Technical Bulletin 302

Five Star® Cementitious Repair Mortar Aggregate Extension Guidelines

Five Star® cementitious repair mortar products are formulated to be non-shrink and develop strengths quickly. When using these products in larger volumes it may be necessary to add coarse aggregate to help minimize the amount of heat generated as the product hydrates, control the shrinkage, reduce the potential for cracking in the product, and maintain or lengthen the working time of the material. The decision to add coarse aggregate is primarily based on the volume of the product being placed, but consideration may also be given to those items that act as heat sinks (i.e., rebar, etc.).

*Five Star Products highly recommends that a **trial/test batch** of the mortar be mixed prior to starting a large installation because it allows the user to:*

- *verify the mixer batch details (number of bags, pounds of coarse aggregate, volume of water, and mixing time) and confirm the mortar's slump and flowability after mixing.*
- *confirm that the mixer and other equipment are in good working order and are capable of handling and mixing the mortar at the planned batch size.*

Material installation volumes that are less than two cubic feet (56.5 liters) do not need to be extended with coarse aggregate.

To determine whether a product can/should be extended with coarse aggregate, refer to the product's Five Star® Technical Data Sheet. It should be noted that the amount of coarse aggregate added is not intended to be an exact science (down to the last ounce or gram). It is always better to err on the high side; slightly more coarse aggregate in the mix is preferred to not enough.

Prior to mixing large volumes, Five Star strongly recommends the user make a trial mix to establish the exact mix ratios of water and coarse aggregate. The user can then verify the mixer capability, the slump, the flow, and the "pumpability" of the product to avoid any large volume mixing issues.

A. Coarse Aggregate Specification Requirements

A suitable coarse aggregate specification for typical concrete applications is to use a ⅜ inch nominal, clean, washed, pea gravel that meets the requirements of ASTM C33. Pea gravel is called out because of its rounded nature, making it suitable for pumping.

A suitable coarse aggregate specification for high temperature application > 400°F (204°C) is to use a ¼ inch (6.7 mm) or ⅜ inch (9 - 10 mm) nominal, clean, washed basalt/granite coarse aggregate that meets the requirements of ASTM C33. The closed pore structure of the basalt/granite coarse aggregate prevents water from getting trapped in the pores and "exploding or popping" when exposed to high temperatures. Limestone or pea gravel should not be used in high temperature applications.

The most critical criterion is that the coarse aggregate be clean and free of fines. Alternate coarse aggregate sizes and specifications (i.e. DOT approved grades) may also be used. However, coarse aggregate size should never exceed 1/3 the depth of the installation. Contact your Five Star® Technical Sales Representative if alternate coarse aggregate sizes and specifications are being considered for use with a Five Star® cementitious repair mortar.

Exposure to temperatures < 400°F (204°C)	Exposure to temperatures > 400°F (204°C)
Use a 3/8 inch nominal (9 - 10 mm), clean, washed, pea gravel that meets ASTM C33 requirements. If the aggregate moisture content is critical to the mix, the coarse aggregate should be dried.	Use a 1/4 inch (6.7 mm) or 3/8 inch (9 - 10 mm) nominal clean, washed **basalt/granite coarse aggregate** that meets ASTM C33 requirements. If the aggregate moisture content is critical to the mix, the basalt coarse aggregate should be dried.

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A. Coarse Aggregate Specification Requirements continued

Five Star Products has three pre-packaged, washed, screened coarse aggregates which meet ASTM C33 specifications:

NOT TO SCALE

FIVE STAR® 3/8 DRIED COARSE AGGREGATE

FOR TEMPERATURE EXPOSURES < 400°F (204°C)

NOT TO SCALE

FIVE STAR® 3/8 DRIED BASALT COARSE AGGREGATE

FOR TEMPERATURE EXPOSURES > 400°F (204°C)

NOT TO SCALE

FIVE STAR® 3/8 BASALT COARSE AGGREGATE

FOR TEMPERATURE EXPOSURES > 400°F (204°C)

B. Conditioning Coarse Aggregate Prior to Mixing

The temperature of coarse aggregate can dramatically affect the temperature of the mixed product. Coarse aggregate should be temperature conditioned in the same manner as the cementitious grout. Cold or chilled coarse aggregate can be used to cool down the mixed grout and maintain or lengthen the product's working time; and in the same manner, hot coarse aggregate will shorten the product's working time and accelerate strength gain.

The quality and moisture content of the coarse aggregate can vary greatly depending on how it is specified, packaged, and stored. As mentioned previously coarse aggregate should be free of dirt and fines which requires that it be washed. Washed aggregate can vary in moisture content depending on how it is packaged and stored.

The ideal degree of "wetness" that a coarse aggregate should be prior to adding it to the mixture is at a Surface Saturated Dry (SSD) condition. This is a condition where the aggregate will not absorb any water but is not dripping wet. An SSD condition is difficult to achieve for every bag of coarse aggregate and is often not practical to monitor and adjust for all the bags of coarse aggregate that will be required for larger installations.

- One way to ensure that there is a consistent water content in the coarse aggregate is to specify that it is washed and dried. Using dried coarse aggregate will ensure that additional moisture is not added to the mix.
- When using a washed coarse aggregate that has not been dried, plan on holding back some (up to 10%) of the total volume of mix water specified for that product.

If the strength of the material is a critical attribute, Five Star recommends making up some trial mixes with the coarse aggregate to verify the material strength before mixing and placing large quantities of material.

C. Coarse Aggregate Extension Guideline Table Definitions

For the purposes of interpreting the tables in this technical bulletin:

- **DEPTH OF POUR**: Cementitious grouts are typically installed in a horizontal plane, so the depth of the grout is normally the smallest dimension. If the grout is being used for an anchoring application or for any application where the depth of the grout is not the smallest dimension, the smallest dimension should be used as "depth" in the tables below.
- **ESTIMATED YIELD ADJUSTMENT**: Five Star provides the estimated yield of a bag of material in the product's Technical Data Sheet. Adding aggregate to a product increases the yield of each bag of material. The number presented in this column is the approximate yield increase per 50 pound (22.7 kg) bag of product. This number can vary depending on the type of stone used, so the values should be treated as estimates. Section D in this document provides more detail as to how this number is calculated.

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C. Coarse Aggregate Extension Guideline Table Definitions continued

- **APPROXIMATE BAGGED STONE QUANTITIES**: This information is provided to help estimate how many 50 pound (22.7 kg) bags of stone should be added. At some depths it is slightly less than the recommended amount, and in other instances it is slightly more than the recommended amount. The information should be treated accordingly.

Table 1: Coarse Aggregate Extension Guidelines for

Five Star Structural Concrete®
Five Star Structural Concrete® ES
Five Star Structural Concrete® ES-60
Five Star Structural Concrete® S300
Five Star Structural Concrete® Underwater PG

50 Pound (22.7 kg) Bag							
DEPTH OF POUR (inches)		% BY WEIGHT OF COARSE AGGREGATE EXTENSION	ACTUAL WEIGHT OF COARSE AGGREGATE EXTENSION (weight added per 50 lb.bag)		ESTIMATED YIELD ADJUSTMENT (volume added to 50 lb. bag product yield)		APPROXIMATE BAGGED STONE QUANTITIES (per 50 lb. bag of product)
inches	mm		pounds	kg	+ cubic foot	+ liter	
1-2	25 - 50	0	0	0	0	0	Install product neat
> 2 - 6	> 50 - 150	25 - 50	12.5 - 25.0	5.7 - 11.3	0.08 - 0.15	2.12 - 4.25	1/4 - 1/2 bag
> 6 - 9	> 150 - 225	> 50 - 65	> 25.0 - 32.5	> 11.3 - 14.7	> 0.15 - 0.20	> 4.25 - 5.52	1/2 - 2/3 bag
> 9 - 12	> 225 - 300	> 65 - 80	> 32.5 - 40.0	> 14.7 - 18.1	> 0.20 - 0.24	> 5.52 - 6.80	2/3 - 3/4 bag
Over 12	Over 300	Contact Five Star Products					

Table 2: Coarse Aggregate Extension Guidelines for

Five Star® Highway Patch
Five Star® Highway Patch Winter
Five Star® Highway Patch FR

50 Pound (22.7 kg) Bag							
DEPTH OF POUR (inches)		% BY WEIGHT OF COARSE AGGREGATE EXTENSION	ACTUAL WEIGHT OF COARSE AGGREGATE EXTENSION (weight added per 50 lb. bag)		ESTIMATED YIELD ADJUSTMENT (volume added to 50 lb. bag product yield)		APPROXIMATE BAGGED STONE QUANTITIES (per 50 lb. bag of product)
inches	mm		pounds	kg	+ cubic foot	+ liter	
1 - 2	25 - 50	0	0	0	0	0	Install product neat
> 2 - 4	> 50 - 100	50	25	11.3	0.15	4.25	1/2 bag minimum
> 4 - 6	> 100 - 150	60	30	13.6	0.18	5.10	2/3 bag
Over 6	Over 150	Contact Five Star Products					

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Table 3: Basalt/Granite Coarse Aggregate Extension Guidelines for temperature exposures > 400°F (204°C)

Five Star Structural Concrete® HTR
Five Star Structural Concrete® HTR ES

50 Pound (22.7 kg) Bag							
DEPTH OF POUR (inches)		% BY WEIGHT OF COARSE AGGREGATE EXTENSION	ACTUAL WEIGHT OF COARSE AGGREGATE EXTENSION (weight added per 50 lb.bag)		ESTIMATED YIELD ADJUSTMENT (volume added to 50 lb. bag product yield)		APPROXIMATE BAGGED STONE QUANTITIES (per 50 lb. bag of product)
inches	mm		pounds	kg	+ cubic foot	+ liter	
1-2	25 - 50	0	0	0	0	0	Install product neat
> 2 - 6	> 50 - 150	25 - 50	12.5 - 25.0	5.7 - 11.3	0.08 - 0.15	2.12 - 4.25	1/4 - 1/2 bag
> 6 - 9	> 150 - 225	> 50 - 65	> 25.0 - 32.5	> 11.3 - 14.7	> 0.15 - 0.20	> 4.25 - 5.52	1/2 - 2/3 bag
> 9 - 12	> 225 - 300	> 65 - 80	> 32.5 - 40.0	> 14.7 - 18.1	> 0.20 - 0.24	> 5.52 - 6.80	2/3 - 3/4 bag
Over 12	Over 300	Contact Five Star Products					

D. Yield

To estimate increase in yield, a coarse aggregate specific gravity of 2.65 is assumed. For every 5.0 lb. (2.3 kg) of coarse aggregate or basalt/granite coarse aggregate added, an approximate increase in yield of about 0.03 ft^3 (0.85 L) can be expected compared to neat product mixed at the same water level.

Ultimate yield may be influenced by aggregate specific gravity, weather conditions, mixing, placement, and water content. Actual yields attained in the field will vary and should be verified where greater accuracy is required. Yields are at maximum water.

E. Testing Considerations

Testing Method	Application
ASTM C109	Coarse aggregate sizes ⅜ inch (9 - 10 mm) or smaller.
ASTM C39	All coarse aggregate sizes > ⅜ inch (9 - 10 mm) regardless of extension percentage weight.

The smallest dimension of the sample vessel (cylinder or cube) should be at least 5 times the size of the coarse aggregate to obtain a representative sample. Sample results obtained using ASTM C39 are often different (lower) than the published Five Star® compressive strengths which use ASTM C109. The trend tends to be that the larger the sample size the lower the compressive strength.

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F. Mixing Instructions Overview

1. Prior to mixing the product, the following needs to be determined:
   - Minimum water volume per bag
   - Maximum water volume per bag
   - 90% of maximum water volume per bag
   - The mixer batch size (the number of bags of material that are planned to be mixed at one time)
   - The mixer batch volume which is
     = the number of bags/units of material + the water + any coarse aggregate that may be required
     The volume of the mixer batch should not exceed half the capacity of the mixer.

   Note: When a product is extended with coarse aggregate, the mixer batch volume is typically reduced because the coarse aggregate in the material will put additional strain on the mixer.

2. The following should be considered when selecting a mixer.
   - Determine the type of mixer to be used (see below).
   - The mixer should be robust and in top working order (gasoline powered mixers tend to have higher mixing capacities and torque compared to electric mixers).
   - The volume of the mixer batch should not be greater than ½ the capacity of the mixer.
   - Having multiple mixers available is recommended and always preferred to relying on a single mixer.

Mortar Mixer: A mixer with a stationary barrel or drum and rotating blades.

- These mixers are recommended for mixing all Five Star® materials because of their ability to shear the product as it mixes.
- The mortar mixer's blades should be in contact with sides of the drum/hopper for adequate mixing to happen.
- A mortar mixer may not be able to handle coarse aggregate extensions greater than 50% by weight. If the mixer is not able to handle the coarse aggregate extension a concrete mixer may be considered.
- If planning to use a coarse aggregate size greater than ⅜ inch (9 - 10 mm) a concrete mixer may be considered.

MORTAR MIXER

Concrete Mixer: A mixer with a stationary blade and a rotating barrel or drum.

- These mixers are not recommended for mixing Five Star® materials because they lift and drop the material as opposed to shearing the material. The mixing action also adds air to the mix.
- A concrete mixer may only be used if coarse aggregate is added to the mix. The coarse aggregate in the mix helps to shear the material.
- If planning to use a coarse aggregate size greater than ⅜ inch (9 - 10 mm), then a concrete mixer may be considered.

CONCRETE MIXER

Contact Five Star Products if you are planning to use a concrete mixer.

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G. Mixing Instructions - Procedure

1. Inspect and clean the mixer; the blades must be in good physical condition and be able to contact the walls of the mixer.
2. Wet down the inside of the mixing chamber with potable water and drain the water out. This is referred to as "wetting out the mixer." Note: Wetting out the mixer is also an effective way to cool off the mixer if it is at a temperature greater than desirable.
3. Accurately measure 90% of the batch mix water volume in one container and in a second container accurately measure 10% of the batch mix water volume.
4. Add 90% of the batch mix water volume to the mixer.

Mortar Mixer		Concrete Mixer	
5.	Start the mixer.	5.	Add coarse aggregate to the mixer.
6.	Add the correct number of bags of the Five Star® product.	6.	Start the mixer.
7.	Mix for 3 – 4 minutes at high speed. The product should develop a flowable, non-dry consistency once the additives in the product react to the mixing and the water.	7.	Add the correct number of bags of the Five Star® product.
8.	Add the coarse aggregate	8.	Mix for 3 – 4 minutes at high speed. The product should develop a flowable, non-dry consistency once the additives in the product react to the mixing and the water .
9.	Mix until coarse aggregate is fully combined with the mixture.	9.	Mix until coarse aggregate is fully combined with the mixture.

10. Stop the mixer and check the consistency of the batch and whether the product is flowable enough to be installed.
11. If more water is necessary, start the mixer and slowly add a portion of the remaining 10% of the batch mix water (in intervals) and allow the material to thoroughly mix. Do not add more water than is published on the bag or an amount that will cause segregation.
12. Stop the mixer and check the consistency of the batch and whether the product is flowable enough to be installed.
13. Repeat steps 10 - 13 as required but stop adding water once the desired consistency is achieved, or the maximum amount of batch water is added (the 10% container is empty).

NOTE: Total mixing time per batch is approximately 5 -7 minutes. Mixing longer than that will add heat to the mix and shorten the working time of the material.

Contact your local Five Star® Technical Sales Representative if you are considering using something other than a mortar mixer, if the coarse aggregate is greater than ⅜ inch (9 - 10 mm), or if additional information is required.

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