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GUIDELINE FOR FIELD QUALITY CONTROL
APPLICATION PROCEDURES-CELLULAR CONCRETE

This recommended guideline has been prepared by member companies of the National Roof Deck Contractors Association. This association includes both contractors who apply lightweight concrete as well as manufacturers of materials who supply the contractors. This document is intended as a general guide. If questions arise on specific points, it is suggested that the contractor or material manufacturer be contacted for clarification.

This document is intended to provide customers and applicators information that the industry believes is important to proper application of cellular concrete used in roof insulation applications. Procedural differences do exist between various cellular concrete manufacturers to accommodate their product and testing agency approvals. Please contact those manufacturers tor their specific recommendations.

Application Equipment

- Concrete Pump . Moyno type pumps are used to transfer cellular concrete from the mixer to its point of placement. Progressive cavity pumps are constant volume delivery pumps consisting of a rotor and stator. These pumps are sized to deliver adequate material volume through hoses attached to the pumps.

  Since Moyno pumps are not pressure sensitive, kinks and obstructions in the hose are to be avoided. The possibility exists that the hose will burst if the hose is not free flowing.

- Concrete Deliver-v Hose . The preferred hose is 2" I.D., rubber lined, with full flow fittings, rated at 800 PSI. The last 50 feet of hose should be high pressure reinforced rubber hose.

  The 2" diameter demands a fuller flow of material within the hose and reduces the material build-up on the hose walls and fittings.

  Rubber lined hoses substantially reduce the amount of water lost from the concrete between the hopper and the deck. Eliminating this variable unknown allows you to control the product you are delivering. Additionally, there is less build-up of material on the hose walls.

Full flow fittings reduce friction and the local pressure variables along the concrete hose. With restricted fittings the cellular concrete is pressurized on one side of the fitting. The pressure is then suddenly reduced as the concrete passes through the fitting This sudden pressure reduction may cause many or the cells to burst. Also, restricted fittings promote material build-up, thus exacerbating the problem.

The 800 PSI rating is recommended by the pump manufacturer.

The last 50 feet of hose is the most frequently moved. Therefore, the heavy duty rubber hose is recommended to minimize kinking.

Raw Material Delivery Equipment

[illegible]

1. Cement Load Cell: The cement load cell measures the weight of cement being introduced to the mixer. Weight of cement is the major controlling raw material in density of cellular concrete. The load cell used to measure cement should be calibrated each time it is set up in a new location.

2. Foam Generator: The foam generator must be calibrated for the rate at which foam is being generated and for the density of foam being generated. The second most important factor controlling cellular concrete is the foam generation rate. Assuming the cement weight is correct, the final concrete density is controlled by the volume of foam introduced in the mixture. Foam rate is measured in foam volume per second. Time is used to determine foam volume introduced during the mixing of cellular concrete.

   Foam rate calibration must occur each morning at start up and at least once during mid day or more frequently if foam generating equipment is not functioning properly.

   Foam density must be measured once a day to insure it is in the range specified by foam supplier.

3. Water Meter: Water is used to mix the dry materials in order to pump the mixture efficiently. Variation in water volume can affect the concrete wet density as well as finishing characteristics of the cellular concrete.

   The water meter should be calibrated once a month to insure it is recording the proper gallons of water induced for the mix design being placed.

4. Concrete Hopper: As an added control tool, the concrete hopper from which the mixed cellular concrete is pumped, should be marked indicating one cubic yard volume. This mark onlv is used as an indication of concrete volume being produced. The mark can be used as an indicator of problem mixes before they are pumped in placed.

Eauivment Calibration Procedures

1. **Cement Load Cell: Bagged cement or any other known weight is useful in determining the accuracy of a cement load cell. A bag of cement contains 94 lbs. net of cement. To determine the accuracy of a load cell: Record the empty hopper weight or adjust scale to 0. Add the 7 bags of cement to the hopper (7 X 94 lbs. = 658 lbs.). Check load cell. If net increase is other than 658 ibs., determine % error. If load cell is more than 10% in error, have it calibrated. If it is not accurate adjust cement weight load cell rating.**

   Example: If load cell read 710 lbs. net when 7 bags of cement was put in hopper, load cell is off by:

   710 Ibs. Reading
   -658 lbs. Accurate Cement Weight
   52 lbs. Error

   52 lbs./658 lbs. X 100 = 7.9% error

   If batch design required 600 lbs. cement, load cell must read 7.9% more than 600 lbs. or 107.9% X 600 lbs. = 647 Ibs.

2. **Foam Density: A clean 5 gallon pail may be used, although it is slightly less accurate than a 1 cubic foot container. The volume of the 5 gallon container should be checked. The most accurate method of doing this is to fill the pail with water. Get the net weight of the water (full weight - empty weight), Divide the weight of the water by 62.4 (lbs. water/cubic foot). This will give the volume of the pail in fractions of a cubic foot.**

Example: 5 Gallon Pail Full of Water	**48 Ibs.**
Less Weight of Empty Pail	**- 2 1/4 lbs.**
Net Weight of Water	**45 3/4 lbs.**

   45.25 lbs. / 62.4 Ibs./cubic foot = .725 Cubic Feet = Volume of Pail

   To check the densitv of foam, determine the net weight of the foam (full weight - empty weight). Divide this by the volume of the pail (.725 cubic feet determined above).

Example: 5 Gallon Pail Full of Foam	**5 lbs.**
Less Weight of Empty Pail	**2 3/4 lbs**
Net Weight of Foam	**2 1/4 lbs:**

   2.75 lbs. / .725 cubic feet = 3.1 lbs/cubic foot foam density

3. <u>Foam Flow Rate:</u> **To obtain the flow rate of foam, start the foam generator. Time the length of time required to fill a calibrated 55 gallon drum with foam, taking care not to create voids. Foam flow rate is volume of drum divided by number of seconds required to fill it.**

Example: It takes 11.1 seconds to fill 7.35 cubic foot drum.

<u>7.35 cubic feet</u> = .6622 cubic feet/second = flow rate
11.1 seconds

If this were the case and initial batching required 19 cubic feet of foam, to determine the time setting divide cubic feet required by flow rate.

Example: <u>Required Cubic Feet Foam</u> = <u>9 cubic feet</u> = 28.7 sec.
Flow Rate of Foam .6622 cubic feet/ sec

Set foam time to 29 seconds.

4. <u>Water Meter</u>: **The surge tank or water tank on some mixers can be used to determine the water meter accuracy. Determine the inner diameter and inner length of the tank and drain pipe from tank to dump value. Calculate the volume in cubic inches using the following formula.**

Example: <u>H D</u>=2 X H Height in inches
4 D = Diameter in inches

231 cubic inches = 1 gallon

Divide the result by 231 to get volume in gallons

Example: Tank outside dimensions: 24" diameter, 48 5/16" long

Inside diameter of drain pipe: 5"

Length of pipe from tank to center of value: 4 7/8"

Inside dimensions of tank are approximately 1/4" smaller than outside dimensions. Therefore, the inside dimensions of the tank are 23 3/4" diameter and 48 l/16' long.

Volume of Tank: <u>3.1416 (23.75) 2</u> X 48.06 = 21,291.29 cubic inches
4

Volume of Pipe: <u>3.1416(5) 2x4.88</u> = <u>95.82</u> cubic inches
4

Total Volume of Water 21,387.11 cubic inches

<u>21,827.11 cubic inches</u> = 94.5 gallons
231 cubic inches/gallon

Fill tank 3 times. Average water meter readings. If it is more than 10% different from the volume of the surge tank, have meter calibrated.

~~Adjust water meter reading to compensate for inaccuracies.~~

Example: Water meter read 87.9 gallons when 94.5 gallon tank was filled.

Volume of Tank	**945 gallons**
Water Meter Reading	**87.9 gallons**
Error 6.6 gallons	

6/6 x 100 = 7% Error
94.5

~~If batch design calls for 35 gallons, meter must read 7% less than 35 gallons.~~

7%X35=25

35 Gallons Required
-2.5 Gallons Meter Error

325 Gallons Corrected Meter Reading

If the mixer does not have a surge tank, an empty 55 gallon drum may be used to verify water meter accuracy.

<u>Oualitv Control Test Procedures</u>

1. Concrete **Wet Densitv:** **The ultimate control of cellular is the wet density of the product as point of placement, Raw materials are varied in the mixing process to get the correct wet density. This section describes the measurement procedure employed to test wet density. This test for wet density should be conducted each hour or more frequently during the pouring process.**

   Several sizes of containers of known volume are filled with cellular concrete and weighed. The procedure for measuring wet densities described below, uses a 5 gallon container. Other containers of measured volume may be used in place of a 5 gallon pail. The procedures using other containers remain the same.

   5 Gal. Pail Method

   To determine the density of cellular concrete determine the net weight of 10 quarts of concrete (full 10 quart pail weight - empty 10 quart pail weight). Multiply this weight by 3 to obtain the density of concrete in PCF.

Example:

5 Gal. Pail Full of Concrete	31 lbs.
Empty 5 Gallon Pail	-2 lbs.
Net Weight of Concrete	29 lbs.

$$\frac{29 \text{ lbs.}}{.725 \text{ cubic feet}} = 40 \text{ lbs./cubic foot Concrete Density}$$

Pails must be kept clean or density calculations will be inaccurate and misleading.

Scale - The weight used to measure pail weights scale should be accurate from 2 to 50 pound range. The scale should be calibrated in maximum l/2 pound increments. Either a platform scale or a spring tension scale is acceptable. Each had advantages. The platform scale is usually more accurately calibrated (usually in l/16 or l/10 pound increments). The spring tension scale is smaller and more easily kept clean.

The scale must be maintained in a clean, smoothly functioning condition. A scale jammed with concrete or rust will give inaccurate measurements and be very misleading. A known "standard weight" in the range of the weights usually measured is valuable in determining the continued accuracy of a scale. It can be as sophisticated as a purchased laboratory standard or as simple as known weight bag of rocks.

Finishing Equipment

Listed below are generally used finishing equipment:

Pipe or Square Tube Screeds of proper thickness support the straight edge and give hose man a target thickness.

16' Aluminum Straieht Edge is placed on screeds and pulled over wet concrete to obtain proper thickness and a degree of smoothness.

Finished Sled is set to proper thickness and pulled over wet concrete similar to straight edge.

A Darby is a finishing tool with a blade approximately 4' long and 4" wide. The entire surface or only footprints and saeed bar marks may be Darbied.

A Bull Float is used for the same purpose as a Darby.

A Trowel approximately 2' long can be used in tight spots and to finish out footprints and screed bar tracks.

- Strings may be pulled to assist in gauging initial leveler coats on irregular surfaces or finish grade on intricate, especially sloped areas.

Foam Generation Procedures:

Quality of foam generation is the starting point for quality application of cellular concrete. Pregenerated foam is a mixture of water, a foam concentrate, and air in proper proportions, at proper pressures.

All foam generators first dilute the foam concentrate with water then mix this dilution under pressure with air in a mixing chamber or block. This mixture passes through a conditioner where it is further agitated to produce more uniform, smaller bubbles. The material then exits a nozzle. In some foam generation equipment, the conditioning chamber is included in the nozzle. At this point the foam has the appearance of aerosol shaving cream.

The foam density and flow rate should be checked once a day before starting concrete production and any time that the dilution ratio is changed. See Equipment Calibration Procedures section for foam density and flow rate testing procedures.

Dilution water should be potable, clean and free from deleterious amounts of acid, alali, and organic materials.

The foam concentrate should be accurately diluted, in accordance with the foam concentrate manufacturer's and form generator manufacturer's recommen- dation. As a rule, more slopeable concrete can be obtained with slightly more concentrated dilution ratios. Check with manufacturer. On manual dilution from generators, water should be introduced at the bottom of the dilution tank, under sufficient pressure to stir the dilution into a homogeneous solution.

For those foam generators requiring a separate air compressor, the air compressor should be sufficient size and capacity to provide air at uniform pressure throughout the foam generation process. See requirements of foam generator manufacturer. An air reservoir tank, 60 gallon capacity is beneficial in minimizing air pressure surges.

A brief discussion of the major foam generation equipment available in the industry today follows in alphabetical order of manufacturers. Manufacturer's literature should be reviewed closely as the following is not intended to be all inclusive.

- **Celcore: Recommends either a mechanical or pressurized tank system for its foam generating system. Most commonly used are dual 200 gallon tanks. Operation can be continuous as one tank can be filled while the other is in use. Filling valves are closed and tank is pressurized. Air and liquid dilution flow through pressure/flow regulators to mixing chamber to two nozzles. A control panel on the mixerman's platform opens and closes a series of electrically actuated solenoids, which in turn control the production and flow of foam into the mixer. The Celcore foam generator generally does not have a timer. The Celcore mixer has a volume of one cubic yard. The mixerman fills the mixer by volume. Concrete wet density is adjusted by varying the amount of cement per batch**

Cellufoam: Mechanical foam generator. Cellufoam foam generators can be used with single or dual non-pressurized dilution tanks. Water and concentrate are properly proportioned into tank. The dilution is gravity fed to the foam generator. The generator is dual impeller type. No separate air compressor is required. Engine RPM and pump pressure are the only indicators of proper operation. No adjustment of air or liquid pressures is possible. The only adjustment available is in the dilution ratio of concen- trate to water. The foam passes from the pump through a foam concentrate to water. The foam passes from the pump through a foam conditioner to a nozzle. The timer is located on the mixerman's platform The timer is preset to deliver the desired quantity of foam to the mixer when the timer button is depressed. The timer can be adjusted to vary the quantity of foam delivered per batch, if concrete wet density needs to be adjusted.

The foam production rate of a Cellufoam foam generator is approximately 20 CPM. Most high production roof deck operations require two foam generators connected to one timer and one set of tanks.

Mearl: Mearl makes both pressurized tank and mechanical foam generators. The pressurized tank foam generators are available with single or dual tanks of from 30 to 200 gallon capacity. The most commonly used by the roof deck industry is the dual 200 gallon tank system. An integral air compressor comes with the unit. Operation is similar to the Celcore pressurized tank system except that the Mearl foam generator is usually equipped with a timer. The timer electrically operates solenoid valves to start, automatic stop, and reset the flow of foam into the mixer.

The mechanical foam generator utilizes a non-pressurized tank to hold the properly proportioned dilution of foam concentrate and water. It requires a separate air compressor. The premixed solution is pressurized by a mechanical pump with a balanced pressure maintained against the compressed air supply. Air and liquid pressure are adjustable on both the mechanical and pressurized tank generators. The foam passes through a conditioner and nozzle into the mixer. An electrical timer is used to operate the solenoids and start and stop the liquid pump. Concrete wet density can be adjusted by increasing or decreasing the setting on the timer, thus adjusting the amount of foam entering the mixer.

Strong: Mechanical foam generator. Strong manufactures an automatic dilution generator and a manual dilution generator. The manual dilution foam generator is the more commonly used. The manual dilution foam generator comes with an integrated 225 gallon tank but requires a separate air compressor. Like the Mead mechanical generator, the premixed solution is pressurized by a mechanical pump. The pressurized liquid and air pass through a mixing block. The resulting foam passes through a foam conditioner and nozzle into the mixer. Both liquid and air pressures are adjustable. Pump operation and foam flow control solenoid are automatically operated by a digital timer located on the mixerman's platform. Concrete wet density can be adjusted by increasing or decreasing the amount of foam entermg the mixer by changing the preset time on me timer.

Mixing Procedure

Cellular concrete contains three components, water, Portland cement, and pregenerated roam. They should be added to the mixer in that order. Each component should be accurately measured. Refer to [redacted] for checking the accuracy of the water meter and cement load cell. It is imperative to accurately measure the components of a cellular concrete batch.

Once about half of the water has entered the mixer, the cement auger is activated. Foam should not be added until all of the cement is in the mixer and mixed with water. Dry cement reacts adversely with some foams. If the foam generator capacity and the crew's ability to place and finish concrete demand it, it may be necessary to introduce foam into the mixer before the cement augering is completed. If this is required, start the foam introduction as late in the cement augering cycle as possible. Twenty to thirty seconds after foam is added, concrete will be homogeneous and should be discharged from the mixer.

Placing Procedures:

- Substrate Preparation - Prior to placing concrete, the substrate should be broom cleaned. All curbs, roof drains, wood blocking etc. should be in place. Concrete decks should be dampened to avoid premature drying of slurry coat. All surfaces should be free of standing water, ice, and frost.

- Slurry Coat - If polystyrene insulation board is to be used, an adequate slurry coat is required. This is important with cellular concrete to prevent floating of insulation boards. If an insufficient slurry is placed and voids exist under the boards, the top pour will flow into these voids and force the insulation boards up. For this same reason, insulation boards should be walked-in to firmly and completely seat them in the slurry coat.

  Depending on the weather, the wetness/stiffness of the slurry coat, the thickness of the insulation board, the adequacy of the slurry coat, and the wetness/stiffness of the top pour; it may take the slurry coat from 20 minutes to overnight to adequately bond the insulation boards to prevent floating.

- Multiple Pours - If cellular concrete is to be placed in thicknesses greater than 4 inches, or sloped greater than (1 ' foot, it is normal to place it in two or more lifts. When marking multiple pours, the successive pours should be placed as soon as the preceding pour can be walked on with minimal damage.

  In hot, low humidity conditions, wet the substrate surface prior to making second pass.

- High Rise Applications - On high rise applications, some foaming products could require a couple of cubic feet of foam will have to be added to the mixer to compensate for foam breakdown due to higher pumping pressures. A richer foam concentrate to water ratio can be useful in producing a stronger foam to help compensate for higher pumping pressures. Starling and stopping the pump should be minimized. While this is true for all cellular concrete pumping operations, it is especially important on high rise construction. It is harder on the equipment clutch and when the concrete is allowed to stand in long vertical hose lengths, it will segregate. The pump should be operated at the highest speed that will allow continuous pumping to avoid segregation.

- **Cold Joints** - Screed bars should be left at edge of last pour to form square cold joints. Tapered thin pours of cellular concrete should be avoided as they tend to dry too fast, not fully hydrate the cement, and be weak.
- **Clean Out** - Hoses and equipment should be cleaned daily. Cellular concrete builds up in hoses and equipment faster and harder than aggregate lightweight insulating concrete because of its higher cement content and the fact that no aggregate is incorporated in the build-up. Some crews run a charge of Perlite through the equipment to scrub the hoses. Pumping a rabbit/pig through hose will clean out the hose. Others flush with hydrant pressure, while others flush hoses with wash out water through the pump while kinking and opening the hose to swell the hose and get surges of water.

- Wet Density - Density checks should be taken throughout the day at the reference frequency hose discharge point. Refer to Quality Control Test Proceures for the method of checking the wet density. Wet density should be checked hourly, whenever hose lengths are added or taken off, whenever one changes roof levels, whenever significant (2 gallons) water changes are made, whenever foam concentrate dilution ratios are changed, and whenever a new load of cement arrives. The only handle one has on the quality or cost of deck he is placing is wet density. Any of the above can affect the wet density. Additionally, changes in ambient temperature, water temperature, or hose restrictions can affect the wet density of cellular concrete.

Finishing Procedure:

The types of screeds vary. However, the most commonly used are pipe screeds and an aluminum straight edge.

Cellular concrete should not be overworked. Once screeded to the proper thickness the pipe screeds are removed. Their imprint and foot tracks are finished with a darby, aluminum bull float, or finishing trowel. Some crews double screed and only finish screed bar marks and footprints. Others place the concrete to proper thickness by eye gauging by screed bars. They do not
"pull" the surface, but finish it with a darby or bull float. The latter method requires a very skilled hose man to avoid irregular surface and bird baths.

Cellular concrete tears more easily and more quickly than aggregate light- weight insulating concrete. To minimize tearing and make "slab joints" look acceptable, always carry a little fresh, wet concrete under the flashing tool onto the "old" slab. Contact between the finishing tool and the "old" slab will usually result in tears or rough surfaces. If esthetics are essential, short slabs all poured and finished in one direction may be required.

Cellular concrete builds up on finishing tools quickly. Frequent cleaning of tools is essential. Excessive build up on straight edges will result in slab thicknesses less than expected.