UNIFIED VOICE

for the concrete burial vault industry

NATIONAL CONCRETE BURIAL VAULT ASSOCIATION, INC.

Performance Standards and Plant Certification

This publication will serve as the standard whereby burial vault producers, customers and all interested parties may judge the structural integrity of outer burial receptacles being brought to the marketplace. The procedures outlined in this report are designed to demonstrate performance under the wide variety of soil and vehicle loads which the typical concrete burial vault and grave liner must withstand. The NCBVA has established testing procedures which will demonstrate whether or not the units manufactured meet minimum performance specifications and criteria.

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1 Introduction

The National Concrete Burial Vault Association (NCBVA) was chartered in 1929 as a voluntary nonprofit organization of independently owned and operated concrete burial vault manufacturers throughout the United States and Canada. The purpose of the organization is to provide a unified voice for the concrete burial vault industry regardless of product affiliation, brand recognition or location. Every major brand affiliation of concrete vault manufacturer is represented as a member of the organization. As an association, the NCBVA represents groups that provide the majority of all outer burial receptacles interred within the boundaries of its membership.

The NCBVA recognizes its leadership role in funeral service to continually research and develop, then specify and promote, minimum performance standards for the burial vault industry. This publication will serve as the standard whereby burial vault producers, customers and all interested parties may judge the structural integrity of outer burial receptacles being brought to the marketplace. The procedures outlined in this report are designed to demonstrate performance under the wide variety of soil and vehicle loads that the typical concrete burial vault and grave liner must withstand. The NCBVA has established testing procedures that demonstrate whether or not the units manufactured meet minimum performance specifications and criteria.

2 Engineering and Testing

The bulk of the testing data and load verification statistics cited in this report have been provided by the Twin City Testing Corporation, an independent testing facility located in Minneapolis, Minn. As of 1989 They were nationally renowned experts in evaluation and testing of concrete structures, mix designs and specifications. Their history of reliable and pertinent verification enabled Twin City Testing to develop a unique testing process for the burial vault industry which simulated actual burial conditions and the static loads, impact loads and other dynamic loads associated with the performance of outer burial receptacles. Meanwhile, in the decades following the 1989 Twin Cities report, yet another method for simulating the effect of full-cover loading evolved. In October 2020, an updated review of the testing was performed and submitted by James W. Phillips, Ph.D., P.E. from the University of Illinois at Urbana-Champaign, and this report “Certification of Strength test methods for Burial Vaults” serve as an addendum to the 1989 Twin Cities report titled NCBVA Performance Specifications Project No. 4124 89- 043.01

3 Outer Burial Receptacle Performance Requirements – Past, Present and Future

The concrete outer burial receptacle evolved around the turn of the twentieth century. Its primary function was to provide protection for the casketed remains. As cemeteries began to offer perpetual care of grave spaces, the primary function of the outer burial receptacle gradually changed. Cemeteries started requiring the use of outer burial receptacles to support the weight of the earth and cemetery equipment, preventing a succession of grave collapses due to settling. This enabled the cemeteries to perform their perpetual custodial duties with a minimum of gravesite backfilling, seeding and other maintenance functions.

Over the succeeding years the requirements for the outer burial receptacle evolved further as cemeteries in large metropolitan areas began to use more and more modern and heavy equipment to excavate grave sites, transport fill materials and generally maintain cemetery grounds. The use of this larger, heavier and more efficient equipment necessitated an increased level of performance from the outer burial receptacle. The burial vault industry has made changes in design and structural integrity of their units to accommodate these additional stresses and performance requirements.

As the burial vault industry advanced and provided stronger, more reliable concrete units to fulfill cemetery minimum requirements, consumers' desires for additional features were simultaneously enhanced. At first, outer burial receptacles incorporated coatings such as asphalt and other similar coatings in conjunction with the concrete to reduce the risk of the intrusion of exterior elements. The design of outer burial receptacles incorporated the air dome principle in some areas of the country, as well as tongue-in-groove sealing joints using various sealants. Eventually the evolution of the burial vault led to the development of fiberglass, polystyrene, ABS plastic and various metal lining materials. These were incorporated in the production of burial vaults to offer additional strength and security.

It is the Association's intent to not only provide specifications, but to suggest a method for certification and verification on a plant-by-plant basis. The NCBVA recognizes that cemeteries will continue to make changes regarding equipment and burial practices, which in turn require increasingly greater performance demands on outer burial receptacles. The NCBVA realizes these specifications and certification process must be flexible enough to accommodate and allow for such industry changes in the future.

4 Types and Functions of Outer Burial Receptacles

As a result of changes in the functions and demands required of outer burial receptacles, the NCBVA has defined two distinct categories of burial units. The purpose for the two category levels is to differentiate between minimal structural requirements specified by many cemeteries, and the additional features increasingly expected by consumers in today's market. The definitions of a concrete burial vault and a concrete grave liner as accepted by the NCBVA are noted below.

4.1 Definition of a Concrete Graveliner

A burial receptacle placed in the ground in a cemetery, either sectional, dome or box form designed and built to support the weight of the earth and standard cemetery maintenance equipment and to prevent the grave from collapsing.

4.2 Definition of a Concrete Burial Vault

A lined and sealed burial receptacle which performs all the functions of the concrete grave liner, and in addition is designed and constructed using one or more lining and sealing materials to increase the overall tensile strength of the finished unit and to reduce the risk of the intrusion of exterior elements.

Given the definitions, a “concrete grave liner” must be able to perform to minimum specifications, while the “concrete burial vault” will most likely far exceed minimum loading and stress conditions that would be acceptable for the minimum unit.

Specifications contained in this report will establish the minimum (I think something needs to go after min…), which can be used as a baseline to judge all concrete outer burial receptacles. A concrete burial vault, then, may perform much more than the minimum specifications required for all outer burial receptacles. Numerous types of materials are available to the manufacturer for use in providing the lining and sealing functions. Additional sealing feature claims made for a burial vault are the sole responsibility of the individual manufacturer. Please note, however, that any time a manufacturer makes a performance claim (whether or not reflected in a warranty), the manufacturer assumes responsibility for research and development, testing and verification of such claims.

5 Loads and Stresses on an Interred Burial Vault or Graveliner

An interred outer burial receptacle is subject to a variety of different stresses placed on it by the gravesite environment. The performance of the unit is best judged by evaluating it under these different types of loading conditions. The NCBVA intends to review the typical loading conditions that burial vaults and grave liners are subject to on an ongoing basis. Additional explanations and detailed information can be obtained by referring to SECTION 2.

5.1 Static Loads

Static Loads are the continual force at work on the outer burial receptacle from all sides and directions under normal grave conditions. These conditions include a combination of constant pressure exerted on a unit as a result of soil, moisture and the effects of temperature change. Specifically, this would include the force exerted by the weight of the backfilled soil, as well as the additional pressures created by fluctuations in the water table, freeze/thaw temperatures and other normal variations found in the natural state.

5.2 Differential Loads

Differential Loads can occur from stockpiled soil excavated from an adjacent grave. Although these loads can be heavy, their effect should be short term and within the factor of safety assumed in the design of the outer burial receptacle. The additional stresses placed on the unit by differential loads are considered to be normal and usual conditions for all interment sites.

5.3 Dynamic Loads

Dynamic Loads could typically occur from vehicles driving over the top of a backfilled grave. As cemetery equipment has changed over the years it is this dynamic load that has increased substantially. NCBVA continually reevaluates the changes of dynamic loads in cemeteries and their corresponding effect on minimum specifications for outer burial receptacles. Considering the anticipated low speed of such vehicles, the effects of these loads should be similar to that of increased static load or differential loads.

5.4 Impact Loads

Impact Loads represent a short lived, high-energy contact by a mass. They are the most significant load to which the outer burial receptacle will ever be subject. The most common impact load occurs when large amounts of backfill soil are dumped on top of the outer burial receptacle during interment. This process may include large chunks of frozen earth or boulders striking the cover of the unit, creating extremely high stress. The use of compaction equipment (e.g., hand-tamping devices, Wacker-Packers, etc.) exert greater impact forces and have become customary in many cemeteries. Some of the subject cemeteries in the Twin City Testing study even went to the extreme of using the backhoe bucket to tamp the grave. It is difficult to anticipate the maximum possible impact load for the interred unit. In certain areas of the country dynamite must be used in a blasting operation in order to excavate gravesites. In other areas jack hammers or impact hammers are also used to break up rock and densely compacted subsoils. Obviously, the effect of these operations on outer burial receptacles in adjoining grave spaces is significant. The factor of safety for our minimum specifications, however, does include reasonable potential impact loads and conditions.

Every effort has been made to include the effects of these loads in determining the minimum specifications for burial vaults and grave liners. The NCBVA believes that all units manufactured according to the following guidelines will perform adequately under normal burial conditions. As previously stated, ongoing research and development may necessitate revisions and/or additions to these performance standards from time-to-time.

6 Minimum Performance Standards for Concrete Outer Burial Receptacles

6.1 Concrete Materials

6.1.1 Mix Design

The performance of a precast concrete burial vault or grave liner depends primarily upon the quality and strength of the concrete mix used in the manufacturing process. It is necessary, therefore, that currently accepted and technically correct procedures be followed to establish the mix design used in the manufacturing process. This mix design must be determined initially by accepted laboratory methods. There are many commercial laboratories that will provide this service in conjunction with their testing services. Most cement suppliers and admixture companies will also aid in the development of a technically correct and dependable mix design, sometimes at little or no cost to the producer. Some producers will have qualified plant personnel on staff who are capable of designing the mix.

After a mix has been determined as the plant standard, it must be field tested by using the batching and mixing equipment, as well as transporting and placement equipment normally used in production. The test of the mix design will allow for curing under normal conditions and then the appropriate tests administered to confirm that the concrete produced meets the strength and performance criteria of the mix design model.

The following publications contain some detailed methods of mix design:

- Portland Cement Association: Design and Control of Concrete Mixtures

- [American Concrete Institute: Recommended Practice for Selecting Proportions for Normal and Heavy Weight Concrete (ACI 211.1-74)]
- [Recommended Practice for Selecting Proportions for Structural Lightweight Concrete (ACI 211.2-69)]

All mix designs are developed using a specific brand of cement, fine and coarse aggregates which have been tested and come from reliably consistent sources, as well as brands of admixtures, etc. Anytime that any one of the components of the plant's standard mix design is changed, the mix design must be re-evaluated and the appropriate field tests performed.

6.1.2 Cement

Cement needs to comply with ASTM C 150 and be of the specified type. There are five primary types of cement generally used in the following applications:

- Type I Standard cement for general construction
- Type II Moderate heat of hydration and moderate sulfate resistance
- Type III High early strength
- Type IV Low heat of hydration Type V
- High sulfate resistance

Types I and III or a blend of Types I and II are generally used for concrete burial vaults and grave liners, while Types II, IV and V are considered specialty cements designed for unique applications. Types I-A and III-A ASTM C 150 are the corresponding cement types with interground air-entraining agents. For maximum control of air content, the NCBVA recommends the use of air-entraining admixtures instead of interground agents.

Evidence of conformance shall be a certified mill test report for each shipment or lot of cement. Cement should be stored in water-tight bins or, in the case of bagged cement, in a dry covered area. Any cement that develops lumps which cannot be easily broken up with light finger pressure must be discarded.

The NCBVA recommends a minimum of 700 pounds of cementitious material per cubic yard of concrete mixed. This ratio of cement, when mixed with an acceptable water/cement ratio, should provide the manufacturer with consistently acceptable strength concrete.

6.1.3 Mix Water

Mixing water to be used in producing concrete needs to be clean and not contain any injurious levels of acids, alkalis, oils, organic material, salts or other substances which may prove to be deleterious to concrete or steel. In most cases, potable water is an acceptable component of the concrete mix. The use of any non-potable water should be allowed only after the appropriate tests for contaminants have been performed. (These tests should be conducted by local water supply institutions).

6.1.4 Water/Cement Ratio

The NCBVA recommends that the plant standard mix design have a water/cement ratio of no more than .45. (See Illustration A) The slump of the mix should not exceed six inches prior to the addition of admixtures.

Illustration A – Typical Mix Design

Water 13.5 Gallons x 8.33 lbs.	112 lbs.
Cement	270 lbs.
Coarse Aggregate	480 lbs.
Fine Aggregate	520 lbs.
Water/Cement Ratio = 112/270 = .41	

The water/cement ratio greatly influences the slump of the concrete and therefore the workability of the concrete. Every effort should be made to keep this ratio as low as possible while still maintaining workability of the mix. By adding more water and increasing the water/cement ratio in order to accommodate placement of the concrete, final strengths of the finished product, as well as the durability of the concrete are diminished significantly. Some practical methods for water reduction and increased workability of mixes would include air-entraining and water-reducing admixtures. The proper use of state-of-the-art vibration equipment for compacting and consolidating the various sections of the vault form also plays an important part in working with lower slump mix designs.

6.1.5 Aggregates

The most important concern regarding aggregates is consistency. Once a mix design is developed and its dependability proven, it should enable the producer to consistently manufacture quality burial vaults and grave liners as long as there are no changes or variations in the mix design components. A primary focal point for guarding against unwanted variables is in the sand and stone supply.

All aggregates must conform to the requirements of ASTM C 33. Evidence of aggregate conformity must be supported with sieve analysis and gradation reports provided monthly by aggregate suppliers.

6.1.6 Fine Aggregate

The gradation of the fine aggregate must be consistent load after load in order to ensure that proper mortar-making properties and eventual concrete strengths are met. The fine aggregates should be obtained only from sources where representative samples have been subjected to all the necessary tests to determine that the concrete-making properties of the material are established.

The supplier will provide sieve analysis information showing the finus modulus of the sand for mix design purposes. A normal fm gradation would range between 2.5 - 3.1. Periodic tests should not allow a variation of the finus modulus by more than plus or minus 20 percent. Any excess variation in fine aggregate supply should require a review of the mix design and the appropriate testing for strength verification. Generally speaking, the higher the fm, i.e., the coarser particles available in the fine aggregate, the better the concrete mix will be for use in outer burial receptacles.

6.1.7 Coarse Aggregate

Only approved sources should be used for obtaining coarse aggregate. Initially, representative samples should be subject to any and all tests required by governing specifications and the samples must demonstrate the necessary and appropriate concrete making properties. Having once established the resistance to abrasion and soundness of the coarse aggregate in question, it is not usually necessary to perform further tests in these areas, unless a change is made in either the source or type of aggregate to be used. The maximum size of the coarse aggregate should be no larger than one third of the burial vault or grave liner wall thickness. It is important to ensure that coarse aggregate can readily flow into every part of the concrete form, including the tongue and groove sections, corners, etc.

6.1.8 Lightweight Aggregate

Lightweight aggregates must conform to the requirements of ASTM C 330. It is especially critical that lightweight concrete mixes undergo a sufficient program of testing in the field to prove that the strength and finished weight of the concrete produced are at an acceptable level. We encourage the producer to carefully investigate both the compressive and flexural strength loss when using such lightweight coarse aggregate. This will vary greatly depending on which lightweight aggregate is selected (e.g., Hadite, Slag, Lica, etc.). In any case, the finished product must still meet all minimum strength standards as set forth by these NCBVA specifications.

Lightweight aggregates are extremely sensitive in the areas of moisture and absorption. These variables can produce wide swings in the quality of the finished product. The moisture absorptive properties of the aggregate must be known within close limits. This will make it possible to develop and practice storage and handling methods capable of delivering the aggregate to the mixer in a condition as near as possible to a constant moisture content.

6.1.9 Admixtures

A variety of admixtures for precast concrete burial vaults and graveliners are used for the following purposes:

- Air-entraining
- Set retardation
- Set acceleration
- Superplasticizers — high range water reducers
- Water reduction and set retardation Self-
- Consolidating concrete (SCC)
- other cementitious materials

Air-entraining admixtures must conform to the requirements of ASTM C 260. Other admixtures must meet the requirements of ASTM C 494, Types A, B, C and D. Any type of admixture considered for use must be a material of standard manufacture, with a well-established test record to confirm its properties. It must always be used according to the manufacturer's recommendations. When using more than one admixture in a concrete mix, it is critical to determine that each material perform as required without affecting the performance of the other. Whatever the form of the admixture, the producer must ensure it is adequately distributed into the mix. Accurate measuring devices, as well as a precise dispensing apparatus, must be used to guarantee a controlled and uniform incorporation of the admixture with the other concrete components.

6.1.10 Calcium Chloride

The NCBVA strongly recommends that producers of burial vaults and grave liners do not use calcium chloride or admixtures containing calcium chloride in the manufacture of their products. There are many other accelerators available in the marketplace that provide a more reliable acceleration of the curing process. When the decision is made to use calcium chloride in the mix design, however, then the calcium chloride must be in solution and is not to exceed more than two percent of cement by weight.

6.1.11 Air-Entrainment

The NCBVA recommends that all mix designs for the manufacture of burial vaults and grave liners incorporate air-entraining. There are many advantages to be derived from using air entrainment. These advantages are especially important for the storage of the finished units in extreme weather and temperature conditions. The advantages of air entrainment include:

- Decreased bleeding,
- Increased resistance to the impact of freeze/thaw conditions,
- Increased resistance to the destructive action of salt, sulfate and other chemicals due to increased impermeability,
- Increased workability or reduction of water/cement ratio for the same degree of workability.

The benefits in the colder northern climates become obvious, while the other attributes can be realized in all areas, especially in light of the many different soil conditions encountered, and their varying salt and sulfate content.

The volume of entrained air should range from five to six per-cent and be maintained with plus or minus two percentage points. It will probably be necessary to determine the quantity of admixture necessary for each mix or combination of ingredients by trial. To exercise closer control of air content it is recommended that air-entraining admixtures, rather than air-entraining cement be used.

A pocket-size air indicator (AASHTO T199) can be used for quick checks of air content, but it is not a substitute for the other more accurate methods (volumetric or pressure). A representative sample of mortar from the concrete is placed in the container. The container is then filled with alcohol and rolled with the thumb over the open end to remove the air from the mortar. The approximate air content is determined by comparing the drop in the level of the alcohol with a calibration chart. The test can be performed in a few minutes. It is especially useful in checking air contents in small areas near the surface that may have suffered reductions in air because of faulty finishing procedures.

With any of the above methods, air-content tests should be started within five minutes after the sample has been obtained. For any given water/cement ratio, air entrainment will usually cause about a five percent reduction of concrete strength. This effect may be overcome significantly by taking full advantage of the water reduction that is possible in air-entrained mixes, without an accompanying reduction in workability.

6.1.12 Accelerators and Retarders

Accelerators and superplasticizers are designed to increase the initial cure rate and, therefore, reduce the time between placement of the concrete in the form and the beginning of the finishing process. The higher compressive strength gains in a shorter period of time will obviously allow the producer to strip the vault form much sooner if necessary. Many accelerators incorporate water reducers, and advantage should be taken of this situation.

Admixtures such as SCC can be implemented into a batch design. SCC includes the characteristics provided by superplasticizers. In addition, SCC reduces the need for vibration and improves workability.

Set-retarding admixtures are used for hot weather pouring or when the producer wants to create more time between the placement of the concrete and the beginning of the finishing process. As a vast majority of retarders are water reducers as well, take advantage of this property whenever possible.

6.2 Batching, Mixing and Placing Concrete

6.2.1 General Batching and Mixing Information

The number of burial vaults and grave liners produced per year, as well as other precast concrete products manufactured in the same facility, will greatly affect the size and speed of the concrete batching equipment necessary. Concrete batching plants include simple manual equipment in which the operator sets batch weights and discharges materials manually, semiautomatic plants in which batch weights are set manually and materials are discharged automatically, or fully automatic electronically controlled plants in which mixes are computer controlled. All of these plants are capable of producing concrete of the quality required for precast concrete grave liners and burial vaults provided they are adequately equipped and properly operated and maintained.

No attempt is being made here to legislate or recommend any particular type of concrete plant. However, the goal of any plant, regardless of type, should be to ensure that batching, mixing and transporting equipment are sufficient and adequate to produce properly proportioned and mixed concrete of the necessary uniformity, consistency and strength, and that this concrete can be regularly supplied in sufficient enough quantities to meet production requirements.

6.2.2 Storage and Handling of Aggregates

Fine and coarse aggregate need to be handled and stored by methods that will provide for uniformity in grading and moisture content when they arrive at batch weighing equipment. Unless there is uniformity of the aggregates when they are batched, production of uniform concrete is unlikely, regardless of the accuracy in measurement and the performance of the mixing and placing equipment.

Segregation will occur in each handling of aggregate. The ideal situation is to deliver aggregates directly from the supplier's finish screening operation to storage bins. However, since this is virtually impossible, rehandling of the aggregates must be kept to a minimum.

When it is necessary to stockpile aggregates, the site should be on a hard, compacted, and well drained area. Stockpiles should be built up in horizontal or gently sloping layers. Suitable walls should be provided, or adequate distance allowed between piles, to prevent overlap of different materials. It is inevitable that stockpiles of coarse aggregate will tend to accumulate an excess of fines near their bases. Awareness of this fact, and therefore a regular turnover of coarse aggregate stockpiles, will help to eliminate any potential mix design problems.

Procedures for handling and storage of aggregates are covered in more detail in the following publications of the American Concrete Institute (ACI):

- Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete (ACI 304-73)
- Recommended Practice for Selecting Proportions for Structural Lightweight Concrete (ACI 211.2-69)

Bins should be provided which have adequate separate compartments for cement, fine aggregates and for each required size of coarse aggregate. These compartments should be designed to discharge freely and independently into the weighing hopper.

The bottoms of bins should slope at an angle of at least fifty degrees from the horizontal toward a center outlet in order to avoid accumulation of fines in dead storage areas. When filling the bins, the material should fall vertically, directly over the outlet. To minimize changes in grading as the material is drawn down, bins should be kept as full as is practical at all times.

6.3 Premixed Aggregates

Some aggregate suppliers will pre-mix fine and coarse aggregates for ease of handling, storage and mixing. **The NCBVA does not encourage this procedure and recommends individual weigh batching of all concrete components. If fine and coarse aggregates are pre-mixed, extra care must be taken to assure consistent gradation of the aggregate mixture.** Special emphasis should be placed on margin for error when the mix design is developed, and testing for gradation and concrete strengths should be performed with greater frequency.

6.4 Proportioning of Materials

Fine and coarse aggregates and cement should be measured by weight. Volumetric proportioning, where a component is measured by volume or by a timing mechanism, should be periodically calculated by actually weighing the component output being placed into the mixer. The weights of all aggregates should be based on a saturated surface dry condition corrected for free moisture. Cement should also be measured by weight. (Standard 94-pound bags may be used without weighing. However, any fractional bags should be weighed.)

Water and liquid admixtures may be measured by either weight or volume. Measurements of water content of mixes should always include the free moisture in aggregates. It is recommended that the free moisture content be checked regularly (daily) so that corrections can be made, and mixes adjusted accordingly. Weighing of fine and coarse aggregates can be done either on separate scales, or on a single scale which will first weigh one aggregate, then the cumulative total of aggregates.

Cement should be weighed on separate scales. It is strongly recommended that automatic scales and cutoffs be used for weighing cement. To allow for a precise cutoff when charging the cement weighing equipment, use controlled screw conveyors, rotary vane feeder units, or other effective devices.

Scales should be calibrated at intervals of not more than one year, or whenever there would be reason to question their accuracy. Records of calibration of equipment must be maintained. In the case of volumetric measuring of aggregates, calibration of “weight per volume” or “weight per second” should take place at six-month intervals or more often if noticeable changes in the concrete mix occur.

All component materials must be discharged to the mixer while the drum or blades are rotating. When charging the mixer, cement should be added simultaneously with the fine and coarse aggregates. A constant feeding of water into the mixer should occur — some before, some during and some after other materials are added.

Between five and ten percent of the water should precede the other components, and a similar quantity should follow the discharge of other materials. Discharge admixtures according to the manufacturer’s recommendations. In order to ensure uniform incorporation into the mix, the introduction of admixtures should usually be at a rate proportional to that of the other materials, regardless of whether in liquid, paste or powdered form.

6.4.1 Mixers

Mixing equipment needs to be of sufficient capacity and appropriate type to produce concrete of uniform consistency, with a uniform cement and water content and uniform aggregate distribution throughout each batch as discharged. Both stationary mixers or truck mixers are acceptable. In order to verify the revolutions of the drum, blades or paddles, truck mixers should be equipped with a counter.

The size of batches must not exceed the manufacturer’s recommended mixer capacity.

When loaded with a full batch, the mixer must be able to combine the materials into a thoroughly uniform mass and to discharge the concrete with the necessary consistency.

All types of mixers must be capable of ready discharge of concrete at the specified slump.

Any mechanical details of mixers or agitators (e.g., water measuring and discharge apparatus, condition of blades, speed and rotation of the drum or blades, general mechanical condition of the unit and cleanliness) need to be checked at least annually. Daily examinations for changes in condition of mixers should be performed. Such changes may be caused by the accumulation of hardened concrete or mortar, or general wear of blades. Whenever it becomes necessary, blades should be either replaced or repaired following the manufacturer’s design and arrangement for that unit. When any part or section is worn as much as 10 percent below the original height of the manufacturer’s design it, too, should be replaced or repaired. Before use, any accumulation of hardened concrete needs to be removed and worn blades repaired or replaced. A copy of the manufacturer's design, including dimensions and arrangement of blades should be available to plant personnel at all times.

Mixing operations should produce batch-to-batch uniformity. Overmixing and undermixing must both be avoided. Undermixing produces concrete of variable consistency and low strength, while overmixing causes a loss of air in air entrained mixes, grinding of the aggregates and a general loss of work-ability.

Usually for stationary mixers of one cubic yard or less the minimum mixing time should be one to three minutes. The specific recommended mix time can be supplied by the mixer manufacturer. Mixing time should not exceed three times the specified time. If a batch must be held in the mixer for a longer period, the speed of the drum or blades should be reduced to an agitating rate when possible.

When mixing in a truck mixer loaded to its maximum capacity, the number of revolutions of the drum or blades at mixing speed should be between 70 and 100 RPM. If the batch is at least one half a cubic yard less than the maximum capacity, the number of revolutions at mixing speed may be reduced to 50. All revolutions in excess of 100 should be at agitating speed. ASTM C 94, Standard Specification for Ready-Mixed Concrete, should be followed for all truck mixing operations.

6.4.2 Placing Concrete

The following publications of the American Concrete Institute describe in detail some proven procedures for placing concrete:

- Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete (ACI 304-73)
- Recommended Practice for Cold Weather Concreting (ACI. 306-66)
- Recommended Practice for Hot Weather Concreting (ACI. 305-72)
- Recommended Practice for Consolidation of Concrete (ACI 309-72)

At all stages from the mixer to final placement, the primary goal is to use those methods and arrangements of equipment that result in placing concrete in a uniform, compacted condition without separation of coarse aggregate and paste. Placing equipment should be able to handle concrete of specified proportions so it can be readily consolidated by vibration.

Before placing concrete, inspect the forms for alignment and tightness of joints. A well-maintained form will greatly reduce unsightly voids caused by concrete mix water bleeding through loose joints. The position of reinforcing steel and inserts must be verified.

Concrete release agent should be applied at the manufacturer's recommended rate, avoiding excess airborne overspray. Other than the obvious waste, overspray can come in contact with an employee's skin, and is a major cause of dermatitis.

Transport concrete from mixer to forms in the shortest time possible. Concrete should be discharged into the forms while it is in its original mixed or plastic state, regardless of transporting methods used. Do not retemper by adding water and remixing concrete which has started to stiffen.

Avoiding separation of coarse aggregate from the mix is an important consideration when handling and placing concrete. The final fall of the concrete from bucket, hopper or shoot should be vertical, without any interference, into the center of the vault form. Discharge gates, bucket openings and hoppers must be large enough to quickly and freely pass the lowest slump concrete used in normal operation into the vault form. In addition, gates and openings must seal tightly enough to prevent the loss of fines and paste when using SCC admixtures. The importance of this placement increases greatly as slump increases, as well as the size and amounts of coarse aggregate used, and with reductions in cement content.

Mixing and placing capacity must be great enough so that products are free of cold joints. When a form is only partially filled by one batch, then the next batch of concrete must be placed while the previous batch is still plastic and the two should be vibrated together.

6.4.3 Consolidation of Concrete

Concrete shall be consolidated in such a manner that segregation of the concrete shall be minimized. Consolidation of the concrete mix can take place through vibration techniques or by the use of SCC admixtures.

6.4.4 Traditional Concrete Mix Designs

Vibrators may be internal, external or surface types depending on the type and style of form, and where and how much vibration is necessary to achieve adequate consolidation of the concrete. Recommended techniques to follow for the proper vibration of traditional concrete mix designs are as follows:

- Vibration must be distributed so that the concrete becomes a uniformly dense and plastic mass.
- Vibrators must be used solely for compaction, and not to move concrete horizontally along the forms. Space the points of vibration so the zones of influence overlap.

For the most part, the re-vibration of preceding layers will have no harmful effect. Re-vibration of concrete can be of benefit if the concrete responds to vibration and becomes plastic again. Re-vibration will be beneficial as long as an immersion type vibrator will sink due to its own weight.

External vibrators should not be placed horizontally at distances farther apart than the radius through which the vibration is visibly effective.

When using surface vibrators, move them at a rate so that vibration is sufficient to embed the coarse aggregate while bringing enough paste to the surface for finishing. The vibration and rate of movement should be sufficient to compact the full depth of the layer.

6.4.5 Concrete with SCC Admixtures

Self-consolidating concrete (SCC) is concrete of high workability that requires little or no vibration or other mechanical means for placement. Placing techniques for SCC require different procedures than the techniques used with traditional concrete. Compaction and placement should be consistent with current industry standards. Testing the workability of SCC will include spread. The spread is a measurement used to determine the stability of the mixture.

Cold joints will not be permitted in precast concrete grave liners and burial vaults. If delays occur and the concrete hardens so that it will not receive a vibrator and again become plastic, wash out partially filled forms and reject partially cast members.

Whatever vibration techniques are used, the effectiveness can be judged by the surface condition of the concrete. If the surfaces of the burial vault or grave liner show unacceptable levels of honeycombing, aggregate or mortar pockets, and excessive air bubbles, the vibration procedure should be revised.

6.5 Severe Ambient Conditions

The temperature of the mixed concrete should be between 60 degrees F (Fahrenheit) and 80 degrees F in order to ensure the proper hydration of cement and eliminate dangers of flash set. The optimum concrete temperature for placing is recommended as 70 degrees F. Special precautions must be observed when ambient temperatures are expected to be above 90 degrees F or below 40 degrees F.

6.5.1 Hot Weather Concreting

The only precaution generally required for placing concrete in hot weather, under cover, is to make sure that the temperature of concrete at the time of placing is not above 90 degrees F. It is also necessary to supply adequate moisture during the curing period to prevent surface drying.

Cracking of concrete, the loss of strength below specified requirements, or both, may occur when the ambient temperature is above 90 degrees Fahrenheit (F). Under such conditions, a combination of some of the following procedures may be used to correct these deficiencies:

- Shaded storage for aggregates.
- Sprinkling or fog spraying of aggregates.
- Assuring that mix water supplies are as cool as possible by insulating or shading water supply facilities.
- Application of wet burlap or mats or fog spraying as soon as the water sheen disappears from the concrete. This is especially important for hot, windy, exposed locations.
- Use of set-retarding admixtures.
- Avoid the use of cement with temperatures over 170 degrees Fahrenheit.
- Substitute ice as a partial replacement for mix water.

6.5.2 Cold Weather Concreting

To keep the temperature of concrete within the prescribed limits when ambient temperatures below 40 degrees F are expected, some or all of the following adjustments may be necessary:

- Concrete should never be placed in cold forms. When the temperature of the manufacturing facility is below 40 degrees Fahrenheit, heat should be provided to raise their temperatures to at least 40 degrees Fahrenheit.
- Use of heated mixing water.
- Avoid the use of frozen aggregate or aggregate containing frost or snow.
- Use of insulated forms.

For all types of curing, sudden cooling of concrete should be avoided. No burial vault or grave liner should be subjected to an ambient temperature of 32 degrees F or colder until the concrete has cured to a strength of 5000 psi or greater. With a proper mix design, most burial vaults and grave liners will reach this minimum compressive strength within a period of three days. Your results may vary, and the proper verification should be made by the use of a series of compressive strength cylinder tests. Test results should be obtained after every 500 yards. Certified members are required to report their test results to NCBVA headquarters each April 15th and October 15th.

6.6 Concrete Reinforcing

6.6.1 Concrete Reinforcing - General

The overall strength of the burial vault or grave liner can be greatly enhanced by the proper use of concrete reinforcement components. A basic understanding of the different reinforcing techniques will help the manufacturer select the best reinforcing design for his or her products and will result in greater overall performance. All reinforcement materials must conform to their applicable ASTM specifications.

6.6.2 Smooth Bar versus Deformed Bar

Smooth steel bar provides an excellent anchor for inserts and lifting apparatus. However, it is only capable of adding a negligible amount of tensile strength to the overall unit. Deformed bar, or rebar, when properly placed (See Illustrations B and C) can add a great deal of strength to the finished product. Placing #3 rebar in the burial vault or graveliner cover, in the lower third of the overall cover thickness, will yield a substantial increase in the loads that the unit can withstand.

6.6.3 Welded Wire Fabric

The use of welded wire fabric or wire mesh has been extensive in the burial vault industry for many years. As demands on our products become more stringent, it is important to point out the limitations of this reinforcing technique. Wire mesh offers very little gain in the tensile strength. It will, however, help hold the burial vault or graveliner together as a unit if a crack in the concrete would occur. It’s primary function, therefore, is a secondary reinforcement, offering protection against the collapse of the unit should the structural design of the unit be exceeded. Wire mesh or welded wire fabric will also increase the impact resistance of the finished unit.

Illustration B
Performance of reinforced vs. unreinforced concrete

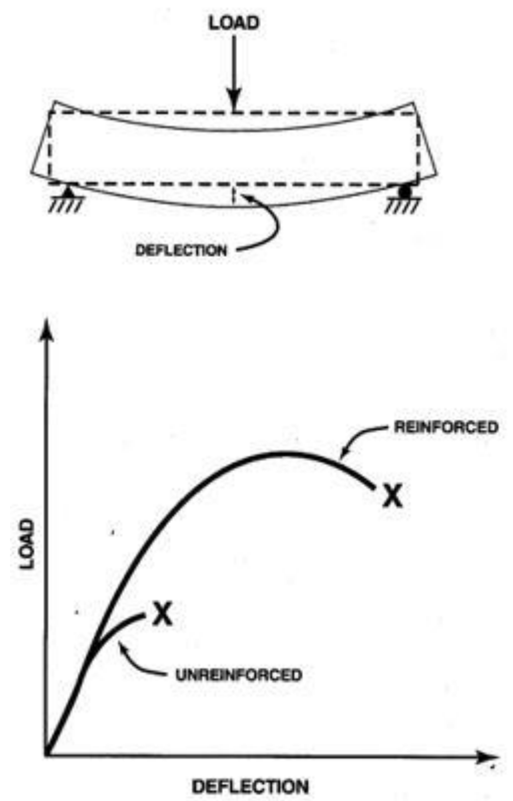
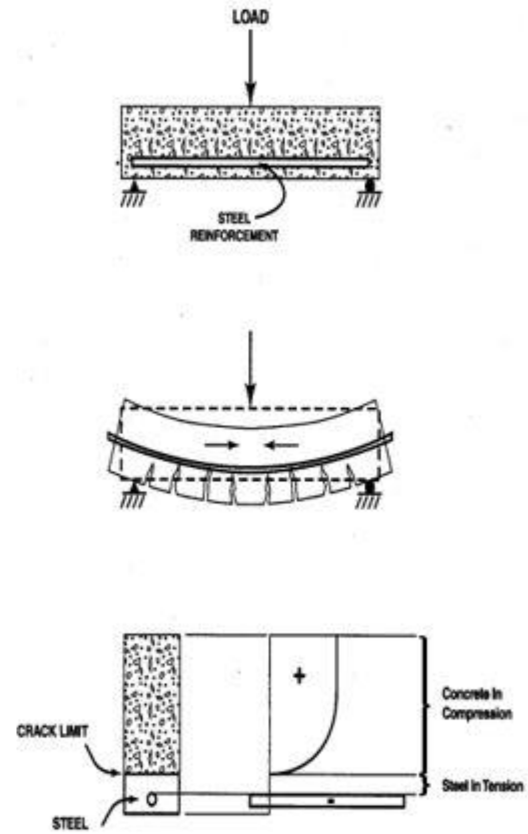


Illustration C
Function of steel reinforcement



6.6.4 Strands and Fibers

Many types of steel, polypropylene and polyester strands and fibers are currently available as secondary reinforcing systems in most cases. The properties of concrete reinforced with fibers include increased strength to withstand impacts as well as an increased flexural strength of the finished products. Use of fibers should be determined from an overall product performance viewpoint as well as economies afforded. The producer must, of course, take precautions to ensure that the material is properly distributed throughout the mix.

6.6.5 Bonded Lamination of Product Components

Many burial vaults use one or more fiberglass, polystyrene, ABS, stainless steel, copper, bronze or other lining materials in conjunction with precast concrete. The bonding of these materials to create a lamination can greatly increase the tensile strength of the burial vault. This overall strength gain depends in large part on the strength of the bond, as well as the number and type of materials being bonded together.

6.7 Concrete Finishing

6.7.1 Finishing — General

The primary concern when finishing a concrete burial vault or graveliner is to allow the concrete to set as much as possible before beginning the finishing process. When the vault form is filled, concrete should be spread evenly, then struck off, and worked as little as possible during early finishing operations. Allow any water brought to the surface by the strike off or rough floating to evaporate. If the amount of water or laitance is excessive, remove it before the surface is again floated or troweled. Do not work the bleed water back into the surface. Excessive bleed water can best be controlled by reworking the mix design. If a smooth surface is desired, delay the final troweling as long as possible. Usually, the final troweling should be done when the surface can no longer be easily dented with the finger, and the surface of the concrete manipulated only enough to produce the specified finish. When a brush finish is appropriate, it should be used as opposed to a troweled finish. Over-troweling or premature troweling tends to promote dusting, flaking and spalling. Coarse aggregates can be forced away from the surface, leaving fines and paste and affecting durability.

6.7.2 Patching

As with any precast concrete product, a certain amount of patching is a necessary and permissible part of producing a quality and aesthetically pleasing product. The key to determining if a burial vault or graveliner is repairable is the ability of the production supervisor to ascertain whether or not the flaw will affect the performance of the finished unit. PATCHING SHOULD BE DONE FOR COSMETIC REPAIRS ONLY.

Therefore, only minor defects may be patched. A structural crack, however, which reduces the overall strength of either a burial vault or graveliner, is not a minor defect. Any unit with a structural crack must be rejected. In the case of a burial vault, any flaw affecting either the sealing capability or the structural integrity of the unit is cause for that burial vault to be rejected.

When patching is appropriate, approved methods of repair should be followed. Defective areas should be patched as soon as possible once the unit is removed from the form. Larger areas and voids should be patched using a proven bonding material or agent in accordance with the manufacturer's recommendations.

Honeycombed sections may result from improper consolidation. Honeycombed areas may be patched, depending on the depth and the extent of the defective concrete, and where it is located on the outer burial receptacle. Honeycombing is particularly objectionable in the tongue or groove areas, and may be cause for rejection of the unit in question. When patching a honeycombed area, any loose coarse aggregate should first be removed, then approved methods of repair followed.

6.7.3 Concrete Curing

To properly cure fresh concrete by any method it is necessary to retain sufficient moisture for complete hydration of cement to occur. This moisture is also necessary to prevent formation of surface cracks due to rapid loss of water while the concrete is plastic. The most effective method of accelerated curing is to apply heat at a controlled rate immediately following the initial set of concrete, and to provide an effective method of supplying or retaining moisture. Common means of curing precast concrete burial vaults and graveliners include the use of radiant heaters, insulated forms, wet burlap covers, plastic covers and curing compounds. Detailed descriptions of curing procedures can be found in the following: Recommended Practice for Curing Concrete (ACI 308-71).

Radiant heat may be applied to forms by means of pipes circulating steam, by hot water, by electric blankets or gas fired or electric radiant heating elements or furnaces.

An effective means of preventing rapid loss of moisture, or dehydration, in any part of the casting must be provided during the cycle of radiant heat curing. Moisture can be applied by a cover of moist burlap or cotton matting. Covering the unit will also help retain moisture. A plastic sheet in combination with an insulating cover, or the application of a liquid seal coat or membrane curing compound can be effective.

Concern for proper curing must be taken during extreme weather conditions and swings in ambient temperatures. Any effort necessary to retain adequate moisture for hydration while keeping the concrete at an ideal curing temperature should be taken. Producers must take precautions against stripping out burial vaults and graveliners before they have reached compressive strengths necessary for handling.

The NCBVA recognizes that a mix design can be developed to achieve minimum standard structural and flexural strengths in a matter of days. All burial vaults and graveliners must be cured to 5,000 psi compressive strength and 500 psi flexural strength prior to the delivery of the unit to a cemetery. Sound inventory management requires the manufacturer to fully understand the mix design and cure rate in order to precisely determine the day on which a precast concrete burial vault or graveliner becomes saleable. The bottom of every unit should be marked with the date of manufacture, and inventory should be rotated so that the oldest units are delivered first.

6.8 Safety and Training

6.8.1 Safety and Training — General

The NCBVA promotes safety and training throughout its membership in all aspects of the manufacture, delivery and servicing of outer burial receptacles. The guidelines have been developed to evolve with changing federal and state mandates. Section 6.6 of these specifications will, therefore, be amended from time-to-time as necessary to help reduce work-related injuries and illnesses. We encourage members to stay current on pertinent government regulations.

The purpose of this section is to address some of the more important safety considerations pertinent to the burial vault industry. The potential hazards covered in this section are generally understood by producers and workmen alike. However, we recognize that human nature may cause people who are constantly exposed to potentially dangerous situations over prolonged periods of time to lose their conscious fear, unless they are constantly reminded of the danger. Every plant must have one supervisor, or safety director whose job it is to make sure that safety never takes second place to either personal apathy or production expediency. Any employee not willing to follow prescribed safety rules should not be allowed to work in a burial vault manufacturing facility.

This section will outline general safety practices for burial vault manufacturing facilities and cannot be expected to include every conceivable hazard that may be present. However, recognizing hazards, establishing good safety practices and procedures, and requiring all personnel to follow established safety rules will result in a more efficient and safer operation in any facility.

6.8.2 OSHA Compliance

It is a foregone conclusion that the NCBVA expects every member facility to be in compliance with federal and state occupational safety regulations. As an organization, however, the NCBVA intends to act as a clearinghouse for new regulations and information pertaining to specific safety problems as they arise at its individual member facilities. It becomes critical that the membership relay information to the NCBVA Executive Director when a specific health and safety problem arises, as well as informing him of the eventual outcome.

Every member facility should have a specific person designated as a Safety Director in order to expedite communication. This would be the same person who currently is responsible for your OSHA No.-300 forms, Material Safety Data Sheets, safety meetings and safety training. The sharing of information and experience between all Safety Directors will help avoid pitfalls and lead to a safer working environment for all burial vault employees.

6.8.3 Lifting, Handling, and Transporting

All lifting, handling and transporting equipment must be certified to carry the bearing load required. All equipment should be clearly labeled and employees trained regarding the purpose and limitations of all manufacturing and delivery equipment. Any lifting equipment which has been fabricated by the vault manufacturer himself for a special purpose should be tested by a certified laboratory and clearly labeled with its maximum capacity prior to use.

Transportation of the vault may be accomplished in a variety of ways, keeping in mind that the vehicle carrying the vault should have a suspension capable of the load, and yet not be too harsh, so as not to damage the load under normal road conditions. All outer burial receptacles should be strapped to the transporting truck or trailer to prevent moving or loss of load in a manner that is both safe and compliant with federal/state/local DOT and other regulations.

Some lifting, handling and transporting guidelines include the following:

- All motor and trailer equipment should be checked daily to make certain that all headlights, marker lights, brake lights and turn signals are in working condition.
- Transport and delivery equipment should be kept as clean and well maintained as possible. If the company name appears on the vehicle, it is important that a good image be presented.
- All cranes and hoists should be certified annually and inspected daily for loose bolts, electrical connections, worn gears, wheels or tracking.
- All wire rope slings, lifting chains, brackets or other handling devices must be inspected prior to use, labeled for their maximum load, and kept in good condition.
- Check welds on trailers and buggies and other cemetery handling equipment.

6.8.4 Disinterment Procedures

The job of disinterring human remains requires special training and precautions for the burial vault employee. While a hazardous condition will not be present with every disinterment, precautionary steps should be taken on each and every disinterment due to the excessive weight involved and the potential exposure to grave effluent. The term grave effluent represents any substance which may be emitted from the burial site which consists of actual human remains, their derivatives or by-products. These substances may be found in a solid, liquid or gaseous form. The following list of guidelines represents some of the areas which deserve attention.

- The extra weight of the casket and human remains must be factored, in addition to the burial vault or graveliner, when determining what type of lifting and handling equipment will be used. When disinterring an outer burial receptacle, the extra weight of potential moisture saturation should also be considered. This could make additional demands on your lifting equipment of more than 2500 pounds in excess of the normal weight of the concrete outer burial receptacle and its contents.
- When disinterring a burial vault or graveliner from a moist burial site, it is common for a vacuum to form beneath the outer burial receptacle. This adds a substantial initial load to your material handling equipment, and every effort should be made to break this vacuum prior to removing the unit. Special employee training should be done regarding this principle.
- In order to be appropriately prepared, know the type of outer burial receptacle, the conditions that you will be facing in the cemetery before going out, as well as any special considerations involving the remains of the deceased.
- If there is any anticipated exposure to grave effluent, special precautions should be taken.
- Review any and all federal, state or local regulations that may apply, and obtain and verify that any necessary paperwork accompany the transfer of the remains.

6.8.5 Safety Practices and Housekeeping

The following represent some general requirements concerning plant safety practices and procedures. It should be noted, however, that state or local regulations in an individual burial vault producer’s own geographical area will take precedence over any recommendations as stated here:

- All electrical wire and equipment, whether in temporary or permanent use, must follow the standards set by the (capitalize T or remove the) Underwriters’ Laboratories, Inc. The installation and maintenance of all such wiring and equipment must comply with pertinent provisions of the National Electrical Safety Code. All electrical circuits and equipment must also be properly grounded in compliance with this code. This will necessitate a three-wire polarized system on all tools, extension cords, receptacles, etc.
- All personnel must wear safety hats.
- All personnel must wear safety footwear.
- All personnel must wear safety glasses.
- Immediately remove all debris from the work area.
- Install the proper type and amount of fire-fighting equipment, and train personnel in its use.
- Store flammable gasses, liquids, etc., out of the immediate work area in approved storage units.

- Maintain hand tools in good condition. They should be sharp, free of broken handles, free of mushroomed heads, etc.
- Wire rope, slings, shackles, and other rigging equipment must be in good condition. Saws and other equipment are to be properly guarded.
- Provide adequate shielding for all welding operations.
- All levels of labor will be required to immediately report all job-connected accidents and injuries. Failure to do so may result in a loss of protection for both employer and employee.
- All drums of flammable materials must be grounded.
- In some areas of the country (including many national cemeteries) graves are dug two and three units deep. OSHA regulations require that any excavation in excess of five feet must have cribbing, and if an employee is to descend into any gravesite in excess of five feet, a ladder must be provided.
- Guard against the overspray of concrete release agent. If the release agent comes in contact with the employee's skin it may cause dermatitis.
- Every effort should be taken to control airborne particulate resulting from the handling, weighing and mixing of cement and fine aggregate in the batching area. Excess dust and particulate should be vented from the work area.
- General facility maintenance and housekeeping can directly impact the overall commitment by employees to all safety requirements.

6.9 Quality Control

6.9.1 General Objectives

Although a manual may set forth the method and means of producing precast concrete outer burial receptacles of high quality, such a manual, no matter how thorough, will not of itself ensure that uniform high quality burial vaults and graveliners will result. There must be a recognition by producers that uniform quality requires intelligent effort and faithfulness to detail in selecting the proper design, proper materials and proper methods for forming, mixing, placing, curing, storing, transporting and installing. A qualified individual must be made responsible for each of these stages of operation, and having been made responsible, must be given the necessary authority to ensure their performance.

Too often individuals in ultimate control have the desire for products of proper quality but fall short of producing them through failure to delegate the necessary authority and to fix the responsibility for results. It is not uncommon to find a production superintendent in a position to ignore the recommendations of the specifications where, in his/her opinion, they slow down the production process or increase the cost. If under such conditions, quality is subordinated to cost, acceptable products cannot be expected.

It should not be assumed that just because a genuine effort is made to produce high quality outer burial receptacles, that their cost will necessarily be increased. Rigid control of manufacturing processes through uniform procedures will usually show a cost savings when compared to careless and haphazard practices. The establishment of uniformity in practices will provide the level of quality required and following these practices, day after day, will almost invariably result in lower manufacturing costs when adopted as the norm for work in manufacturing facilities.

Overall product quality will not result from individual effort. Each facility needs to establish a level of quality based on uniform practices in all stages of production and require strict observance of such practices by all levels of personnel.

6.9.2 Uniformity in Practice

Certain fundamental requirements must be met in order to achieve a satisfactory level of quality control. Some of the more important are as follows:

- Concrete of a uniform quality batch after batch,
- Uniform methods for placing and compacting concrete,
- Standard curing to follow each concrete burial vault or graveliner,
- Uniform methods of handling and storage.
- Where possible, eliminate highly varied procedures which are particularly prone to human error or mistakes in judgment.
- Develop uniform methods for reporting and record keeping.
- Subject every manufacturing operation to independent inspection by personnel other than those directly involved in production whenever possible.

6.10 Testing

6.10.1 Concrete Testing

Concrete strength for precast concrete burial vaults and graveliners will be determined by two standard testing methods. These tests are designed to measure the COMPRESSIVE STRENGTH and the FLEXURAL STRENGTH of the cured product.

6.10.2 Compressive Strength

When a mix design is developed by laboratory methods, it will project statistical probabilities of concrete strength at specific times after the curing process begins. Even under the best conditions, however, there are many variables which can affect the mix and cure rate of the concrete and its final compressive strength (see Illustration D). For the purpose of consistency and to avoid as many variables as possible, the NCBVA requires a compressive strength of a minimum of 5,000 psi at twenty-eight days of age. The verification of compressive strength will be accomplished by producing three sets of concrete test cylinders. Specific procedures for making test cylinders will be according to the following method:

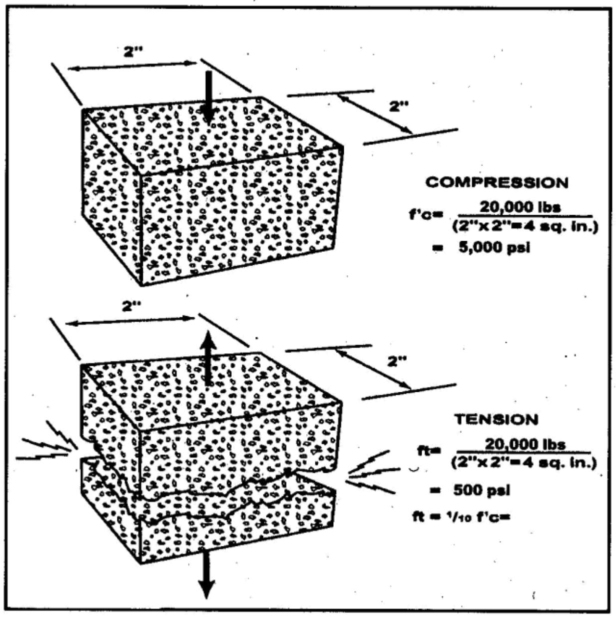
Test Method for Compressive Strength of Cylindrical Concrete Specimens – ASTM C 39

It is impractical to expect that all concrete cylinders will show strengths in excess of the minimum requirements. The strength level of the concrete will be considered satisfactory if the average of all sets of three consecutive strength tests equal or exceeds 5,000 psi.

6.10.3 Flexural Strength

The second test for concrete strength will be a flexural test. This test will show the relationship of the compressive strength and the bond capabilities of the aggregates when placed in tension. Due to stresses that burial vaults and graveliners are subjected to after interment, a minimum flexural strength is critical in long term performance of the finished product. Of the many variables which affect the flexural strength of concrete, the NCBVA encourages its members to especially research their mix designs regarding water/cement ratio, bag mix, finus modulus of their sand and the size and angularity of their coarse aggregate as they impact the flexural strength of their burial vaults and graveliners. These factors will vary, of course, depending on what aggregates are available in the producer's geographical area. The NCBVA requires a minimum flexural strength of 500 psi at twenty-four hours of age. The test will be performed by manufacturing sets of concrete beams according to the following specifications:

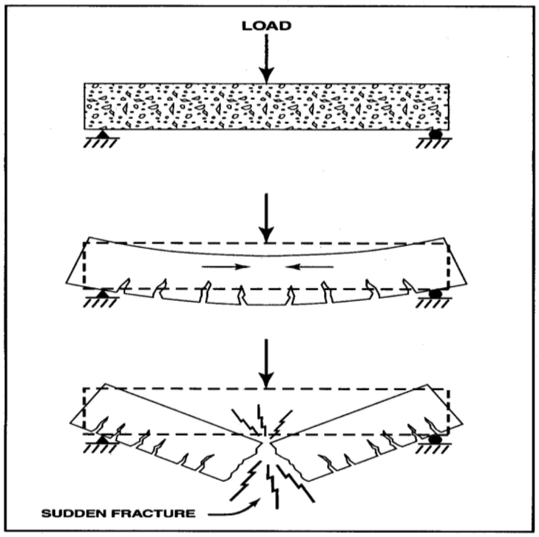
Illustration D - Compressive load vs. tensile stress



- A set of four test beams will be manufactured using forms provided by the NCBVA.
- Forms will measure fourteen inches in length by two inches in width and four inches deep.
- Placement of concrete in form should be done in one phase.
- Concrete shall be consolidated as necessary.
- Using the smooth rod, strike off excess concrete with a sawing motion across the top of the form.
- Allow adequate time for an initial set of the concrete and protect the test beams from a rapid loss of moisture.
- Allow the beams to cure for 20 to 24 hours in a 60 to 80 degrees Fahrenheit ambient curing environment.

The set of beams will be individually placed in tension according to the description in Illustration E. Once again, it would be impractical to expect that each and every beam will fracture at a point in excess of the minimum standard. The flexural strength level of the concrete will be considered acceptable if the beam tested equals or exceeds 450 psi.

Illustration E – Flexure and failure under loading



6.10.4 Slump

As previously stated, the slump of the concrete used in burial vaults and graveliners is predictable at the time that the mix design is calculated. With the use of traditional concrete, the NCBVA allows a slump of six inches or less (prior to the use of water reducers) in the manufacture of any outer burial receptacles. With the use of an SCC admixture, the NCBVA recommends a 24-inch spread. Verification of your actual slump should be performed on a regular basis by a qualified technician. Cement and admixture suppliers often provide this service, as would a commercial laboratory.

6.10.5 Air Content

When an air-entraining agent is used in concrete mix design, it is important to periodically verify the air content is within the specified tolerances. Testing will be in accordance with ASTM C 173 (volumetric) or ASTM C 231 (pressure).

6.10.6 Organic Impurities and Deleterious Substances

Test fine aggregate for organic impurities as specified in ASTM C 40. Limit the deleterious substances in coarse aggregates to the allowances given in ASTM C 33. Tests for organic impurities and deleterious substances should be performed at frequent enough intervals to ensure that all applicable specifications are met.

6.10.7 Record Keeping

In order to establish evidence of the proper manufacture and quality of precast concrete burial vaults and graveliners, a system of records should be kept in each facility which will provide full information regarding the testing of materials, concrete proportioning, placing and curing, and delivery of units.

The bottom of each vault should be marked with the date of manufacture and inventory should be rotated so that the oldest units are delivered first.

6.11 Finished Product Testing

6.11.1 Center Load Pressure Test

This Center Load Pressure Test specification is designed to test the performance of the burial vault and graveliner when interred and subjected to the forces present in the cemetery environment. The scope of the test is intended to assure that the units can withstand the common and ordinary static, differential, dynamic and impact loads which may affect the burial vault or graveliner after interment. The Center Load Pressure Test must be administered by a certified NCBVA technician.

This test is performed in conjunction with the NCBVA Plant Certification Program. Every unit, whether a burial vault or a graveliner, must be capable of passing the minimum standard Center Load Pressure Test in order to be approved for use by the NCBVA. The normal NCBVA procedures for a plant certification require that only the minimum graveliner unit be tested and the subsequent strengths be verified and listed on the certification report. However, any and all burial vaults and graveliners can be tested and rated at the time of your plant certification for an additional fee per unit.

6.11.2 Critical Load Area

Having understood the many loads at work on outer burial receptacles a test will be conducted that will give an accurate representation of the unit's capabilities. In order to perform this test, the point on the burial vault or graveliner that is most likely to fail under critical loads will be selected. A great number and variety of tests, some explained in the Twin City Testing report, determined that this area would be the top center of the unit. Specific testing techniques and results will focus on this critical load area to establish minimum strengths of the finished products.

For purposes of consistency and to facilitate the testing process, the NCBVA has determined that this critical load area will consist of a one square foot section on the top center of the burial vault or graveliner. Pressure will be applied to this one square foot area at a prescribed rate. The outer burial receptacle must be able to withstand a minimum of 5,000 pounds of load on the one square foot section at the critical

load area in order to pass the NCBVA's minimum standards. Any unit which shows a permanent deflection of more than one-half inch will be determined to be a failure by the NCBVA technician.

6.11.3 Center Load Pressure Test Requirements

All outer burial receptacles must withstand a minimum of 5,000 pounds of pressure on a one square foot area on the top center of the unit, with a less than one-half inch permanent deflection upon release of pressure.

A. Failure of the test consists of:

- The inability to sustain the 5,000-pound load for five minutes, OR
- Any deflection of the top surface of more than one-half inch during the test.
- Any deflection of any surface other than the top of more than one-quarter inch during the test.

B. Random selection of an outer burial receptacle for minimum specifications:

- The producer will determine all units suitable for delivery.
- Of the selected outer burial receptacles, the producer will mark with a number a minimum of five units.
- The technician will draw a lot to determine the unit to be tested according to the test procedures.

6.11.4 Center Load Pressure Test Conditions

Recognizing that all burial vaults use some sort of sealing mechanism (i.e., butyl, hot melt, asphalt, etc.) while many graveliners use no sealing system, it is important to realize that different testing conditions are necessary to properly determine the strength of the finished unit. The procedures are outlined in sections A and B below. The producer has the option of testing units that employ a sealing mechanism with or without utilizing the seal. Most units tested with a seal may not be suitable for burial and may have to be discarded after the test is complete. The alternative of not utilizing the seal in the testing of these units will greatly minimize the overall expense of the program to the individual producer.

A. Outer burial receptacle with a seal

To test the burial vault or graveliner, using a seal in the cover, the procedure is as follows:

1. Prior to test, the base of the unit shall be placed on 4 X 4's spaced approximately one foot from each end of the base.
2. The cover shall be sealed on the base and allowed to sit for the two-hour period.
3. Place a weight, typically a vault, on the cover to allow full sealing of the cover onto the base.
4. After the unit has been sealed for two hours, proceed with the Center Load Pressure Test. Test to minimum specifications or to failure load.

B. Outer burial receptacle without a seal

To test the burial vault or graveliner without a seal in the cover, the procedure is as follows:

1. Place base on 4 X 4's spaced approximately one foot from each end of the test product.
2. Place cover on base. The producer may choose to use a gasket material in the tongue and groove area of a burial vault or graveliner in place of the permanent seal.
3. Proceed with the Center Load Pressure Test. Test to minimum specifications or to failure load.

C. Performance of the Center Load Pressure Test

A test frame will be assembled around the center of the test unit. No apparatus or equipment should be allowed to restrain deflection in any way. To accomplish this, spacers shall be placed at the bottom outside corners in order to maintain a clear space of at least one inch between the straps and the sidewalls and the bottom of the product being tested. Corner spacers shall be in contact with the sidewalls and bottom for a distance not to exceed four inches from the horizontal corners where the bottom intersects the sides.

Gasket material should be used to assure that a one square foot bearing plate will uniformly load the test unit. Special care should be taken for units with arch-shaped tops or carapaces.

A hydraulic ram will be pressurized until the ram engages the bearing plate and will be set at a preload pressure of 500 pounds for a minimum of one minute.

The technician will add additional pressure to the test unit in 500-pound increments. This pressure will be added gradually, taking at least thirty (30) seconds to add each additional 500-pound load. Once the 500-pound increment has been added, the test unit should be allowed a minimum of one minute at rest prior to the next load increase. This procedure should be repeated until the full 5,000-pound load is applied.

The outer burial receptacle must withstand the 5,000 pounds of load on the one square foot section at the critical load area for a minimum of five (5) minutes without failure. (See section 6.11.3)

6.11.5 Maximum Center Load Rating System

It is understood that many burial vaults are designed to withstand much greater stresses and loads than the minimum graveliner requirements. The NCBVA provides for the rating of these units as compared to the minimum standard of a 5,000-pound load on a one square foot area in the top center of the unit. The NCBVA technician must test a random sample of burial vaults and graveliners in the producer's product line to the point of failure or the testing equipment's highest level of critical load pressure. No apparatus or equipment should be allowed to re-strain deflection in any way. The procedures for determining the maximum Critical Load Rating of an outer burial receptacle are as follows:

The outer burial receptacle will be tested to the minimum standard level according to the procedures.

*** IMPORTANT — PLEASE READ ***

There are many factors that contribute to the overall rating of a burial vault or graveliner in the Center Load Pressure Test. It would be considered normal that the same brand and style of outer burial receptacle would be rated differently from one plant to another due to variations in raw materials, mix design, reinforcement array and curing conditions. Because of the number of these variables involved, all claims of product performance according to NCBVA tests and standards must be substantiated on a plant-by-plant basis. The results, then, would have meaning only for the comparison of different units within an individual producer's own product line. Standards on specific burial vault or graveliner designs cannot therefore be used for the comparison or the promotion of the product line of one producer to another, or of one brand to another when such brands are produced at separate facilities.

7 Plant Certification Program

7.1 General

The NCBVA has set forth the preceding performance standards as guidelines for minimum performance of all outer burial receptacles manufactured by its members, and as a source of information for other interested parties. It is assumed that all producers will continually strive to comply with or surpass the specifications outlined in this manual and make every effort to institute reliable quality control and safety programs in their manufacturing facilities.

The NCBVA Plant Certification Program is designed for those members of the NCBVA who desire to have their plants inspected and certified on the basis of their level of compliance to the performance standards. The Plant Certification Program is a system whereby an unbiased NCBVA technician, retained by the NCBVA as an independent contractor, can objectively rate the facility and products according to the standards set by the NCBVA. This program is voluntary and is available to NCBVA members in good standing. The cost of the program will be covered by an inspection fee paid for by the participating plant.

The size of the facility, the type of batching system, the number of units produced daily and the number of employees should have no bearing on the outcome of this evaluation. Quality, safety and performance of the finished product are the concerns of our organization. Therefore, every facility will be rated based on its ability to produce high quality precast outer burial receptacles and meet the conditions recommended in the preceding performance standards.

Upon completion of the certification program, the subject facility will receive a designation that reflects its level of compliance to the recommended performance standards. This designation will be expressed in the form of a pass/fail designation. A “fail designation” implies that many changes must be made in order to come into compliance with NCBVA minimum performance standards and certification requirements. A “pass designation” would signify that the majority of the performance standards have been met and that the producer has achieved a high level of competency in the manufacturing facility, procedures and finished product. The designation, good for a period of 60 months, is for the inspected facility only and is not a valid indicator that other plants owned or operated by the same company and/or management also are in compliance.

7.2 Right of Appeal

Any manufacturer who does not agree with the designation determined by the NCBVA technician shall have the right to appeal such determination to the Performance Standards Committee. Such Committee shall conduct a hearing, accept written and/or oral testimony from the technician, the appealing manufacturer and others, and render a decision that shall be submitted in writing to the appealing manufacturer and other appropriate persons. If the manufacturer does not agree with the decision of the Performance Standards Committee, the manufacturer shall have the right to appeal to the NCBVA Board of Directors, which shall render a decision based on the Committee’s decision and the transcript or tape of the Committee hearing. The appealing manufacturer may, at its own discretion, be represented by counsel at such hearing, and any requested Board review of such Committee decision.

7.3 Funding and Operation of the Plant Certification Program

Plant Certification by the NCBVA is for a period of five (5) years. A facility which is certified during calendar year 2022 would be certified through December 31, 2027.

The cost of the Plant Certification Program will be paid entirely by the facility wishing to be certified. The amount will be predetermined by the NCBVA on an annual basis. Any facility desiring a certification during a given year may register for such certification at the beginning of that year. One half (1/2) of the certification fee is due when that request for inspection is submitted. Upon receipt of the request, the NCBVA will contact the facility to schedule a mutually acceptable date for the certification. The balance of the certification fee is due no less than thirty (30) days prior to the established inspection date.

During the certification the NCBVA technician will gather several samples and perform a variety of tests on materials and products. Most testing will be performed by the inspector, except the 4” x 8” cylinder test which will be tested by an independent laboratory. The results of these tests will be confidential. All costs, technician’s fee, travel expenses, etc., are covered by the certification fee. The only additional cost would occur if the facility wanted extra units subjected to the Center Load Pressure Test as explained in Section 7.2.1. The cost for this additional testing will be on a per unit basis determined annually by the NCBVA Board of Directors.

A MINIMUM OF 80 PERCENT COMPLIANCE IS NECESSARY FOR CERTIFICATION

7.4 What will the NCBVA Technician check?

It is important to understand what the NCBVA technician will be checking during certification. The following sections are intended to review the various performance standards.

The following section headings correspond to the sections beginning on page 6 of this Performance Standards Manual. Section 1 (Introduction), Section 2 (Engineering and Testing), Section 3 (Outer Burial Receptacle Requirements—Past, Present and Future), Section 4 (Types and Functions of Outer Burial Receptables), and Section 5 (Loads and Stresses on an Interred Burial Vault or Graveliner))

7.4.1 Mix Design and Cement - Compliant or Not Compliant

The technician will ask to review your plant standard mix design and will discuss the components with you. You will be rated on your mix design based on a combination of the following factors:

- The components of your mix design and the procedures used in arriving at them.
- Verification of the suitability of your mix design as it pertains to wall-thickness and other limitations of your forms, as well as placement of the concrete and consolidation procedures.
- Documentation of the development of your mix design. (This may have been done either in house or with outside expert assistance.)
- Recognition of the water/cement ratio.
- Test results on the fine aggregate, including finus modulus.
- Specification of suitable coarse aggregate that is obtained from a reliable source. (Note: a state-approved aggregate would be the best-case scenario.)
- A check of the admixtures and whether or not they are being used according to the manufacturer’s recommendations.
- In the case of multiple admixtures, proof of their chemical compatibility and their use in recommended ratios.

The technician will discuss the advantages of the various cements available as they pertain to the manufacture of outer burial receptacles. A verification of the cement storage area will be made and a system for the verification of cement type on a load-by-load basis should be evident.

7.4.2 Mixing Water - Compliant or Not Compliant

The technician will ask for verification of the potability of mixing water. If it is in fact not potable, test results showing that the levels of deleterious materials are within the limitations necessary for producing a quality concrete mix must be provided.

7.4.3 Water/Cement Ratio - Compliant or Not Compliant

This section is verify that the water/cement ratio used is less than .45. Discussion will center around workability, slump, and the obvious effects that the water/cement ratio has on the strengths of the finished concrete.

7.4.4 Aggregates - Compliant or Not Compliant

In this section, the technician will primarily be looking for the verification of tested material, a consistent supply, and records showing a consistent finus modulus with a variance of no more than 20 percent. Maximum size of coarse aggregates must correspond to the width of your thinnest side wall.

7.4.5 Admixtures - Compliant or Not Compliant

The technician will be looking at your selection of admixtures. If you are presently using Calcium Chloride the advantages and disadvantages of its use will be discussed. The proper measuring, dispensing and mixing procedures of all admixtures used in the concrete will be reviewed. If you use more than two admixtures, the technician will want to see verification that they are chemically compatible and used in the recommended proportions.

7.4.6 Air Entrainment - Compliant or Not Compliant

The technician will discuss the advantages of air entrainment. Air entrainment fluctuates under various mixing, placing and consolidation conditions. Regular checks on air content must be made to ensure consistency. When using chemical air entrainers the goal would be to achieve an air content that does not exceed six percent of total volume.

7.4.7 Accelerators and Retarders - Compliant or Not Compliant

If accelerators or retarders are being used in the production process, the technician will want to verify that the manufacturer’s suggested dosages are being followed, and that dispensing and mixing are done according to specifications.

7.4.8 Batching and Mixing - Compliant or Not Compliant

There will be a verification and discussion of general batching and mixing equipment. The technician will look at the general condition of equipment to ensure that it is properly functional. The ability of your batching equipment to supply properly blended quality concrete in adequate amounts for the number of vault forms that you have will also be checked. For facilities who purchase ready-mix, a verification of the components will be completed to ensure compliance within the spec.

7.4.9 Storage and Handling of Aggregates - Compliant or Not Compliant

The technician will be looking for the proper storage of aggregates in separate bins. The NCBVA does not recommend the use of premixed aggregates. If a premixed aggregate situation is present, a discussion will follow that emphasizes the extra quality control attention that is necessary to produce acceptable concrete. It is also important that aggregates are handled in such a manner that they arrive at the mixer in a consistent condition, regardless of time of year or weather conditions.

7.4.10 Proportioning of Materials - Compliant or Not Compliant

The technician will be looking for individual weighing of each component, as well as verification that calibration of the scales or proportioning equipment has been done within the past year. If volumetric proportioning methods are being used, the technician will want to review the accuracy with which the volumes relate to the mix design. The accuracy of volumetric proportioning should be verified at six-month intervals.

7.4.11 Mixers - Compliant or Not Compliant

The inspection will focus on the volume of concrete produced as it relates to the capacity of the mixer according to manufacturer's recommendations. The inspector will also look for wear and tear on the mixer, its general maintenance condition, and whether or not the producer is following the manufacturer's suggested mixing time for this particular mixer. Mixing time will be checked and discussed, as well as whether the producer is using a stationary mixer or ready-mix concrete for his units.

7.4.12 Placing Concrete - Compliant or Not Compliant

The technician will be looking for any segregation of coarse aggregates that may occur in the placing of concrete. The transportation of concrete from the mixer to the forms should be in a timely fashion in order that no cold joints occur. It should be kept in mind that when a great distance is covered, or when transporting is done over rough terrain, segregation can occur.

7.4.13 Consolidation Of Concrete - Compliant or Not Compliant

A general verification of the plant's vibration process will be performed. When traditional concrete mix designs are being used, the technician will be checking to see that vibrators are placed appropriately and used properly and are not being used to move the concrete. If SCC is being used, proper mixing, delivery and placing of the high slump mix will be reviewed by the technician.

7.4.14 Severe Ambient Conditions - Compliant or Not Compliant

The technician will check the temperature of the concrete being placed and will discuss what measures can be taken on a regular basis to protect against severe ambient conditions and to guard against intemperate concrete. The technician will also check to make sure that the outside storage of units in extreme temperature conditions does not occur until the units have reached a compressive strength of 3,000 psi.

7.4.15 Concrete Reinforcing - Compliant or Not Compliant

The technician will discuss the reinforcing techniques used in the plant. The technician will make sure the producer has a proper understanding of different reinforcing methods and will look for the proper placement and use of reinforcing materials. In general, the technician will verify the proper application of the various reinforcing techniques being used.

7.4.16 Concrete Finishing - Compliant or Not Compliant

General finishing techniques will be analyzed by the technician, checking that troweling is routinely done at the proper time, and that bleed water is given sufficient time to evaporate before troweling. The technician will look especially for inappropriate steel troweling, which can seal bleed water into the products. Other methods such as wood floating, the use of magnesium floats, or brushing avoid some of the more common problems that can result in the finishing stage.

7.4.17 Patching - Compliant or Not Compliant

The technician will examine some of the recent patching that has been done in the plant. The technician will discuss the pros and cons of the rejection of units, helping to establish a clear criterion for when to reject a unit, and when patching may be appropriate. At this point the technician will do a general visual examination of inventory to ensure that proper patching procedures are being followed, and that inventory contains no patched units which have basic structural defects.

7.4.18 Curing - Compliant or Not Compliant

The major emphasis regarding curing will relate to the compressive strength of the concrete at the time the forms are stripped. The technician will review your current curing techniques (i.e., heating systems, plastic sheeting, burlap covers, curing compounds) and discuss alternate techniques which will help the producer achieve maximum strength concrete in the optimum time to meet production schedules. Some obvious problem areas will be discussed, such as gas-forced air furnaces and excessive wind or ambient temperature conditions which could cause rapid dehydration. The technician will help the producer develop methods that will retain moisture and control the temperature to produce ideal curing conditions.

7.4.19 Safety and Training - Compliant or Not Compliant

Throughout the technician’s examination of the plant, he will be noting any and all potential safety hazards and areas where additional employee training would be beneficial. The technician is not intended to provide a thorough safety certification of your plant. While many OSHA and state regulations are geared to the manufacturing plant’s operation and equipment as a whole, it is the goal and objective of the NCBVA to identify and address many areas of concern specific to the burial vault industry. These would include storage and handling of materials, mixing, placing, handling of finished product, cleanup, employee hygiene and other areas. We feel that the sharing of information concerning potential problems and their solutions can best be disseminated through our organization.

7.4.20 Compliance and Housekeeping - Compliant or Not Compliant

The technician will determine whether your overall housekeeping is affecting the safety and operation of your plant.

7.4.21 Section 6.7 Quality Control - Compliant or Not Compliant

The technician will be looking for an in-place quality control program. A written program would be recommended. This program, written or otherwise, should provide for both the uniform and consistent application of quality control procedures, as well as promote a clear understanding of plant-wide quality standards for raw materials, mix design and the production process. The technician will look specifically at overall quality of the product inventory, overall condition of forms, batching, mixing, placement, material handling systems, and decorative finishing of the units. Employee accountability for quality control at every point in the manufacturing process will also be reviewed. In each plant the technician will work closely with the one person who has primary responsibility for overseeing and administering the quality control program.

Special tests performed in accordance with ASTM standards will be administered on a plant-by-plant basis in the following areas:

- Compressive Strength
- Flexural Strength
- Finished Product Test

In the Center Load Pressure Test a minimum unit will be randomly selected from five (5) stock units and subjected to the procedure described in these sections. A pass or fail determination will be made on the unit after the test has been administered.

DEFINITIONS

ACCELERATOR (p. 13) An admixture that accelerates the setting and early strength development of concrete.

AIR ENTRAINMENT (p. 13) The process for increasing the microscopic air content in the concrete matrix. (See ASTM C 231 for specific information on air entraining methods.)

AIRBORNE PARTICULATE (p.26) Foreign matter released into the surrounding atmosphere, occurring in either a solid or gaseous form (e.g., cement dust, form oil, grave effluent).

AMBIENT TEMPERATURE (p. 19) The temperature of the environment surrounding the concrete casting. This would include temperatures of the air, forms, molds, etc.

BLEED WATER (p.22) The water that is found on the surface during the plastic state of concrete that occurs as a result of excess moisture in the concrete mix design, improper gradation of aggregates or inadequate air content. (Also refer to "laitance".)

BONDED LAMINATION (p. 21) The process of adhering two dissimilar materials for the purpose of increasing the tensile strength in a concrete burial vault.

CENTER LOAD PRESSURE TEST (p. 30) A procedure used by the NCBVA to test finished outer burial receptacles by applying pressure to a one square foot section in the top center of the unit.

COLD JOINT (p. 18/19) The lack of adhesion between concrete that is plastic and concrete that has lost its plasticity.

COMPRESSIVE STRENGTH (p. 27) A measurement of the ability of concrete to withstand a pressure load to the point of fracture.

CONCRETE BURIAL VAULT (p. 7) A lined and sealed burial receptacle which performs all the functions of the concrete graveliner, and in addition is designed and constructed using one or more lining and sealing materials to increase the overall tensile strength of the finished unit and to reduce the risk of the intrusion of exterior elements.

CONCRETE GRAVELINER (p. 7) A burial receptacle placed in the ground in a cemetery, either sectional, dome or box form designed and built to support the weight of the earth and standard cemetery maintenance equipment and to prevent the grave from collapsing.

CRITICAL LOAD AREA (p. 30) The one square foot section in the top center of the outer burial receptacle used in the NCBVA's Center Load Pressure Test.

CRITICAL LOAD RATING (p. 32) A comparison system for rating the strengths of the finished outer burial receptacles produced by a single manufacturer, based on the performance of the units in the Center Load Pressure Test.

CRIBBING (p. 26) The structural reinforcement of an excavated grave.

DEFLECTION (p. 30) A measurement of the ability of a concrete product to bend and return to its original shape when placed under a flexural load.

DEHYDRATION (p. 23) When factors such as heat and wind cause a rapid evaporation of the mix water in concrete, adversely affecting the hydration process.

DELETERIOUS SUBSTANCES (p. 29) Organic substances and other impurities that adversely affect the alkali aggregate reaction in concrete, that results in discoloration, and/or loss of strength in a concrete casting. (See ASTM C 33.)

DIFFERENTIAL LOAD (p. 8) Intermittent or temporary increases and/or decreases in static load over and above normal grave conditions. (e.g., the stockpiling of excavation soil from a neighboring grave above the subject unit.)

DYNAMIC LOAD (p. 8) The rapid but temporary increase in the forces exerted on a subject outer burial receptacle by vehicles and/or other equipment.

FINUS MODULUS (p. 11) This is a measure of the sieve analysis relating to the gradation of the fine aggregate. The finus modulus (fm) of your fine aggregate can be provided by your sand supplier.

FLASH SET (p. 19) The extremely rapid onset of the initial concrete set, caused by high concrete temperatures, high ambient temperatures, rapid dehydration of the concrete mix or a combination of these factors.

FLEXURAL STRENGTH (p. 27) A measurement of the ability of concrete to bend when placed in tension to the point of fracture.

FREE MOISTURE (p. 16) The water that is taken out of the aggregate sample in order to reach a saturated surface dry condition of that sample.

GRAVE EFFLUENT (p. 25) Any substance which may be emitted from the burial site, consisting of actual human remains, their derivatives or byproducts. These substances may be found in a solid, liquid or gaseous form.

HONEYCOMBING (p. 22) The segregation of large aggregate most commonly found in the corners of the outer burial receptacle due to the leeching of the fine aggregates and cement paste. Honeycombing is most frequently caused by improper gradation of aggregate, the incorrect placement of concrete or inadequate consolidation.

HYDRATION (p. 10) The chemical interaction of water and cement during the strength development process of concrete. This reaction generates a substantial amount of heat during its early stages.

IMPACT LOAD (p. 9) A short lived, high-energy contact by a mass on the outer burial receptacle. (e.g., by compaction equipment, boulders or chunks of frozen earth striking the subject unit.)

LAITANCE (p. 22) The water and other floating impurities that are brought to the surface during the floating or troweling process of recently placed plastic concrete (also refer to “bleed water”).

LIGHTWEIGHT AGGREGATES (p. 12) These are aggregates prepared by expanding or sintering products, such as blast-furnace slag, clay, diatomite, fly ash, shale or slate. (See ASTM Designation 330 for further information on light-weight aggregates.)

MIX DESIGN (p. 9) The predetermined proportioning ratios of the components of concrete, including fine and coarse aggregate, cement, water and any additional admixtures.

PLASTIC (p. 18) The condition of the concrete prior to its initial set, as characterized by its workability and placability.

POTABLE (p. 10) Water that is suitable for drinking. Potable water, without deleterious substances which could prove harmful to concrete, is the only water acceptable for use in producing concrete.

PREMIXED AGGREGATE (p. 15) A blend of fine and coarse aggregates which may or may not be consistently volu-metrically proportioned or blended as called for by a quality mix design.

PSI (p. 20) Pounds per square inch. A unit of measure for determining the compressive and flexural strength of concrete.

REBAR (p. 20) A bar that is intended for use as reinforcement in reinforced concrete construction. The surface of the bar is provided with lugs or protrusions which inhibit longitudinal movement of the bar relative to the concrete which sur-rounds the bar in such construction and conform to the provisions of this specification. (See ASTM Designation: A 615.)

RETARDER (p. 14) An admixture that decreases the setting and reduces the early strength development of concrete.

SATURATED SURFACE DRY CONDITION (p. 15) The determination of the percentage of evaporable moisture in a sample of aggregate by drying. This relates to the moisture that is present in the sand and stone when they are added to the concrete mixture, which would offset the amount of water needed as specified in the mix design.

SCC – SELF-CONSOLIDATING CONCRETE (p. 18) Concrete of high workability that requires little or no vibration or other mechanical means of placement.

SEGREGATION (p. 15) A condition wherein the fine and coarse aggregate of the concrete matrix are no longer homogeneously mixed. This can be caused by the over-vibration or overworking of the concrete.

SLUMP (p. 29) A measure of the flowability of concrete. This property is directly related to the water/cement ratio and to admixtures used as specified in the concrete mix design. This property is measured using a Slump Cone, by the vertical differential between the top of the slump cone and the original center of the specimen’s top surface.
SPALLING (p. 22) A surface condition of concrete characterized by flaking, dusting and scaling, usually occurring as a result of premature troweling, over-troweling and the failure to remove laitance.

SPREAD (p. 18) A measurement used to determine the stability of the mixture when dealing with self-consolidating concrete.

STATIC LOAD (p. 8) The continual force at work on the outer burial receptacle from all sides and directions under nor-mal grave conditions.

SUPERPLASTICIZER (p. 14) A high range water reducer. An admixture that reduces the quantity of mixing water required to produce concrete of a given consistency by 12% or greater. (See ASTM C 494.)

TENSILE STRENGTH (p. 20) The measurement of the resistance of a concrete casting to forces of rupture and stress in the direction of length.

VOLUMETRIC PROPORTIONING (p. 15) The process of measuring the concrete components as specified in the mix design by volume as opposed to by weight.

WATER/CEMENT RATIO (p. 11) The ratio determined by dividing the weight of the water by the weight of the cement in a concrete mix design. NCBVA performance standards require that this ratio not exceed .45. (NOTE: The weight of water is equal to 8.33 pounds per gallon.)

WELDED WIRE FABRIC (p. 20) A material composed of cold-drawn steel wire, as-drawn or galvanized, fabricated into sheets or rolls by the process of electric resistance welding. The finished material shall consist essentially of a series of longitudinal and transverse wires arranged substantially at right angles to each other and welded together at points of intersection.

ZONES OF INFLUENCE (p. 18) The area of plastic concrete effectively influenced by the vibration process. These areas will vary significantly based on the type of vibrator tool used and the point of contact with the concrete.

The membership of the National Concrete Burial Vault Association adopted the Performance Standards at their Annual Meeting on June 22, 1991. Last revised August 2021. Requests for additional copies of these standards, plant certification application and other questions should be addressed to: info@ncbva.org.

ACI AMERICAN CONCRETE INSTITUTE

ACI 211.1-74 Recommended Practice for Selecting Proportions for Normal and Heavy Weight (page 4)
ACI 211.2-69 Recommended Practice for Selecting Proportions for Structural Light-Weight Concrete (page 4, 7)
ACI 304 - 73 Recommended Practice for Measuring, Mixing, Transporting and Placing Concrete. 7, 8
ACI 305 - 72 Recommended Practice for Hot Weather Concreting (page 8)
ACI 306 - 66 Recommended Practice for Cold Weather Concreting (page 8)
ACI 308 - 71 Recommended Practice for Curing Concrete (page 11)
ACI309 - 72 Recommended Practice for Consolidation of Concrete (page 8)

ASTM INTERNATIONAL

ASTM Standards for Quality Control in Precast Concrete Plants: American Society for Testing and Materials, Philadelphia, PA 1989
ASTM C 33 Standard Specification for Concrete Aggregate
ASTM C 39 Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C 40 Standard Test Method for Organic Impurities in Fine Aggregates for Concrete
ASTM C 94 Standard Specification for Ready Mix Concrete
ASTM C 150 Standard Specification for Portland Cement
ASTM C 173 Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C 231 Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C 260 Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C 330 Standard Specification for Lightweight Aggregates for Structural Concrete
ASTM C 494 Standard Specification for Chemical Admixtures for Concrete Mixtures
Portland Cement Association: Design and Control of Concrete Twin City Testing: NCBVA Performance Specifications Project No.: 412489-043.01 March 1, 1989

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