. The distance between the original and displaced position of the center of the top surface of the concrete is measured and reported as the slump of the concrete. Under laboratory conditions, with strict control of all concrete materials, the slump is generally found to increase proportionally with the water content of a given concrete mixture and thus to be inversely related to concrete strength (unless water-reducing admixtures are used). Under field conditions, however, such a strength relationship is not clearly and consistently shown. Therefore, take care when relating slump results obtained under field conditions to strength (ASTM C 143).

specification – an explicit set of requirements to be satisfied by a material, product, system or service that also indicates the procedures for determining whether each of the requirements is satisfied.

standard – as defined by ASTM, a document that has been developed and established within the consensus principles of the Society.

superplasticizer – see admixture, water-reducing. Superplasticizers are also known as high-range water-reducing admixtures.

Supplementary Cementitious Materials (SCMs) – finely divided, powdered or pulverized materials added to concrete to improve or alter the properties of the plastic or hardened concrete.

surcharge – a surface load applied to the structure, transferred through the surrounding soil.

troweling – smoothing and compacting the unformed surface of fresh concrete by strokes of a trowel.

water-cementitious ratio – the ratio of the mass of water, exclusive only of that absorbed by the aggregates, to the mass of portland cement in concrete, mortar or grout; stated as a decimal and abbreviated as w/c.

waterstop – a thin sheet of metal, rubber, plastic or other material inserted across a joint to obstruct the seepage of water through the joint.

water table – the upper limit of the portion of the ground wholly saturated with water.

workability of concrete – that property of freshly mixed concrete or mortar that determines the ease with which it can be mixed, placed, consolidated and finished to a homogenous condition.

This Best Practices Manual is subject to revision at any time by the NPCA Septic Tank Product Committee, which must review it at least every three years.

Special thanks are given to the Septic Tank Product Committee for updating/compiling this manual.

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