Use of AI to develop a mix design for high performance cellular concrete,

using Google Gemini 2.5 as an example. Grok has yielded similar information, though no follow-up questions were asked.

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Here is the first query made:

"good mix design for high compressive cellular concrete 50 pcf density"

More queries (prompts) follow the first one.

"Okay, designing a high compressive strength cellular concrete (CLC) at 50 pcf (pounds per cubic foot) or approximately 800 kg/m ³ requires careful control over the mix constituents, especially the water-to-cementitious materials ratio (w/cm) and the quality of the foam.

Goal: High compressive strength for a 50 pcf CLC. This typically means aiming for strengths above 750 psi (5 MPa), potentially up to 1000-1500 psi (7-10 MPa) or even higher with optimized materials and curing.

Key Principles for High Strength CLC:

- 1. Low Water/Cementitious Ratio (w/cm): This is paramount for strength.
- 2. **High-Quality Cement:** Type I/II Portland cement is standard. Type III (high early strength) can be used if rapid strength gain is needed.
- 3. **Supplementary Cementitious Materials (SCMs):** Fly ash (Class C or F) or silica fume can enhance strength, durability, and workability of the base slurry. Silica fume is particularly effective for high strength.
- 4. **Stable, Fine-Celled Foam:** The foam must be stable and integrate well with the slurry without collapsing.
- 5. No or Minimal Coarse Aggregate: CLC at this density is typically made with cement, water, foam, and sometimes fine sand or SCMs.
- 6. **Proper Curing:** Moist curing is essential for cement hydration and strength development.

Sample Mix Design Starting Point (per cubic yard):

This is a *starting point*. Lab trials are **essential** to verify and adjust.

Target Wet Density: 50 pcf

Components & Proportions:

1. Cementitious Materials:

- **Portland Cement (Type I/II or III):** ~750 950 lbs (This is a high cement content for CLC, geared for strength)
- Fly Ash (Class F or C): ~100 200 lbs (Optional, but recommended. Can replace 15-25% of cement by weight. Improves workability and long-term strength. If using Class C, it has some cementitious properties.)
- Silica Fume: ~40 80 lbs (Optional, but highly recommended for high strength. Typically 5-10% by weight of cement. Increases water demand, so superplasticizer is usually needed.)

Let's choose a combination for our example:

- Portland Cement: 800 lbs
- Fly Ash (Class F): 150 lbs (approx. 16% of total cementitious)
- Silica Fume: 50 lbs (approx. 5% of total cementitious)
- Total Cementitious Material (CM): 800 + 150 + 50 = 1000 lbs
- 2. Water:
 - **Target w/cm ratio:** 0.32 0.40 (Lower is better for strength, but workability of the slurry before foaming is key). Let's aim for **0.35**.
 - Water quantity: 0.35 * 1000 lbs (CM) = 350 lbs (approx. 42 gallons)

3. Fine Aggregate (Optional, but can help):

- Fine Sand (ASTM C33): Up to 200-400 lbs. If used, it will increase the slurry density, meaning more foam is needed. For very high strength, a neat cement/SCM paste is often preferred. For this example, let's initially exclude sand to keep slurry density lower and maximize foam contribution to lightweight nature. *If you add sand, recalculate slurry density and foam volume.*
- 4. Admixtures:
 - **Superplasticizer (High-Range Water Reducer HRWR):** Essential for a low w/cm ratio and if using silica fume. Dosage as per manufacturer's recommendation (e.g., 8-15 fl oz per 100 lbs of CM).
 - Example: 10 fl oz / 100 lbs CM * 1000 lbs CM = 100 fl oz (approx. 0.78 gallons)
 - **Foaming Agent:** Protein-based or synthetic. Dosage as per manufacturer to produce stable foam with a density of ~2.5-4.0 pcf.
- 5. **Foam:**

• Density of Base Slurry (Cement + SCMs + Water):

• Volume of Cement: 800 lbs / $(3.15 * 62.4 \text{ pcf}) \approx 4.08 \text{ ft}^3$

- Volume of Fly Ash: 150 lbs / (2.40 * 62.4 pcf) ≈ 1.00 ft³ (SG of FA varies)
- Volume of Silica Fume: 50 lbs / (2.20 * 62.4 pcf) ≈ 0.36 ft³ (SG of SF varies)
- Volume of Water: $350 \text{ lbs} / (1.00 * 62.4 \text{ pcf}) \approx 5.61 \text{ ft}^3$
- Total Slurry Volume (excluding air from mixing): 4.08 + 1.00 + 0.36 + 5.61 = 11.05 ft³
- Total Slurry Weight: 1000 lbs (CM) + 350 lbs (Water) = 1350 lbs
- Base Slurry Density: 1350 lbs / 11.05 ft³ ≈ 122.2 pcf
- Foam Volume Calculation:
 - Let V_s = volume fraction of slurry, V_f = volume fraction of foam. V_s + V_f = 1.
 - Target Density = (V_s * Density_Slurry) + (V_f * Density_Foam)
 - Assume foam density = 3.0 pcf
 - $50 \text{ pcf} = (V_s * 122.2 \text{ pcf}) + ((1-V_s) * 3.0 \text{ pcf})$
 - $50 = 122.2V_s + 3 3V_s$
 - $47 = 119.2 \text{*V}_s$
 - $V_s \approx 0.394$ (Slurry is ~39.4% of the final volume)
 - $V_f \approx 1 0.394 = 0.606$ (Foam is ~60.6% of the final volume)
- For 1 cubic yard (27 ft³) of CLC:
 - Volume of Slurry Needed: 0.394 * 27 ft³ ≈ 10.64 ft³ (Matches closely with our 11.05 ft³ calculation for slurry components, good sanity check. The difference is due to slight variations in exact specific gravities and rounding. Use the component volumes for batching.)
 - Volume of Pre-formed Foam Needed: $0.606 * 27 \text{ ft}^3 \approx 16.36 \text{ ft}^3$

Summary of Starting Mix Proportions (per cubic yard):

- Portland Cement: 800 lbs
- Fly Ash (Class F): 150 lbs
- Silica Fume: 50 lbs
- **Water:** 350 lbs (target w/cm = 0.35)
- **Superplasticizer:** As per manufacturer (e.g., ~100 fl oz)
- **Pre-formed Foam (target 3 pcf density):** ~16.4 ft³ (Foaming agent as per manufacturer, diluted and processed through foam generator)

Target Fresh Properties:

- Wet Density: 50 ± 2 pcf
- Slump/Flow: CLC is typically characterized by its flowability rather than slump. A flow spread of 8-12 inches (200-300 mm) using a flow cone or by inverting a slump cone might be appropriate.

Mixing Procedure (Critical):

- 1. Add about 80% of the water and the superplasticizer to the mixer.
- 2. Add silica fume (if used) and mix thoroughly to disperse.
- 3. Add cement and fly ash. Mix until a smooth, homogenous slurry is formed (typically 3-5 minutes).
- 4. Add the remaining water to achieve the desired slurry consistency. Avoid adding too much water.
- 5. Generate the pre-formed foam to the correct density (e.g., 2.5-4.0 pcf) using the foaming agent and foam generator.
- 6. Inject the pre-formed foam slowly into the slurry while the mixer is running at a medium speed.
- 7. Continue mixing only until the foam is uniformly incorporated and the target density is achieved (usually 1-3 minutes). Over-mixing can break down foam bubbles.
- 8. Check the wet density immediately. Adjust foam addition if necessary for subsequent batches.

Curing:

- Moist cure for at least 7 days, ideally longer (up to 28 days) for maximum strength development. This can be achieved by covering with plastic sheeting, using curing compounds, or water ponding/spraying.
- Avoid rapid drying, especially in the early stages.

Important Considerations & Trial Batches:

- **Material Variations:** Cement, SCMs, and foaming agents vary. Always conduct lab trials.
- **Foam Quality:** Foam bubble size, stability, and density are crucial. Ensure your foam generator is working correctly and the foaming agent is properly diluted.
- Workability: The base slurry must be workable enough to evenly incorporate the foam.
- **Strength Testing:** Test compressive strength at 7, 14, and 28 days (ASTM C495 for CLC).
- **Density Control:** Regularly check wet density during production.
- **Scaling:** The above is for 1 cubic yard. Scale ingredients appropriately for your batch size.

This detailed starting point should give you a strong foundation for developing your highstrength 50 pcf cellular concrete. Good luck! Gemini "thought process"

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Messages

User

good mix design for high compressive cellular concrete 50 pcf density Model

Here's a thinking process that could lead to the cellular concrete mix design: 1. **Deconstruct the Request:** * ** Product:** Cellular Concrete (CLC) * ** Key Property:** High Compressive Strength * **Target Density:** 50 pcf (pounds per cubic foot) * **Implied Need:** A starting point for a mix design, not necessarily a final, lab-verified one. 2. **Understand Cellular Concrete Basics:** * What is it? Lightweight concrete made by introducing air/foam into a cementitious slurry. * Components: * Cement (binder) * Water * Foam (pre-formed or generated in-situ, usually pre-formed for better control) * Optional: Fine aggregate (sand), supplementary cementitious materials (SCMs), admixtures. * Density-Strength Relationship: Generally, lower density = lower strength. 50 pcf is on the higher end for CLC, so achieving "high compressive strength" *for that density* is the goal. * Key to Strength: * Low w/c ratio (within workable limits for the slurry) * Good quality cement * Proper foam structure and stability * Good curing 3. **Address the 50 pcf Density Target:** * This is a *wet density* target, which will decrease slightly upon drying. * The foam is what primarily controls the density. * The base slurry (cement, water, sand if any) has a much higher density (e.g., cement paste ~130-140 pcf, mortar ~135-145 pcf). * Therefore, a significant volume of foam will be needed. 4. **Consider "High Compressive Strength" for 50 pcf:** * What's "high" for this density? Typical CLC at 50 pcf might be in the 500-1000 psi range. "High" could mean aiming for the upper end of this, or even slightly above (e.g., 1000-1500 psi). This will heavily depend on materials and execution. * How to achieve higher strength: * **Low w/c ratio:** Critical. Too much water weakens the paste and can destabilize foam. * **Cement content:** Higher cement content generally means higher strength. * **SCMs:** Fly ash (Class C or F) or silica fume can improve particle packing, reduce permeability, and contribute to long-term strength. Silica fume is particularly good for high strength. * **Fine Aggregate:** Well-graded fine sand can improve strength and reduce shrinkage, but it also increases slurry density, requiring more foam. For 50 pcf, sand might be used sparingly or not at all to keep slurry density down. * **Foam Quality:** Stable, small, uniform bubbles are crucial. * **Curing:** Proper moist curing is essential. 5. **Start Formulating a Mix Design Strategy:** * **Cement:** Use a good quality Portland Cement (Type I/II or Type III for faster strength gain if needed). * **Water-to-Cement (w/c) Ratio:** Aim low, e.g., 0.35 - 0.45 by weight. Lower is better for strength, but workability of the slurry

before foaming is key. Let's start with 0.40 as a reasonable balance. * **Sand:** For 50 pcf, minimizing or eliminating sand is often preferred to maximize foam volume and control density. If sand is used, it must be very fine. Let's try a neat cement paste first, then consider sand as an option. * **Foam:** Pre-formed foam is standard. The amount will be determined by the target density and the density of the base slurry. * **SCMs:** * Fly Ash: Can replace 15-25% of cement. Improves workability, reduces heat, can enhance long-term strength. Class F is common. * Silica Fume: 5-10% replacement. Significantly boosts strength and reduces permeability, but can make the mix sticky and increase water demand if not used with a superplasticizer. * **Admixtures:** * Superplasticizer (High-Range Water Reducer - HRWR): Essential if using a very low w/c ratio or silica fume to maintain slurry workability. * Foaming Agent: The chemical concentrate used to generate the foam. Follow manufacturer's dosage. 6. **Develop a "Neat Cement Paste" Base Slurry (Example 1):** * Target w/c: 0.40 * Cement: 1 part by weight * Water: 0.40 parts by weight * Calculate slurry density: * Assume cement specific gravity (SG) \approx 3.15 * Assume water SG \approx 1.0 * Volume of 1 lb cement = 1 / (3.15 * 62.4 pcf) \approx 0.00509 ft³/lb * Volume of 0.4 lb water = $0.4 / (1.0 * 62.4 \text{ pcf}) \approx 0.00641 \text{ ft}^3/\text{lb} * \text{Total weight} = 1 + 0.4 = 1.4 \text{ lb}$ * Total volume = 0.00509 + 0.00641 = 0.0115 ft³ * Slurry density = 1.4 lb / 0.0115 ft³ ≈ 121.7 pcf. (This seems reasonable for a neat paste). 7. **Develop a "Cement + Fly Ash" Base Slurry (Example 2):** * Target w/(c+fa): 0.38 (can often go lower with fly ash) * Cement: 0.8 parts (80%) * Fly Ash (Class F): 0.2 parts (20%) * Total Cementitious: 1 part * Water: 0.38 parts * Calculate slurry density: * Assume fly ash SG \approx 2.4 * Volume of 0.8 lb cement = 0.8 / (3.15 * $(62.4) \approx 0.00407 \text{ ft}^3 \text{ * Volume of } 0.2 \text{ lb fly ash} = 0.2 / (2.4 \text{ * } 62.4) \approx 0.00134 \text{ ft}^3 \text{ * Volume of } 0.38$ lb water = $0.38 / (1.0 * 62.4) \approx 0.00609$ ft³ * Total weight = 0.8 + 0.2 + 0.38 = 1.38 lb * Total volume = 0.00407 + 0.00134 + 0.00609 = 0.0115 ft³ * Slurry density = 1.38 lb / 0.0115 ft³ ≈ 120 pcf. (Still in the ballpark). 8. **Calculate Foam Requirement (Conceptual):** * Let D target = 50 pcf * Let D_slurry = 120 pcf (from example above) * Let D foam \approx 2-4 pcf (typical preformed foam density, assume 3 pcf for calculation) * Volume fraction of slurry (V s) + Volume fraction of foam $(V_f) = 1 * D_target = (V_s * D_slurry) + (V_f * D_foam) * 50 = (V_s * 120)$ + $((1-V_s) * 3) * 50 = 120*V_s + 3 - 3*V_s * 47 = 117*V_s * V_s = 47 / 117 \approx 0.40$ (Slurry is 40% of the final volume) * V f = 1 - 0.40 = 0.60 (Foam is 60% of the final volume) * This means for every 1 cubic foot of CLC, you need 0.4 ft³ of slurry and 0.6 ft³ of foam. 9. **Refine Mix Proportions (per cubic yard or other unit):** * Let's aim for 1 cubic yard (27 ft³) of CLC. * Volume of slurry needed = 0.40×27 ft³ = 10.8 ft³ × Volume of foam needed = 0.60×27 ft³ = 16.2 ft³ * *Using the Neat Cement Slurry (Example 1, density ~121.7 pcf):* * Weight of slurry needed = 10.8 ft³ * 121.7 pcf \approx 1314 lbs * Recall slurry was 1 part cement, 0.4 parts water (total 1.4 parts by weight) * Cement = (1 / 1.4) * 1314 lbs \approx 939 lbs * Water = (0.4 / 1.4) * 1314 lbs \approx 375 lbs (w/c = $375/939 = 0.399 \approx 0.40$) * *Using the Cement + Fly Ash Slurry (Example 2, density ~120 pcf):* * Weight of slurry needed = 10.8 ft³ * 120 pcf = 1296 lbs * Recall slurry was 0.8 cement, 0.2 fly ash, 0.38 water (total 1.38 parts by weight) * Cement = (0.8 / 1.38) * 1296 lbs ≈ 751 lbs * Fly Ash = (0.2 / 1.38) * 1296 lbs ≈ 188 lbs * Water = (0.38 / 1.38) * 1296 lbs ≈ 357 lbs (w/(c+fa) = 357/(751+188) = 357/939 = 0.38) 10. **Add Admixtures:** * Superplasticizer: Dose according to manufacturer, typically 0.5-1.5% by weight of cementitious material. Critical for low w/c. * Foaming Agent: Dose for foam generator according to manufacturer (e.g., 2-5% solution in water, then foam generation). 11. **Structure the Answer:** * Start with a disclaimer: Lab trials are essential. * List key components. * Provide a sample "Starting Point" mix design (e.g., the cement + fly ash one, as it's good for strength and workability). * Explain the role of each component. * Give ranges for critical parameters (w/cm, SCM replacement). *

Discuss factors affecting strength (foam quality, curing, etc.). * Outline mixing procedure. * Emphasize trial batches and testing. 12. **Self-Correction/Refinement:** * Is 50 pcf achievable with *high* strength? Yes, but "high" is relative for CLC. Manage expectations. * Did I include sand? Decided against it for the primary example to simplify and maximize foam content for 50 pcf. Mention it as an option for slight density increases or specific properties. * Is the w/cm ratio realistic? 0.35-0.45 is a good range. Below 0.35 without superplasticizer is very difficult for the slurry. * Are the SCM percentages reasonable? Yes, 15-25% fly ash, 5-10% silica fume are standard. * Is the explanation clear? Ensure logical flow. * Units: Be consistent (pcf, lbs, ft³ or kg, L, m³). The request used pcf, so stick with imperial. This thought process moves from understanding the core request to breaking down the material science, performing some basic calculations, and then structuring the information into a helpful, actionable response, while also including necessary caveats.

Model

Okay, designing a high compressive strength cellular concrete (CLC) at 50 pcf (pounds per cubic foot) or approximately 800 kg/m³ requires careful control over the mix constituents, especially the water-to-cementitious materials ratio (w/cm) and the quality of the foam. **Goal:** High compressive strength for a 50 pcf CLC. This typically means aiming for strengths above 750 psi (5 MPa), potentially up to 1000-1500 psi (7-10 MPa) or even higher with optimized materials and curing. **Key Principles for High Strength CLC:** 1. **Low Water/Cementitious Ratio (w/cm):** This is paramount for strength. 2. **High-Quality Cement:** Type I/II Portland cement is standard. Type III (high early strength) can be used if rapid strength gain is needed. 3. **Supplementary Cementitious Materials (SCMs):** Fly ash (Class C or F) or silica fume can enhance strength, durability, and workability of the base slurry. Silica fume is particularly effective for high strength. 4. **Stable, Fine-Celled Foam:** The foam must be stable and integrate well with the slurry without collapsing. 5. **No or Minimal Coarse Aggregate:** CLC at this density is typically made with cement, water, foam, and sometimes fine sand or SCMs. 6. **Proper Curing:** Moist curing is essential for cement hydration and strength development. ---**Sample Mix Design Starting Point (per cubic yard):** This is a *starting point*. Lab trials are **essential** to verify and adjust. **Target Wet Density:** 50 pcf **Components & Proportions:** 1. **Cementitious Materials:** * **Portland Cement (Type I/II or III):** ~750 -950 lbs (This is a high cement content for CLC, geared for strength) * **Fly Ash (Class F or C):** ~100 - 200 lbs (Optional, but recommended. Can replace 15-25% of cement by weight. Improves workability and long-term strength. If using Class C, it has some cementitious properties.) * **Silica Fume:** ~40 - 80 lbs (Optional, but highly recommended for high strength. Typically 5-10% by weight of cement. Increases water demand, so superplasticizer is usually needed.) *Let's choose a combination for our example:* * Portland Cement: 800 lbs * Fly Ash (Class F): 150 lbs (approx. 16% of total cementitious) * Silica Fume: 50 lbs (approx. 5% of total cementitious) * **Total Cementitious Material (CM):** 800 + 150 + 50 = 1000 lbs 2. **Water:** * **Target w/cm ratio:** 0.32 - 0.40 (Lower is better for strength, but workability of the slurry before foaming is key). Let's aim for **0.35**. * **Water quantity:** 0.35 * 1000 lbs (CM) = 350 lbs (approx. 42 gallons) 3. **Fine Aggregate (Optional, but can help):** * **Fine Sand (ASTM C33):** Up to 200-400 lbs. If used, it will increase the slurry density, meaning more foam is needed. For very high strength, a neat cement/SCM paste is often preferred. For this example, let's initially **exclude sand** to keep slurry density lower and maximize foam contribution to lightweight nature. *If you add sand, recalculate slurry density and foam volume.* 4. **Admixtures:** * **Superplasticizer (High-Range Water Reducer - HRWR):**

Essential for a low w/cm ratio and if using silica fume. Dosage as per manufacturer's recommendation (e.g., 8-15 fl oz per 100 lbs of CM). * Example: 10 fl oz / 100 lbs CM * 1000 lbs CM = 100 fl oz (approx. 0.78 gallons) * **Foaming Agent:** Protein-based or synthetic. Dosage as per manufacturer to produce stable foam with a density of ~2.5-4.0 pcf. 5. **Foam:** * **Density of Base Slurry (Cement + SCMs + Water):** * Volume of Cement: 800 lbs / (3.15 * $62.4 \text{ pcf} \approx 4.08 \text{ ft}^3 * \text{Volume of Fly Ash: } 150 \text{ lbs / } (2.40 * 62.4 \text{ pcf}) \approx 1.00 \text{ ft}^3 \text{ (SG of FA varies)}$ * Volume of Silica Fume: 50 lbs / $(2.20 * 62.4 \text{ pcf}) \approx 0.36 \text{ ft}^3$ (SG of SF varies) * Volume of Water: 350 lbs / $(1.00 * 62.4 \text{ pcf}) \approx 5.61 \text{ ft}^3 * \text{Total Slurry Volume (excluding air from mixing):}$ 4.08 + 1.00 + 0.36 + 5.61 = 11.05 ft³ * Total Slurry Weight: 1000 lbs (CM) + 350 lbs (Water) = 1350 lbs * **Base Slurry Density:** 1350 lbs / 11.05 ft³ ~ **122.2 pcf** * **Foam Volume Calculation:** * Let V s = volume fraction of slurry, V f = volume fraction of foam. V s + V f = 1. * Target Density = $(V_s * Density_Slurry) + (V_f * Density_Foam) * Assume foam density$ $= 3.0 \text{ pcf} * 50 \text{ pcf} = (V_s * 122.2 \text{ pcf}) + ((1-V_s) * 3.0 \text{ pcf}) * 50 = 122.2 \text{ *}V_s + 3 - 3 \text{ *}V_s * 47$ = 119.2*V s * V s \approx 0.394 (Slurry is ~39.4% of the final volume) * V f \approx 1 - 0.394 = 0.606 (Foam is ~60.6% of the final volume) * **For 1 cubic yard (27 ft³) of CLC:** * Volume of Slurry Needed: 0.394 * 27 ft³ \approx **10.64 ft³** (Matches closely with our 11.05 ft³ calculation for slurry components, good sanity check. The difference is due to slight variations in exact specific gravities and rounding. Use the component volumes for batching.) * Volume of Pre-formed Foam Needed: 0.606 * 27 ft³ \approx **16.36 ft³** --- **Summary of Starting Mix Proportions (per cubic yard):** * **Portland Cement:** 800 lbs * **Fly Ash (Class F):** 150 lbs * **Silica Fume:** 50 lbs * **Water:** 350 lbs (target w/cm = 0.35) * **Superplasticizer:** As per manufacturer (e.g., ~100 fl oz) * **Pre-formed Foam (target 3 pcf density):** ~16.4 ft³ (Foaming agent as per manufacturer, diluted and processed through foam generator) **Target Fresh Properties:** * Wet Density: $50 \pm 2 \text{ pcf}$ * Slump/Flow: CLC is typically characterized by its flowability rather than slump. A flow spread of 8-12 inches (200-300 mm) using a flow cone or by inverting a slump cone might be appropriate. --- **Mixing Procedure (Critical):** 1. Add about 80% of the water and the superplasticizer to the mixer. 2. Add silica fume (if used) and mix thoroughly to disperse. 3. Add cement and fly ash. Mix until a smooth, homogenous slurry is formed (typically 3-5 minutes). 4. Add the remaining water to achieve the desired slurry consistency. Avoid adding too much water. 5. Generate the pre-formed foam to the correct density (e.g., 2.5-4.0 pcf) using the foaming agent and foam generator. 6. Inject the pre-formed foam slowly into the slurry while the mixer is running at a medium speed. 7. Continue mixing only until the foam is uniformly incorporated and the target density is achieved (usually 1-3 minutes). Over-mixing can break down foam bubbles. 8. Check the wet density immediately. Adjust foam addition if necessary for subsequent batches. **Curing:** * Moist cure for at least 7 days, ideally longer (up to 28 days) for maximum strength development. This can be achieved by covering with plastic sheeting, using curing compounds, or water ponding/spraying. * Avoid rapid drying, especially in the early stages. **Important Considerations & Trial Batches:** * **Material Variations:** Cement, SCMs, and foaming agents vary. Always conduct lab trials. * **Foam Quality:** Foam bubble size, stability, and density are crucial. Ensure your foam generator is working correctly and the foaming agent is properly diluted. * **Workability:** The base slurry must be workable enough to evenly incorporate the foam. * **Strength Testing:** Test compressive strength at 7, 14, and 28 days (ASTM C495 for CLC). * **Density Control:** Regularly check wet density during production. * **Scaling:** The above is for 1 cubic yard. Scale ingredients appropriately for your batch size. This detailed starting point should give you a strong foundation for developing your high-strength 50 pcf cellular concrete. Good luck!

Parameters

Response thumb_up

Okay, designing a high compressive strength cellular concrete (CLC) at 50 pcf (pounds per cubic foot) or approximately 800 kg/m³ requires careful control over the mix constituents, especially the water-to-cementitious materials ratio (w/cm) and the quality of the foam. **Goal:** High compressive strength for a 50 pcf CLC. This typically means aiming for strengths above 750 psi (5 MPa), potentially up to 1000-1500 psi (7-10 MPa) or even higher with optimized materials and curing. **Key Principles for High Strength CLC:** 1. **Low Water/Cementitious Ratio (w/cm):** This is paramount for strength. 2. **High-Quality Cement:** Type I/II Portland cement is standard. Type III (high early strength

what if i change to 70 pcf wet density. what strength can i expect and what would be a good mix design

Okay, moving to a 70 pcf (pounds per cubic foot) or approximately 1120 kg/m³ wet density will generally allow for significantly higher compressive strengths compared to a 50 pcf mix. This is because a larger proportion of the mix will be the denser, stronger cementitious slurry, and a smaller proportion will be air (foam).

Expected Compressive Strength:

For a well-designed 70 pcf CLC with a low water-to-cementitious materials ratio (w/cm) and potentially supplementary cementitious materials (SCMs), you can expect compressive strengths in the range of:

- 1500 2500 psi (10 17 MPa) is a reasonable target range.
- With highly optimized materials (especially good quality silica fume, very low w/cm, and excellent curing), strengths upwards of **3000+ psi (20+ MPa)** might be achievable.

The actual strength will heavily depend on the w/cm ratio, quality of cement, use of SCMs, type and amount of fine aggregate (if any), foam quality, and curing conditions.

Good Mix Design Starting Point for 70 pcf CLC (per cubic yard):

At this higher density, incorporating some fine sand is often beneficial for dimensional stability, reduced shrinkage, and potentially cost, while still maintaining good strength.

Target Wet Density: 70 pcf

Components & Proportions:

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- 1. Cementitious Materials (CM):
 - Portland Cement (Type I/II or III): ~800 950 lbs
 - Fly Ash (Class F or C): ~150 250 lbs (e.g., 15-25% replacement of cement by weight)
 - **Silica Fume:** ~50 90 lbs (e.g., 5-8% by weight of cement, very effective for strength)

Let's choose a combination for our example:

- Portland Cement: 830 lbs
- Fly Ash (Class F): 165 lbs (approx. 16.5% of total CM)
- Silica Fume: 65 lbs (approx. 6.5% of total CM)
- Total Cementitious Material (CM): 830 + 165 + 65 = 1060 lbs
- 2. Water:
 - Target w/cm ratio: 0.32 0.38 (Keep this low for strength. Let's aim for 0.34).
 - Water quantity: 0.34 * 1060 lbs (CM) = **360.4 lbs** (approx. 43.2 gallons). Let's use **360 lbs**.
- 3. Fine Aggregate:
 - **Fine Sand (ASTM C33):** ~350 500 lbs. Using sand will increase the slurry density, requiring less foam. It can also help with overall matrix strength.
 - Let's target a sand content of around 40% of the cementitious material weight: 0.40 * 1060 lbs = 424 lbs. Let's use 425 lbs.

4. Admixtures:

- Superplasticizer (High-Range Water Reducer HRWR): Essential for a low w/cm and with silica fume. Dosage as per manufacturer's recommendation (e.g., 8-15 fl oz per 100 lbs of CM).
 - Example: 10 fl oz / 100 lbs CM * 1060 lbs CM = 106 fl oz (approx. 0.83 gallons)
- **Foaming Agent:** Protein-based or synthetic. Dosage as per manufacturer to produce stable foam with a density of ~2.5-4.0 pcf.

5. **Foam:**

• Density of Base Slurry (Cement + SCMs + Water + Sand):

- Volume of Cement: 830 lbs / (3.15 * 62.4 pcf) ≈ 4.22 ft³ (SG of Cement ~3.15)
- Volume of Fly Ash: 165 lbs / (2.40 * 62.4 pcf) ≈ 1.10 ft³ (SG of FA ~2.2-2.6, using 2.4)
- Volume of Silica Fume: 65 lbs / (2.20 * 62.4 pcf) ≈ 0.47 ft³ (SG of SF ~2.1-2.3, using 2.2)
- Volume of Water: $360 \text{ lbs} / (1.00 * 62.4 \text{ pcf}) \approx 5.77 \text{ ft}^3$
- Volume of Sand: 425 lbs / $(2.65 * 62.4 \text{ pcf}) \approx 2.57 \text{ ft}^3$ (SG of Sand ~2.65)
- Total Slurry Volume (excluding air from mixing): 4.22 + 1.10 + 0.47 + 5.77 + 2.57 = 14.13 ft³
- Total Slurry Weight: 1060 lbs (CM) + 360 lbs (Water) + 425 lbs (Sand) = 1845 lbs
- Base Slurry Density: 1845 lbs / 14.13 ft³ ≈ 130.6 pcf
- Foam Volume Calculation:

- Let V_s = volume fraction of slurry, V_f = volume fraction of foam. V_s + V_f = 1.
- Target Density = (V_s * Density_Slurry) + (V_f * Density_Foam)
- Assume foam density = 3.0 pcf
- $70 \text{ pcf} = (V_s * 130.6 \text{ pcf}) + ((1-V_s) * 3.0 \text{ pcf})$
- $70 = 130.6V_s + 3 3V_s$
- $67 = 127.6 \text{*V}_s$
- $V_s \approx 0.525$ (Slurry is ~52.5% of the final volume)
- $V_f \approx 1 0.525 = 0.475$ (Foam is ~47.5% of the final volume)
- For 1 cubic yard (27 ft³) of CLC:
 - Volume of Slurry Needed: 0.525 * 27 ft³ ≈ 14.18 ft³. (This matches very closely with our calculated slurry component volume of 14.13 ft³, which is excellent!)
 - Volume of Pre-formed Foam Needed: 0.475 * 27 ft³ ≈ 12.82 ft³

Summary of Starting Mix Proportions (per cubic yard):

- Portland Cement (Type I/II or III): 830 lbs
- Fly Ash (Class F): 165 lbs
- Silica Fume: 65 lbs
- Total Cementitious Material: 1060 lbs
- **Water:** 360 lbs (target w/cm = 0.34)
- Fine Sand (ASTM C33): 425 lbs
- **Superplasticizer:** As per manufacturer (e.g., ~106 fl oz)
- **Pre-formed Foam (target 3 pcf density):** ~12.8 ft³ (Foaming agent as per manufacturer, diluted and processed through foam generator)

Target Fresh Properties:

- Wet Density: 70 ± 2 pcf
- Flow: Similar to the 50 pcf mix, aim for good flowability.

Mixing Procedure & Curing:

Follow the same best practices as outlined for the 50 pcf mix:

- 1. Add ~80% water + superplasticizer.
- 2. Add silica fume, mix.
- 3. Add cement, fly ash, and sand. Mix to a homogenous slurry.
- 4. Add remaining water to desired consistency.
- 5. Generate and slowly inject pre-formed foam while mixing.
- 6. Mix only until foam is incorporated and target density is achieved.
- 7. Moist cure for at least 7 days, ideally longer (up to 28 days).

Important Considerations & Trial Batches:

- Lab Trials are Essential: These are starting points. Actual material properties, ambient conditions, and mixing equipment will influence the final outcome.
- Sand Quality: Well-graded fine sand is preferred. Ensure it's clean.
- **Slurry Consistency:** The base slurry (before foam addition) should be fluid enough to accept the foam but not so wet that it leads to segregation or reduced strength. The superplasticizer is key here.
- Strength vs. Workability: There's always a trade-off. A very low w/cm is great for strength but makes the slurry stiff. Superplasticizers help, but there's a limit.
- **Foam Stability:** Even at higher densities, stable foam is important to prevent excessive collapse and ensure uniform air void distribution.

This mix design should provide a good basis for achieving high compressive strength at 70 pcf. Adjust based on your specific materials and trial batch results.

Yes, adding colloidal silica (also known as nano-silica when the particles are in the nanometer range) can potentially improve the compressive strength of your cellular concrete, often even more effectively than silica fume on a per-weight basis due to its extremely fine particle size and high reactivity.

Here's a breakdown:

How Colloidal Silica Works to Improve Strength:

- 1. **Highly Efficient Pozzolanic Reaction:** Colloidal silica particles are significantly smaller (typically 5-100 nanometers) than silica fume particles (typically 0.1-1 micrometer, or 100-1000 nm). This incredibly high surface area leads to a much faster and more efficient pozzolanic reaction with calcium hydroxide (CH), a byproduct of cement hydration. This reaction produces more calcium silicate hydrate (C-S-H), which is the primary binding phase responsible for concrete strength.
- 2. **Nano-Filler Effect:** The tiny particles can fill the nano-scale voids within the cement paste matrix, leading to a denser and less porous microstructure even beyond what silica fume can achieve.
- 3. **Nucleation Sites:** Colloidal silica particles can act as nucleation sites for the C-S-H gel, promoting more uniform and accelerated hydration of cement particles.
- 4. **Improved Interfacial Transition Zone (ITZ):** It can refine the ITZ between the cement paste and any fine aggregates (if used), leading to a stronger bond.

Potential Benefits for Your 70 pcf CLC:

- Higher Compressive Strength: This is the primary goal.
- Accelerated Early Strength Gain: Due to its high reactivity.
- **Reduced Permeability and Porosity:** Leading to improved durability.

• Improved Rheology (Potentially): Though it can also increase water demand.

Important Considerations When Using Colloidal Silica:

- Dosage: Colloidal silica is typically used in much smaller dosages than silica fume, usually in the range of 0.5% to 3% (occasionally up to 5%) by weight of cementitious material. Higher dosages can sometimes lead to issues or diminishing returns and significantly increase cost.
- 2. **Dispersion:** Colloidal silica comes as a liquid suspension (usually in water). It's already well-dispersed, which is an advantage. However, it must be thoroughly mixed into the cementitious slurry to ensure uniform distribution.
- 3. Water Content: The water in the colloidal silica suspension must be accounted for as part of the total mix water to maintain your target w/cm ratio. Failure to do so will increase the w/cm and could negate the strength benefits.
- 4. **Cost:** Colloidal silica is generally more expensive than silica fume and significantly more expensive than cement or fly ash. Its use needs to be justified by the required performance.
- 5. Workability & Water Demand: Like silica fume, colloidal silica's high surface area will increase the water demand of the mix. A superplasticizer (HRWR) is almost certainly necessary, and its dosage might need to be increased.
- 6. Interaction with Foam: This is a critical consideration for CLC.
 - **Foam Stability:** The extremely fine particles and their surface chemistry *could* potentially interact with the foaming agent and affect foam stability (either positively or negatively). **This absolutely needs to be tested in trial batches.**
 - **Integration:** Ensure the base slurry with colloidal silica can still uniformly incorporate the pre-formed foam.
- 7. Setting Time: It can accelerate the setting time of the concrete.

Revised Mix Design Aspect (Example if incorporating Colloidal Silica):

Let's say you want to try adding 2% colloidal silica (by weight of total CM) to your 70 pcf mix design:

- Total Cementitious Material (CM) from previous example: 1060 lbs
- Colloidal Silica (solid content): 2% of 1060 lbs = 21.2 lbs
- If the colloidal silica suspension has a 50% solids content (common), you would need 21.2 lbs / 0.50 = 42.4 lbs of the liquid suspension.
- The water content in this suspension would be 42.4 lbs 21.2 lbs = 21.2 lbs of water.

Adjustment to Water Calculation:

- Original target water: 360 lbs
- Water from colloidal silica: 21.2 lbs
- New batching water to add: 360 lbs 21.2 lbs = 338.8 lbs

You would then slightly adjust the cement, fly ash, or silica fume proportions if you are *replacing* a portion of them with colloidal silica, or simply add it if it's an *addition*. Often, it's considered an addition or a partial replacement for silica fume.

Recommendation:

If you are aiming for very high strengths and are willing to manage the added complexity and cost:

- 1. **Start with small dosages:** Begin with 1-2% colloidal silica by weight of total cementitious materials.
- 2. Account for its water content meticulously.
- 3. Ensure you are using an effective superplasticizer and adjust its dosage as needed.
- 4. CRITICALLY IMPORTANT FOR CLC: Conduct trial batches specifically to assess the impact of colloidal silica on foam stability and the overall fresh properties of the cellular concrete. Observe if the foam breaks down more easily or if the target density is harder to achieve or maintain.
- 5. Compare the strength gain and cost-effectiveness against a mix using only silica fume or a higher dosage of silica fume.

Colloidal silica is a powerful tool, but its successful use in CLC requires careful formulation and thorough testing, especially concerning its interaction with the foam system.

Adding acrylic fibers like AC-50 (which are typically monofilament synthetic fibers) to your cellular concrete mix will have several effects, mostly positive for certain properties, but with some considerations:

Potential Positive Effects:

- 1. **Reduced Plastic Shrinkage Cracking:** This is a primary benefit. As the CLC begins to dry and shrink in its plastic state (before it has gained significant strength), the fibers help to distribute tensile stresses and bridge micro-cracks, significantly reducing the formation and width of plastic shrinkage cracks. This is very valuable for CLC which can be prone to such cracking.
- 2. Improved Toughness and Ductility (Post-Crack Performance):
 - CLC is inherently brittle due to its high air content. Acrylic fibers can improve its post-cracking behavior. Once a crack forms, the fibers bridge the crack, providing residual strength and preventing the crack from widening rapidly.
 - This means the material will be less likely to shatter or break apart suddenly when overloaded or impacted. It will exhibit a more ductile failure mode.
- 3. **Increased Impact Resistance:** The fibers help absorb and dissipate energy from impacts, making the CLC more resistant to chipping, spalling, or breaking when subjected to sudden loads or dropped objects.

- 4. **Improved Shatter Resistance:** Similar to impact resistance, the fibers help hold the matrix together even if it's severely damaged, preventing it from completely disintegrating into small pieces.
- 5. Enhanced Cohesion of the Fresh Mix: Fibers can sometimes help improve the cohesion of the fresh CLC mix, potentially reducing segregation if the slurry is very fluid, though this is less of an issue with properly designed CLC.
- 6. **Potential for Improved Freeze-Thaw Resistance (Indirectly):** By controlling microcracking, fibers can potentially improve the long-term durability and resistance to freezethaw cycles, though CLC's air void system itself already contributes significantly to this.

Potential Negative Effects or Considerations:

1. Compressive Strength:

- Acrylic fibers are not primarily added to increase peak compressive strength.
- At typical low dosages, they usually have a negligible effect on compressive strength.
- At higher dosages, or if not well dispersed, they can sometimes cause a slight *reduction* in compressive strength as they can act as localized stress concentrators or disrupt the cement paste continuity if not properly wetted and bonded.

2. Workability/Flowability:

- This is a **key consideration for CLC.** Fibers, even at low dosages, will reduce the flowability and increase the viscosity of the base slurry.
- Since CLC relies on a fluid slurry to properly incorporate the pre-formed foam, a reduction in flowability can make it more difficult to achieve uniform foam distribution and the target density.
- You may need to:
 - Slightly increase the water-to-cementitious materials (w/cm) ratio (which could negatively impact strength if not done carefully).
 - Increase the dosage of your superplasticizer (HRWR) to counteract the stiffening effect of the fibers. This is generally the preferred approach.

3. Dispersion:

- Achieving uniform dispersion of the fibers is crucial. If fibers clump together (balling), they become ineffective and can create weak spots.
- Proper mixing sequence and time are important. Fibers are typically added to the slurry *before* the foam is introduced.

4. Foam Interaction:

- If mixing is too aggressive after fiber addition or if fibers are very stiff/long, there's a slight theoretical risk they could damage foam bubbles, though this is less common with typical short acrylic fibers used for concrete.
- The primary concern is the reduced flowability of the slurry affecting foam incorporation.
- 5. **Density:** Fibers have their own density and occupy volume. For CLC, this needs to be accounted for in the mix design if precision is critical, though at typical low fiber dosages (e.g., 1-3 lb/yd³ or 0.6-1.8 kg/m³), the effect on overall density is usually minor but should be checked.

Recommendations for Using Acrylic Fibers (like AC-50) in your 70 pcf CLC:

- **Dosage:** Start with a low dosage, as recommended by the fiber manufacturer, typically in the range of **1.0 to 1.5 lbs per cubic yard (0.6 to 0.9 kg/m ³)**. For CLC, it's often better to err on the lower side to minimize workability issues. AC-50 often comes in premeasured bags for easy dosing.
- **Fiber Length:** Shorter fibers (e.g., 1/4" to 1/2" or 6mm to 12mm) are generally better for CLC to aid dispersion and minimize impact on flowability.
- Mixing:
 - 1. Add fibers to the cementitious slurry (cement, SCMs, sand, water, superplasticizer) *before* introducing the foam.
 - 2. Mix thoroughly to ensure uniform dispersion of fibers. Avoid over-mixing, which can entrain excessive unwanted air or damage fibers.
 - 3. Then, introduce the pre-formed foam as usual.
- Trial Batches: Absolutely essential. Observe the effect of fibers on:
 - The flowability of the base slurry.
 - The ease of foam incorporation.
 - The final wet density achieved.
 - The visual appearance (any signs of fiber balling).
 - Make test specimens to evaluate plastic shrinkage, toughness, and any impact on compressive strength.
- Adjust Superplasticizer: Be prepared to increase the superplasticizer dosage to maintain the desired slurry flowability after adding fibers.

In summary: Adding acrylic fibers like AC-50 to your 70 pcf CLC is likely to be beneficial for reducing plastic shrinkage, improving toughness, and increasing impact/shatter resistance. The main challenge will be managing the reduction in slurry workability. Careful dosage, proper mixing, and adjustment of superplasticizer will be key to successful incorporation. The primary strength characteristics will still be dictated by your w/cm ratio and cementitious content.

You're asking a very important question, especially when considering wall applications where bending stresses can occur.

Here's how AC-50 acrylic fibers (and similar micro-synthetic fibers) typically affect flexural strength:

- 1. Peak Flexural Strength (Modulus of Rupture):
 - Acrylic fibers like AC-50 generally have a **minor to negligible positive effect, or sometimes even a slight negative effect, on the** *peak* **flexural strength** (the load at which the first crack appears).
 - They are not designed to significantly increase the load-carrying capacity *before* cracking. The inherent tensile strength of the cellular concrete matrix itself will largely dictate this initial cracking strength.
 - The primary role of these fibers is not to act as primary flexural reinforcement like steel rebar.
- 2. Post-Crack Flexural Performance (Toughness and Ductility):

- This is where AC-50 fibers make a significant positive contribution.
- Once the CLC matrix cracks under flexural load, the fibers that bridge the crack come into play. They help to:
 - **Increase toughness:** The material can absorb more energy before complete failure.
 - **Improve ductility:** The failure mode becomes less brittle. Instead of a sudden snap, the wall will show more warning and be able to deform more before collapsing.
 - **Provide residual strength:** The fibers continue to carry some stress across the crack, meaning the member doesn't lose all its load-carrying capacity immediately after cracking.
- This improved post-crack behavior is often measured by tests like ASTM C1609 (Standard Test Method for Flexural Performance of Fiber-Reinforced Concrete (Using Beam With Third-Point Loading)), which looks at parameters beyond just the peak load.

Importance for Walls of a Structure:

- **Load-Bearing Walls:** If the CLC walls are designed as primary load-bearing elements resisting significant out-of-plane loads (like wind pressure) or in-plane bending, then relying solely on AC-50 fibers for flexural strength would be insufficient and generally not per code for structural applications. Such walls would typically require conventional steel reinforcement (rebar or welded wire mesh) designed by an engineer.
- Non-Load-Bearing or Infill Walls: For these applications, the demands on flexural strength are usually lower. The benefits of AC-50 fibers become more relevant:
 - **Crack Control:** They are excellent for controlling cracking due to drying shrinkage, thermal stresses, or minor movements, which is crucial for wall aesthetics and durability.
 - **Impact Resistance:** Walls with fibers will be more resistant to damage from accidental impacts.
 - **Integrity:** If a crack does occur due to settlement or other unforeseen loads, the fibers help hold the wall material together, preventing pieces from easily spalling off and maintaining some level of integrity.
 - **Handling and Construction:** Fibers can help reduce damage during the handling and erection of precast CLC panels.

In Summary:

- Don't expect AC-50 acrylic fibers to significantly increase the *initial* flexural strength (the load at which the first crack forms) of your CLC.
- Do expect AC-50 fibers to significantly improve the *behavior after cracking*, leading to increased toughness, ductility, and residual strength. This means the wall will be more resilient and less prone to catastrophic brittle failure.

For walls, especially if they have any structural role or are subject to potential impacts or movement, the improved toughness and crack control provided by AC-50 can be very valuable.

However, if significant, engineered flexural *strength* is required, these fibers are a secondary reinforcement and should not replace primary steel reinforcement.

It's always best to conduct flexural tests (e.g., ASTM C78 for Modulus of Rupture or ASTM C1609 for toughness) on your specific CLC mix with and without fibers to quantify the actual effects.

do all polycarboxylate water reducers (PCE) contain defoamer and does this attack the foam in clc

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This is an excellent and very important question when working with Cellular Lightweight Concrete (CLC)! The interaction between polycarboxylate ether-based superplasticizers (PCEs) and the pre-formed foam is a critical factor for success.

Here's the breakdown:

1. Do all PCEs contain defoamers?

- No, not *all* of them, but many PCEs, especially those designed for conventional concrete, *do* contain defoaming agents.
- Why? PCEs themselves are powerful surfactants. When mixed into concrete, they can entrain a significant amount of air. To control this unintended air entrainment and achieve predictable air content in conventional concrete (or to minimize air in applications like self-consolidating concrete), manufacturers often incorporate defoaming agents into their PCE formulations.
- The type and amount of defoamer can vary significantly between different PCE products and manufacturers. Some PCEs might be formulated with very little or no defoamer if they are intended for specific applications or if their molecular structure is designed to be less air-entraining.

2. Does the defoamer in PCEs attack the foam in CLC?

- Yes, this is a major concern and a well-known issue.
- Defoamers are designed to destabilize air bubbles by reducing the surface tension that holds them together, causing them to coalesce and break.
- The pre-formed foam used in CLC relies on the stability of its bubble structure, which is created by the foaming agent.
- If a PCE containing a significant amount of aggressive defoamer is introduced into the CLC slurry, it can:
 - Attack and break down the pre-formed foam bubbles as they are being mixed in.

- **Destabilize the foam structure** within the fresh CLC mix, leading to foam collapse over time (even after placement, before setting).
- This results in:
 - Loss of foam volume and consequently, an increase in the CLC density.
 - **Lower yield** (you get less volume of CLC than expected).
 - **Non-uniform density** within the pour.
 - **Reduced insulating properties and potentially lower strength** if the density deviates too far from the target.

3. What is the effect of PCEs (in general) on foam in CLC?

Even beyond the specific issue of added defoamers, the inherent surfactant nature of PCEs themselves can interact with the foaming agent:

- **Competition at the Air-Water Interface:** Both PCEs and foaming agents are surfactants that work at interfaces. They can compete for a place at the air-water interface of the foam bubbles. This competition can:
 - Potentially displace the foaming agent, weakening the bubble film.
 - Alter the surface tension characteristics in a way that is detrimental to foam stability.
- **Interaction between Surfactants:** The two types of surfactants (PCE and foaming agent) can interact with each other in the aqueous phase, sometimes forming complexes that are less effective at either water reduction or foam stabilization.
- **Rheology Modification:** PCEs drastically reduce the viscosity of the cementitious slurry. While a certain level of fluidity is needed to incorporate foam, an overly fluid, low-viscosity slurry (due to high PCE dosage) might not have enough "body" to hold the foam bubbles stably, potentially leading to faster coalescence or segregation of foam.

Key Recommendations and Considerations:

- 1. PCE Selection is Crucial:
 - Look for PCEs specifically marketed as "CLC-compatible" or "foamfriendly." Some admixture manufacturers are aware of this issue and have developed PCEs with low or no defoamer, or with defoamers that are less aggressive towards typical CLC foaming agents.
 - **Consult the PCE manufacturer:** Explicitly ask them about the suitability of their product for CLC and whether it contains defoamers that could be problematic.

2. Foaming Agent Selection:

 Some foaming agents are more robust and resistant to chemical attack than others. Discuss this with your foaming agent supplier. Protein-based foams are sometimes considered more resilient than some synthetic foams in certain chemical environments, but this is not a universal rule.

3. Trial Batches are ESSENTIAL:

• This is the most important step. Always conduct small-scale trial batches with the exact PCE, foaming agent, and other mix components you plan to use.

- Observe:
 - Ease of foam incorporation.
 - Stability of the fresh CLC density over time (e.g., measure density immediately after mixing, then again after 15, 30, and 60 minutes). Significant density increase indicates foam collapse.
 - Visual appearance are bubbles breaking down rapidly?

4. Dosage Control:

• Use the minimum effective dosage of PCE. Overdosing can exacerbate any negative interactions.

5. Mixing Sequence:

• Sometimes the order of addition can have a minor impact, but it's unlikely to solve a fundamental incompatibility. Typically, the PCE is added to the slurry before foam introduction.

6. Consider Alternatives (If Necessary):

• If you consistently face issues with PCEs and foam stability, you might need to consider older generation superplasticizers (like naphthalene or melamine sulfonates). However, these are generally less efficient at water reduction than PCEs, so achieving a very low w/cm ratio might be more challenging.

In summary: Yes, PCEs, particularly those containing defoamers, can significantly and negatively impact the foam stability in CLC. Careful selection of a compatible PCE and thorough trial batching are absolutely critical to ensure a stable, consistent CLC product.

Okay, this is a very practical and important question. Finding specific "low defoamer" PCEs requires a bit of investigation because admixture formulations are proprietary and can change. However, here's how you can approach finding them and some major manufacturers who are likely to have suitable options or can guide you:

Key Strategies to Find Low Defoamer PCEs:

- 1. **Directly Contact Technical Representatives:** This is your BEST approach. Call the technical support lines of major admixture manufacturers.
 - **Be very specific:** Tell them you are producing Cellular Lightweight Concrete (CLC), specify your target density (e.g., 70 pcf), and mention the type of foaming agent you are using (if known, e.g., protein-based or synthetic).
 - **Ask explicitly:** "Do you have a polycarboxylate superplasticizer that is low in defoamer content and compatible with pre-formed foam for CLC applications?" or "Which of your PCEs would you recommend for cellular concrete to minimize foam destabilization?"
- 2. Look for Products Marketed for CLC/Lightweight Concrete: Some manufacturers have products specifically flagged or tested for use in foamed or lightweight aggregate concretes.
- 3. Review Technical Data Sheets (TDS):

- Look for statements about air entrainment. If a TDS states the PCE "does not significantly entrain air" or is "low air entraining," it *might* have less defoamer, but this isn't a guarantee it's foam-friendly for CLC.
- Some TDS might even mention compatibility with foamed concrete.
- 4. **Small Suppliers/Specialty Chemical Companies:** Sometimes smaller, more specialized admixture companies might have more niche products or be more flexible in discussing formulations.

Major Admixture Manufacturers to Contact:

These are global or large regional players who have extensive PCE product lines. They are your primary contacts:

- 1. Sika (Sika ViscoCrete® series):
 - Sika has a very broad range of ViscoCrete PCEs. They are likely to have options suitable for CLC. You'll need to speak with a technical rep to identify the best one.
 - They do have products specifically aimed at lightweight concrete applications.

2. Master Builders Solutions (MasterGlenium® series, formerly BASF):

- The MasterGlenium line is also extensive. They have different PCE chemistries for various applications. Again, direct contact is key.
- They often have specific solutions for challenging concrete types.
- 3. GCP Applied Technologies (ADVA® Cast series, formerly Grace):
 - GCP's ADVA Cast products are well-known PCEs. Inquire about versions suitable for CLC.
 - They have a strong technical support network.
- 4. Euclid Chemical (EUCON® series):
 - Euclid Chemical has a wide array of superplasticizers, including PCEs under their EUCON brand. They are knowledgeable about various concrete applications.
- 5. CHRYSO (CHRYSO®Optima or Premia series):
 - CHRYSO offers a broad range of PCEs. They often work closely with clients to tailor solutions.
- 6. Fosroc (Auracast® or Structuro® series):
 - Fosroc is another major international player with advanced PCE technology.

When you contact them, be prepared to discuss:

- Your target CLC density.
- The type of cement and any SCMs (fly ash, silica fume) you're using.
- The type of foaming agent (protein or synthetic, and brand if possible).
- Your mixing procedure.
- The desired workability/flow of your base slurry.

Important Note on Trial Batches:

No matter what a manufacturer tells you or what a TDS says, **you MUST conduct trial batches with your specific materials.** This is the only way to truly verify:

- The compatibility of the PCE with your foaming agent.
- The stability of the foam and the resulting CLC density over time.
- The effect on the workability of your slurry.
- The final compressive strength.

Start with small trial batches, carefully measuring densities immediately after mixing and then at intervals (e.g., 15, 30, 60 minutes) to check for foam collapse. This will quickly tell you if a particular PCE is too aggressive towards your foam.

This is an interesting and slightly counterintuitive question! If you've specifically chosen a "no defoamer PCE" (or a very low defoamer PCE) for your Cellular Lightweight Concrete (CLC) to protect your pre-formed foam, you generally **do not want to add a separate defoamer back into the mix.**

The whole point of using a "no defoamer PCE" in CLC is to:

- 1. Achieve the desired water reduction and flowability from the PCE.
- 2. **Preserve the integrity and stability of the pre-formed foam** that you are intentionally adding to create the cellular structure and achieve the target low density.

Adding a separate defoamer would directly counteract the reason for choosing a "no defoamer PCE" and would likely lead to:

- Destabilization of your pre-formed foam.
- Increased density of the CLC (as the foam breaks down).
- Loss of yield.
- Inconsistent properties.

Why might someone even consider adding a defoamer in this scenario?

Perhaps the "no defoamer PCE" itself, while not containing an *added* defoamer, still causes some unwanted air entrainment in the *base slurry* (the mix of cement, water, SCMs, and PCE *before* the pre-formed foam is added). This can happen because PCEs are powerful surfactants.

If the problem is unwanted air entrainment in the *base slurry* by the PCE (before adding your intentional CLC foam):

1. Re-evaluate the PCE:

- Is it truly "no defoamer" or just "low defoamer"? There's a spectrum.
- Is it the right PCE for your materials? Some PCEs interact differently with various cement chemistries.

- **Dosage:** Are you using the correct dosage? Overdosing can sometimes lead to more air entrainment.
- 2. Mixing Energy & Time (for base slurry):
 - Excessive mixing speed or duration when preparing the base slurry can whip in unwanted air. Optimize your mixing process for the slurry.
- 3. Slight Adjustment to PCE Dosage:
 - Sometimes a very minor reduction in the PCE dosage can reduce unwanted air entrainment without significantly compromising workability, especially if you are already at the higher end of the recommended dosage.

4. Consult the PCE Manufacturer Again:

• Explain the issue. They might have a different PCE in their line that is less prone to entraining air in the base slurry while still being foam-friendly for the CLC foam. They might also have specific advice on mixing.

If you ABSOLUTELY had to consider a defoamer (which is highly discouraged for CLC):

If, for some very specific and unusual reason, you found yourself in a situation where you *had* to use a defoamer with a "no defoamer PCE" in a CLC context (again, this is generally a bad idea), you would need:

- A very mild, highly controllable defoamer.
- Extremely precise dosing capabilities.
- Extensive trial and error.

You'd be looking for a defoamer that could *slightly* reduce air in the base slurry without being aggressive enough to significantly damage the intentionally added pre-formed foam later. This is a very fine balancing act and prone to failure. Common defoamer types include:

- Silicone-based defoamers
- Oil-based defoamers (mineral oil, vegetable oil)
- Polyol-based defoamers
- Polyalkylene glycols

However, the far better approach for CLC is:

- 1. Select a PCE that is truly compatible with your CLC system and does not cause excessive unwanted air in the base slurry.
- 2. Optimize your mixing process for the base slurry to minimize incidental air entrainment.
- 3. Focus on the quality and stability of your *pre-formed foam* and its interaction with the chosen PCE.

In short: For CLC, avoid adding a separate defoamer if you've chosen a PCE designed to be foam-friendly. Address any unwanted air in the base slurry through PCE selection, dosage, or mixing adjustments. The risk of damaging your intentional CLC foam structure with an added defoamer is too high.

Adding extra gypsum (calcium sulfate dihydrate, CaSO₄·2H₂O) to a Portland cement mix for cellular concrete can have several effects, both potentially positive and negative, depending on the amount added, the type of cement, and the overall mix design. It's generally **not a common practice to add significant amounts of extra gypsum** beyond what's already interground with the Portland cement clinker during its manufacture, and doing so requires careful consideration.

Portland cement already contains gypsum (typically 3-5% by weight) added at the cement plant. This "original" gypsum plays a crucial role:

• **Controlling Setting Time:** Its primary function is to control the rapid hydration of tricalcium aluminate (C₃A) in cement. Without gypsum, C₃A would react very quickly with water, leading to "flash set" – a rapid stiffening of the paste that makes it unworkable. Gypsum reacts with C₃A to form ettringite, which coats the C₃A particles and slows down their hydration.

Effects of Adding Extra Gypsum to a Portland Cement Mix for Cellular Concrete:

Potential (Minor or Specific) Benefits:

- 1. Slightly Extended Setting Time (at low additions): Small additions of gypsum might further retard the C₃A hydration, potentially giving a bit more working time for the cellular concrete. However, this is a delicate balance.
- 2. Compensation for Low Sulfate Cements (Rare): If, for some reason, the Portland cement being used is unusually low in its original sulfate content, a small, controlled addition of gypsum might be needed to ensure proper retardation of C₃A. This is uncommon with modern cements.
- 3. **Potential (Unreliable) for Strength Enhancement (Very Specific Conditions):** In some very specific scenarios with particular cement chemistries and dosages, optimized sulfate content can lead to a denser microstructure and slightly improved later-age strengths. However, this is complex and not a primary reason to add extra gypsum without expert knowledge.
- 4. **Dimensional Stability (in some specialized systems):** Some specialized cementitious systems (like calcium sulfoaluminate cements, not standard Portland cement) use higher sulfate contents for controlled expansion or shrinkage compensation. This is generally not relevant for adding gypsum to standard Portland cement for CLC.

Potential Negative Effects (More Likely with Uncontrolled Additions):

- 1. **Delayed Setting or Non-Setting (Excessive Gypsum):** If too much gypsum is added, it can excessively retard the set, or in extreme cases, prevent the concrete from setting properly at all. The cement paste may remain soft for an extended period.
- 2. Reduced Compressive Strength:
 - **Excessive Ettringite Formation:** Too much sulfate can lead to an overproduction of ettringite. While initial ettringite formation is beneficial for setting control,

excessive or late-forming ettringite can be disruptive to the hardened cement paste structure, leading to internal stresses, microcracking, and reduced strength.

- **Increased Porosity:** Poorly reacted or excessive gypsum can increase the porosity of the hardened paste.
- 3. **False Set:** This is a rapid stiffening of the concrete shortly after mixing, but without significant heat generation. The concrete can often be remixed to regain workability. It can sometimes be caused by the dehydration of the interground gypsum in the cement (forming hemihydrate or anhydrite) if the cement is stored at high temperatures, or by imbalances in the sulfate-aluminate reactions. Adding more gypsum could potentially exacerbate this if not managed carefully.
- 4. Sulfate Attack (Delayed Ettringite Formation DEF): If the concrete is exposed to high temperatures during curing (e.g., > 65-70°C or 150-160°F) and there is an excess of sulfates available, delayed ettringite formation can occur long after the concrete has hardened. This expansive reaction can cause severe cracking and deterioration. While less common in ambient cured CLC, it's a known risk with high sulfate and high curing temperatures.

5. Impact on Foam Stability:

- Gypsum dissolves in water, increasing the ionic strength of the mix water. This change in water chemistry *could* potentially affect the stability of the pre-formed foam, depending on the type of foaming agent used. Some foaming agents are sensitive to high electrolyte concentrations. This would need to be tested.
- 6. **Increased Shrinkage:** While sometimes claimed to reduce shrinkage, excessive sulfates can also contribute to different forms of shrinkage or expansion, leading to instability.

Considerations for Cellular Concrete:

- Lower Cement Content (Potentially): CLC often has a higher proportion of air and a lower absolute amount of cement per unit volume compared to conventional concrete. The impact of any additive, including extra gypsum, might be more pronounced or behave differently.
- **Sensitivity to Setting:** Precise control over setting time is important for CLC to allow for proper placement and for the foam structure to stabilize before the matrix hardens.
- Focus on w/cm ratio and SCMs for strength: For high-strength CLC, efforts are usually focused on lowering the water-to-cementitious materials ratio and using SCMs like silica fume or fly ash, rather than manipulating sulfate content beyond what the cement manufacturer provides.

Conclusion:

Generally, it is not advisable to add extra gypsum to a standard Portland cement mix for cellular concrete unless you have a very specific, well-understood reason and are doing so based on expert guidance and thorough testing.

The risks of negatively impacting setting time, strength, durability, and potentially foam stability often outweigh any minor or niche benefits. The gypsum content in commercially available Portland cement is already optimized by the manufacturer for general concrete performance.

If you are experiencing issues with setting time or other properties, it's better to:

- Consult with the cement manufacturer.
- Adjust your water content or w/cm ratio.
- Consider appropriate chemical admixtures (retarders, accelerators, water reducers) designed for concrete.
- Evaluate different types or sources of cement.

Adding calcium aluminate cements (CAC), or specific calcium aluminate phases, to a Portland cement (PC) based cellular concrete (CLC) mix is a complex topic. It can offer certain performance enhancements, particularly for **rapid strength gain and improved durability in specific aggressive environments**, but it also introduces significant challenges and potential problems if not handled correctly.

What are Calcium Aluminate Cements (CAC)?

CACs are hydraulic cements made primarily from limestone (calcium carbonate) and bauxite (aluminum ore). Their main reactive phase is monocalcium aluminate (CA or CaAl₂O₄). They differ significantly from Portland cement in their chemistry, hydration products, and performance characteristics.

Potential Benefits of Adding CAC to PC-based CLC:

- 1. **Rapid Early Strength Development:** This is the most significant potential benefit. CAC hydrates much faster than PC. Even small additions to a PC mix can significantly accelerate setting and early strength gain. This could be beneficial for:
 - Quick demolding of precast CLC elements.
 - Early trafficking or loading.
 - Cold weather concreting (due to higher heat of hydration).
- 2. Improved Resistance to Certain Chemical Attacks:
 - Sulfate Resistance: Properly cured CAC concrete is highly resistant to sulfate attack because it doesn't form calcium hydroxide (a key reactant in sulfate attack on PC) and its hydration products (like CAH₁₀, C₂AH₈, C₃AH₆, and AH₃ gel) are more stable in sulfate environments.
 - **Resistance to Weak Acids and Pure Waters:** CAC generally shows better resistance to mildly acidic conditions and leaching by soft waters compared to PC.
- 3. **Abrasion Resistance:** CAC concretes are known for their excellent abrasion resistance due to the hardness of their aluminate hydrates. This might be relevant for CLC flooring or surfaces.
- 4. **Refractory Properties (at higher CAC contents, not typical for CLC):** CACs are the basis for refractory concretes used in high-temperature applications. This is generally not a primary driver for CLC additions.

Challenges and Potential Problems of Adding CAC to PC-based CLC:

- 1. "Conversion" Phenomenon in Pure CAC (Less direct impact on blends, but important background):
 - Pure CAC pastes, under warm and moist conditions (typically >25-30°C), undergo a "conversion" process. The initial, metastable hexagonal hydrates (CAH₁₀, C₂AH₈) convert to more stable cubic hydrates (C₃AH₆) and gibbsite (AH₃). This conversion is accompanied by an increase in porosity and a significant loss of strength.
 - **For PC-CAC blends:** The dynamics are different. The presence of PC and its hydration products, especially gypsum and calcium hydroxide, alters the hydration chemistry significantly. The typical "conversion" as seen in pure CAC is less of a direct concern, but interactions are complex.

2. Flash Set or Uncontrolled Setting:

- The aluminates in CAC react very quickly with water. When mixed with PC, which contains gypsum (a sulfate source), the interactions between the aluminates from CAC and sulfates from PC can be very rapid and complex.
- Without careful control (e.g., using retarders specifically designed for PC-CAC blends, or controlling the sulfate content), you can get **flash set**, making the CLC unworkable almost immediately.

3. Ettringite Formation and Potential for Destructive Expansion:

- This is a **MAJOR CONCERN** with PC-CAC blends. Calcium aluminates from CAC can react with sulfates (from the gypsum in PC or from the CAC itself if it has sulfate) and calcium hydroxide (from PC hydration) to form large amounts of ettringite (calcium aluminosulfate hydrate).
- If this ettringite formation occurs expansively after the concrete has set and hardened, it can cause severe cracking and deterioration. This is sometimes referred to as "sulfate attack from internal sources" or can be related to delayed ettringite formation (DEF) if curing temperatures are high.
- The amount of CAC, the C₃A content of the PC, and the total sulfate content are critical factors.
- 4. **Dosage Sensitivity:** The performance of PC-CAC blends is highly sensitive to the proportion of CAC. Small variations can lead to drastically different setting times and strength development.
- 5. **Cost:** CAC is generally more expensive than Portland cement.

6. Impact on Foam Stability:

- The rapid chemical reactions and potentially high heat evolution from CAC hydration could negatively impact the stability of the pre-formed foam in CLC.
- Changes in ionic strength and pH due to CAC addition could also affect foam. This requires thorough testing.
- 7. **Workability:** Achieving a workable slurry that can properly incorporate foam, while managing the rapid reactions, can be very challenging. Specific admixtures might be needed.

Recommendations and Considerations:

- Use with Extreme Caution and Expertise: Blending PC and CAC is not for beginners. It requires a good understanding of cement chemistry and extensive laboratory testing.
- **Low Dosages:** If used, CAC is typically added in small percentages (e.g., 5-15% by weight of total cementitious material) to PC for specific effects like acceleration.
- **Control Sulfate Content:** The total sulfate content (from PC, CAC, and any other sources) is critical to manage ettringite formation.
- **Specialized Admixtures:** Retarders specifically designed for PC-CAC blends (often based on citric acid, tartaric acid, or lignosulfonates, but their effect needs careful verification) may be necessary to control the set. Superplasticizers will likely be needed for workability.
- Thorough Testing:
 - Setting times (ASTM C191, C403).
 - Strength development (compressive and flexural).
 - Dimensional stability (expansion/shrinkage tests, ASTM C157).
 - Foam stability and final CLC density.
 - Durability tests relevant to the intended application (e.g., sulfate resistance ASTM C1012).
- **Consult Experts:** If you are seriously considering this, consult with cement chemists or concrete technologists experienced with PC-CAC blends.

Alternative for CLC Acceleration:

If the primary goal is just faster setting and early strength in CLC, consider these less complex options first:

- Type III Portland Cement (High Early Strength).
- **Non-chloride chemical accelerators** (e.g., calcium nitrate, calcium formate, triethanolamine-based).
- Optimizing the mix design for a lower w/cm ratio (using effective superplasticizers).
- Warm curing (controlled, not excessively high temperatures).

In conclusion: While adding calcium aluminates to a PC-based CLC can offer benefits like rapid hardening and certain durability enhancements, it introduces significant chemical complexities and risks, particularly related to uncontrolled setting and potentially destructive ettringite formation. It should only be attempted with deep expertise and rigorous testing. For most CLC applications, optimizing the PC-based system with conventional SCMs and admixtures is a safer and more predictable approach.

Adding Magnesium Oxide (MgO) to a Portland cement-based mix for cellular concrete is a specialized technique, primarily aimed at **inducing controlled expansion** to compensate for shrinkage or for specific applications like self-stressing concrete. It's not a common additive for general CLC production and comes with its own set of complexities and considerations.

How MgO Works to Induce Expansion:

MgO reacts with water (hydrates) to form magnesium hydroxide (Mg(OH)₂, also known as brucite):

 $MgO + H_2O \rightarrow Mg(OH)_2$

This hydration reaction is accompanied by a significant increase in solid volume, which can lead to expansion in the concrete. The key is to control the *rate and timing* of this hydration:

- **Reactivity of MgO:** The expansive potential and rate of reaction depend heavily on the "reactivity" of the MgO. This is determined by its calcination temperature during production:
 - Light-burned (or reactive) MgO: Calcined at lower temperatures (e.g., 700-1000°C). It hydrates relatively quickly and can cause expansion in the early stages of concrete hardening.
 - **Hard-burned MgO:** Calcined at medium temperatures (e.g., 1000-1400°C). It hydrates more slowly.
 - **Dead-burned MgO:** Calcined at very high temperatures (e.g., >1400°C). It is very slow to hydrate (sometimes taking years) and is generally not suitable for controlled expansion in concrete as it can lead to deleterious long-term expansion and cracking.
- **Particle Size:** Finer MgO particles will hydrate faster.

Potential Benefits of Adding MgO to CLC (If Properly Controlled):

- 1. Shrinkage Compensation: This is the primary intended benefit.
 - Drying shrinkage is a common issue in concrete, including CLC (especially with higher water contents or finer pores).
 - Controlled expansion from MgO hydration can counteract some or all of this shrinkage, reducing the tendency for cracking.
- 2. Improved Durability (Potentially):
 - By reducing micro-cracking due to shrinkage, MgO can potentially improve the overall durability and reduce pathways for ingress of harmful substances.
 - \circ $\,$ $\,$ The formation of brucite can also fill some pores.
- 3. **Self-Stressing Concrete (Specialized):** At higher dosages and with specific MgO types, it's possible to induce a net expansion that puts the concrete into a state of self-compression, which can be beneficial for certain structural applications (though less common for typical CLC).

Challenges and Potential Problems of Adding MgO to PC-based CLC:

- 1. Uncontrolled or Excessive Expansion: This is the BIGGEST RISK.
 - If the MgO hydration occurs too rapidly, too extensively, or too late after the concrete has gained significant strength, it can lead to excessive internal pressures, cracking, and severe damage to the concrete.
 - The selection of the correct type (reactivity) and dosage of MgO is absolutely critical and requires precise knowledge and testing.

- 2. **Delayed Expansion:** If dead-burned or very hard-burned MgO is used (or is present as an impurity in other materials), its slow hydration over months or years can lead to long-term destructive expansion.
- 3. Impact on Setting Time and Early Strength:
 - Highly reactive MgO might accelerate setting slightly.
 - The expansion process itself can interact with the development of the cement paste structure.
- 4. **Dosage Sensitivity:** The amount of expansion is highly sensitive to the dosage and reactivity of the MgO.
- 5. Lack of Standardization and Expertise: Using MgO as an expansive agent is less common than other methods (like sulfoaluminate-based expansive agents) in many regions. Finding reliable sources of MgO with well-characterized reactivity specifically for concrete can be challenging. Expertise in designing these mixes is crucial.
- 6. Impact on Foam Stability in CLC:
 - The chemical reactions and heat generated during MgO hydration could potentially affect the stability of the pre-formed foam.
 - Changes in the ionic composition of the pore solution due to MgO dissolution and brucite formation might also interact with the foaming agent. This needs careful testing.
- 7. Cost: Adding specialized MgO will increase the material cost of the CLC.
- 8. **Carbonation of Brucite:** Magnesium hydroxide (brucite) can react with atmospheric CO₂ over time to form magnesium carbonates. While this can further densify the pore structure, it also involves changes in volume and chemistry that need to be understood in the long term.

Recommendations and Considerations for CLC:

- Use Only with Deep Expertise: Adding MgO for expansion is a highly specialized area. It should not be attempted without significant knowledge of cement chemistry, MgO characteristics, and extensive laboratory trials.
- Source of MgO is Critical: You need MgO specifically produced and characterized for use as an expansive agent in concrete. The reactivity (often measured by specific surface area, hydration tests, or citric acid activity) must be known and consistent.
- **Dosage:** Typically, dosages are low, often in the range of 1-5% by weight of cementitious material, but this is highly dependent on the MgO's reactivity and the desired level of expansion.
- Thorough Testing:
 - Expansion tests (e.g., ASTM C878 for restrained expansion, or free expansion tests like ASTM C157 modified for early measurement).
 - Setting times.
 - Compressive strength development.
 - Foam stability and CLC density.
 - Long-term durability and stability.
- Interaction with Other Admixtures: How MgO interacts with superplasticizers, foaming agents, and SCMs needs to be evaluated.

Alternatives for Shrinkage Reduction in CLC:

Before considering MgO, explore these more common methods for managing shrinkage in CLC:

- **Optimize w/cm ratio:** Lowering the water content is the most effective way to reduce shrinkage.
- Use of SCMs: Fly ash and silica fume can help refine the pore structure and potentially reduce shrinkage.
- Shrinkage Reducing Admixtures (SRAs): These chemical admixtures work by reducing the surface tension of the pore water.
- **Fibers (e.g., acrylic, polypropylene):** While they don't prevent shrinkage, they help distribute shrinkage stresses and control cracking.
- **Proper Curing:** Adequate curing is essential to minimize drying shrinkage.

Conclusion:

Adding MgO to CLC can be a viable way to achieve shrinkage compensation or controlled expansion, but it is a **high-risk**, **high-expertise technique**. The potential for deleterious, uncontrolled expansion is significant if the type, reactivity, and dosage of MgO are not perfectly managed. For most CLC applications, focusing on optimizing the mix with conventional materials and admixtures for shrinkage control is a safer and more predictable approach. If expansion is truly needed, it should be pursued with extreme caution and expert guidance.

Okay, selecting a "good" set accelerator for cellular concrete (CLC) depends on several factors, including the desired degree of acceleration, ambient temperature, compatibility with other mix components (especially the foaming agent and any PCE superplasticizer), and potential side effects like strength reduction or corrosion risk.

Here are some common types of set accelerators used in concrete, along with their pros, cons, and suitability for CLC:

1. Calcium Chloride (CaCl₂):

- **Effectiveness:** Very effective and inexpensive accelerator, significantly speeds up both setting time and early strength development.
- Pros:
 - Highly effective at low dosages (typically 0.5% to 2% by weight of cement).
 - Works well even at low temperatures.
 - Widely available and low cost.
- Cons (Significant for many applications, including potentially CLC):
 - Corrosion Risk: This is the BIGGEST drawback. Chlorides promote the corrosion of steel reinforcement. Therefore, CaCl₂ is strictly prohibited in reinforced concrete, prestressed concrete, or concrete containing embedded aluminum or galvanized steel. For CLC, if there's any steel reinforcement (e.g.,

in precast panels) or metallic components, CaCl₂ should be avoided. Even in unreinforced CLC, if it's in contact with metals later, this could be an issue.

- Increased Drying Shrinkage: Can lead to more shrinkage and cracking.
- **Potential for Discoloration:** Can sometimes cause darker or blotchy concrete.
- **Reduced Sulfate Resistance:** Can decrease the concrete's resistance to sulfate attack.
- **Possible Interaction with Foaming Agents:** The high concentration of chloride ions could potentially affect foam stability. Needs testing.
- Suitability for CLC: Generally not recommended if any metal is present or if longterm durability regarding shrinkage is a major concern. Only consider for unreinforced CLC where corrosion is absolutely not a risk and other drawbacks are acceptable.

2. Non-Chloride Accelerators (NCAs):

These are generally preferred when chloride-induced corrosion is a concern.

- a) Calcium Nitrate (Ca(NO₃)₂):
 - **Effectiveness:** Good accelerator, promotes early strength. Often considered one of the best NCAs.
 - **Pros:**
 - Does not contribute to chloride-induced corrosion.
 - Can improve microstructure and sometimes long-term strength.
 - Less impact on drying shrinkage compared to CaCl₂.
 - Cons:
 - More expensive than CaCl₂.
 - Dosage needs careful control (typically 0.5% to 3% by weight of cement).
 - May slightly retard set at very high dosages or in combination with certain other admixtures before acceleration kicks in.
 - Suitability for CLC: A good option, especially if reinforcement is present. Test for compatibility with foam.
- **b**) Calcium Formate (Ca(HCOO)₂):
 - Effectiveness: Effective accelerator, particularly good for early set.
 - Pros:
 - Non-corrosive.
 - Relatively cost-effective among NCAs.
 - Cons:
 - Can sometimes slightly reduce ultimate strength at higher dosages.
 - Less effective than CaCl₂ or calcium nitrate in very cold weather.
 - Solubility can be an issue if added as a powder directly to cold water.
 - Suitability for CLC: A viable option. Test for compatibility with foam.

• c) Triethanolamine (TEA):

- **Effectiveness:** Primarily a set accelerator, can significantly reduce initial and final setting times. Has less impact on early strength gain compared to calciumbased accelerators.
- Pros:

- Effective at very low dosages (typically 0.01% to 0.1% by weight of cement).
- Non-corrosive.
- Cons:
 - Can cause significant strength reduction, especially at higher dosages or with certain cements. This is a major concern.
 - Can increase air entrainment, which needs to be managed in CLC where air is already intentionally added as foam.
 - May cause rapid stiffening that could be detrimental to foam incorporation if not managed.
- Suitability for CLC: Use with extreme caution due to potential for strength reduction and interaction with air content. Very low dosages might be considered if only set acceleration is needed, but thorough testing is essential.
- d) Other Amine/Alkanolamine-based Accelerators: Various proprietary blends exist, often combining TEA with other compounds to balance performance.
 - **Pros & Cons:** Vary by formulation. Generally aim to provide acceleration without the severe drawbacks of TEA alone.
 - Suitability for CLC: Evaluate specific product data sheets and conduct trials.
- e) Sodium Thiocyanate (NaSCN):
 - **Effectiveness:** Good accelerator.
 - **Pros:** Non-corrosive to steel in the typical sense, but see cons.
 - \circ Cons:
 - Can be more expensive.
 - Potential for slight discoloration.
 - There have been some concerns about its interaction with certain types of aggregates or environments, and its effect on passivation of steel, though generally considered non-corrosive for typical reinforcing steel.
 - Suitability for CLC: Possible, but perhaps less common. Test thoroughly.

3. "High Early Strength" Cements:

- Type III Portland Cement (ASTM C150) or Class R Cement (EN 197-1 CEM I 52,5 R): These cements are ground finer and/or have a modified chemical composition (higher C₃S and C₃A) to achieve rapid hydration and early strength development naturally, without chemical accelerators.
- Pros:
 - \circ Integral part of the cement no separate admixture needed.
 - Generally good compatibility.
- Cons:
 - Higher cost than Type I cement.
 - Higher heat of hydration, which needs to be managed in thicker pours (less of an issue for typical CLC thicknesses but can affect foam stability if excessive).
 - May not provide as much acceleration as a potent chemical accelerator if extreme speed is needed.
- Suitability for CLC: An excellent option if moderate acceleration and good early strength are desired without the complexities of chemical admixtures.

4. Calcium Aluminate Cement (CAC) Additions (as discussed previously):

- Small additions (e.g., 5-15%) of CAC to Portland cement can act as a powerful accelerator.
- **Pros:** Very rapid set and high early strength.
- **Cons:** Complex chemistry, risk of flash set, potential for destructive ettringite formation, cost, potential impact on foam.
- Suitability for CLC: High risk, requires expert knowledge and extensive testing.

Recommendations for CLC:

- 1. Prioritize Non-Chloride Accelerators (NCAs):
 - **Calcium Nitrate** is often a good first choice to investigate due to its effectiveness and relatively benign side effects.
 - **Calcium Formate** is another good option.
- 2. Consider Type III (High Early Strength) Cement: This can be a simpler way to achieve faster strength gain.
- 3. Test, Test, Test:
 - **Foam Compatibility:** This is paramount. The accelerator should not destabilize your pre-formed foam. Observe density stability over time in trial batches.
 - **Interaction with Superplasticizers (PCEs):** Ensure the accelerator and PCE work well together without unexpected rapid stiffening or loss of PCE effectiveness.
 - Setting Time: Measure actual setting times (e.g., ASTM C403).
 - **Strength Development:** Monitor compressive strength at early ages (e.g., 12h, 1 day, 3 days) and later ages (7, 28 days).
 - **Workability Window:** Ensure you have enough time to mix, incorporate foam, and place the CLC.
- 4. **Start with Low Dosages:** Follow manufacturer recommendations and begin with the lower end of the dosage range.
- 5. **Consult Admixture Suppliers:** They can often recommend specific products from their line that are known to be more compatible with foamed concrete or have data on interactions.

Avoid calcium chloride unless you are absolutely certain no reinforcement is present and its other drawbacks are acceptable for your specific CLC application.

Beyond the fundamental components (cement, water, foam, and potentially SCMs like fly ash, silica fume, and colloidal silica, and admixtures like superplasticizers and accelerators), here are some other materials, some more conventional and some more advanced/experimental, that *could* be considered for improving strength performance in Cellular Lightweight Concrete (CLC).

Keep in mind that "strength" can refer to compressive strength, flexural strength, or tensile strength, and different additives may influence these differently. For CLC, compressive strength is often the primary focus.

1. Optimized Fine Aggregates (if not already maximized):

- Well-Graded Fine Sand: While CLC often aims to minimize or eliminate coarse aggregates, using a well-graded fine sand (ASTM C33) up to a certain proportion (e.g., in higher density CLC like your 70 pcf target) can contribute to a stronger matrix. The sand particles provide internal support and reduce the volume of weaker cement paste needed to fill voids (not the foam voids, but inter-particle voids in the slurry).
- **Crushed Fine Aggregates:** Using crushed fine aggregates with better particle shape and texture compared to natural sand can sometimes lead to improved interlock and a stronger paste-aggregate bond.
- Lightweight Fine Aggregates (LWFA):
 - For CLC aiming for specific strength-to-weight ratios, incorporating *strong* lightweight fine aggregates like expanded shale, clay, or slate fines could theoretically replace some of the pre-formed foam while contributing to matrix strength. However, this shifts the mix design more towards a lightweight aggregate concrete rather than a pure CLC, and careful density control is needed. The strength of the LWA particle itself becomes critical.

2. Advanced Pozzolanic/Cementitious Materials:

- **Metakaolin:** A highly reactive pozzolan produced by calcining kaolin clay. It reacts rapidly with calcium hydroxide to form additional C-S-H, similar to silica fume, leading to higher strength and refined pore structure. It can improve early strength significantly.
 - *Consideration for CLC:* Can increase water demand (requiring more superplasticizer) and may affect rheology. Its high reactivity could interact with foam or accelerate setting.
- **Rice Husk Ash (RHA):** When properly processed (controlled burning), RHA is rich in amorphous silica and is a highly effective pozzolan. It can significantly enhance strength and durability.
 - *Consideration for CLC:* Quality and reactivity vary greatly with processing. Can have high water demand. Carbon content needs to be low.
- **Ground Granulated Blast Furnace Slag (GGBFS/Slag Cement):** A latent hydraulic cementitious material. When activated (e.g., by the alkalis in Portland cement), it contributes to long-term strength gain, improved durability, and a denser microstructure.
 - *Consideration for CLC:* Generally slows down early strength gain unless used with activators or in blends with Type III cement. Can improve workability of the slurry.

3. Nano-Materials (Beyond Colloidal Silica):

- Nano-Clays (e.g., Bentonite, Montmorillonite specially treated): Exfoliated nanoclays, when properly dispersed, can act as nano-fillers and potentially influence C-S-H nucleation, refining the microstructure at a very fine scale. Research is ongoing.
 - Consideration for CLC: Dispersion is extremely challenging. Can significantly increase viscosity. Interactions with foam are unknown and likely complex. Highly experimental for CLC.
- Carbon Nanotubes (CNTs) / Carbon Nanofibers (CNFs): These materials have exceptionally high tensile strength. At very low dosages, they have shown potential to improve mechanical properties of cement paste by bridging nano-cracks and refining microstructure.
 - *Consideration for CLC:* Extremely expensive. Dispersion is a major hurdle.
 Practical application in bulk CLC is currently far off, though research is active.
 Potential for significant impact on rheology and foam interaction.

4. Alkali-Activated Materials (Geopolymers) - A Different System:

- While not an "addition" to a Portland cement mix in the traditional sense, one could formulate CLC using alkali-activated binders (geopolymers) instead of Portland cement. These binders often use industrial byproducts like fly ash or slag activated by alkaline solutions (e.g., sodium hydroxide, sodium silicate).
- *Potential for CLC:* Geopolymer CLC can achieve good strength, rapid curing, and excellent durability in certain environments.
- *Consideration:* Different chemistry, different handling, specific activators needed. Foam stability with highly alkaline activators is a key challenge.

5. Fibers (Beyond Basic Crack Control):

- Steel Fibers (Micro or Macro): While acrylic fibers are mainly for plastic shrinkage, steel fibers (especially micro steel fibers) can significantly increase flexural strength, tensile strength, toughness, and even contribute somewhat to compressive strength by confining the matrix.
 - *Consideration for CLC:* Weight (can increase density significantly), cost, dispersion, potential for balling, and corrosion if not stainless steel. May damage foam during mixing if not careful. Difficult to pump.
- **High-Performance Synthetic Fibers (e.g., PVA, Polypropylene Macrofibers):** Certain engineered synthetic fibers can offer more than just shrinkage control and contribute to post-crack flexural strength and toughness.
 - *Consideration for CLC:* Can affect workability. Dosage and type need careful selection.

Important Considerations for Any Additive in CLC:

• **Interaction with Foam:** This is the #1 critical factor. Any new material must be tested for its effect on foam stability, foam incorporation, and the final air void structure.

- Workability/Rheology of the Slurry: The base slurry must remain fluid enough to accept the foam uniformly. Many strength-enhancing materials (especially fine powders) increase water demand and viscosity.
- **Dispersion:** Fine powders and fibers need to be well-dispersed to be effective.
- **Cost-Effectiveness:** Some advanced materials are very expensive, and their benefits must justify the cost for the intended application.
- **Complexity:** Adding more components increases the complexity of the mix design and quality control.
- Trial Batches: Extensive lab testing is non-negotiable for any new material.

For your 70 pcf CLC aiming for high strength:

- **First, optimize:** Ensure you've fully optimized your Portland cement content, SCMs (fly ash, silica fume, possibly colloidal silica), and achieved the lowest possible w/cm ratio with an effective superplasticizer.
- Then consider:
 - **Metakaolin:** Could be a good candidate if very high early strength is needed, but manage water demand.
 - Well-graded fine sand: If not already optimized, ensure its quality and proportion are ideal for matrix strength without unduly increasing density beyond your target after foaming.

Always approach new additives methodically, starting with literature review, small-scale trials, and careful evaluation of all relevant properties.

This is an interesting approach, aiming for a multi-scale fiber reinforcement system in your Cellular Lightweight Concrete (CLC). Combining different fiber types can potentially offer a broader range of benefits, leveraging the strengths of each. Let's break down the potential effects:

1. Acrylic Fibers (e.g., AC-50 - Monofilament Microfibers):

- Primary Role:
 - **Plastic Shrinkage Crack Control:** Excellent at intercepting and bridging microcracks that form in the very early stages as the CLC is drying and has low tensile strength.
 - **Improved Cohesion:** Can help hold the fresh mix together.
- Secondary Benefits:
 - Slight improvement in impact resistance and shatter resistance.
 - Minor contribution to post-first-crack toughness.
- Limitations:
 - Little to no significant increase in peak compressive or flexural strength.
 - Mainly active in the plastic/early hardened state.

2. PVA (Polyvinyl Alcohol) Fibers (Typically Monofilament, Higher Modulus than Acrylic):

- Primary Role:
 - **Post-Crack Ductility and Toughness:** PVA fibers, especially those designed for cementitious composites, have good tensile strength and can form a strong chemical and mechanical bond with the cement matrix. This allows them to bridge cracks effectively after the matrix has failed, significantly increasing toughness and ductility.
 - **Improved Flexural Performance:** Can lead to strain-hardening behavior in some cases (multiple fine cracks instead of one large one), significantly increasing energy absorption capacity.
 - **Impact Resistance:** Better impact resistance than acrylics alone.
- Secondary Benefits:
 - Can contribute to controlling drying shrinkage cracks, though perhaps not as effectively as dedicated very fine acrylics for plastic shrinkage.
- Considerations:
 - **Dispersion:** Can be more challenging to disperse than acrylics, especially longer PVA fibers or higher dosages.
 - **Cost:** Generally more expensive than acrylic fibers.
 - **Bond:** The quality of the bond is crucial. Some PVA fibers are surface-treated to optimize this.
 - **Stiffness:** They are stiffer than acrylics, which might slightly more affect the workability of the base CLC slurry.

Combination of Acrylic and PVA Fibers ("Hybrid Fiber System"):

- Potential Benefits:
 - **Synergistic Effect:** The acrylic fibers tackle the very early plastic shrinkage, preserving the integrity of the matrix for the PVA fibers to work more effectively in the hardened state.
 - **Multi-Scale Crack Control:** Acrylics for micro-cracks, PVAs for meso/macro-cracks once formed.
 - **Enhanced Overall Toughness and Durability:** You get the early crack control from acrylics and the significant post-crack performance from PVAs.
- Challenges:
 - **Workability:** Adding two types of fibers will further reduce the flowability of the base slurry. Careful control of superplasticizer dosage is critical.
 - **Dispersion:** Ensuring both fiber types disperse uniformly without balling or interfering with each other.
 - **Cost:** Increased material cost.
 - **Optimal Proportions:** Determining the ideal ratio of acrylic to PVA fibers would require experimentation. Typically, acrylics are at lower dosages (e.g., 0.6-1.2 kg/m ³ or 1-2 lb/yd³) and PVAs might be at similar or slightly higher dosages (e.g., 1-5 kg/m ³ or 1.7-8.4 lb/yd³) depending on the desired performance.

3. Adding Micro Stainless Steel Fibers to the Acrylic + PVA Mix ("Triple Hybrid System"):

- Primary Role of Micro Stainless Steel Fibers:
 - **Significant Increase in Flexural and Tensile Strength:** Steel fibers have a much higher modulus and tensile strength than synthetic fibers. They can substantially increase the load-carrying capacity of the CLC, both before and after cracking.
 - **Greatly Enhanced Toughness and Energy Absorption:** Superior to synthetic fibers in this regard.
 - Improved Impact and Abrasion Resistance:
 - **Crack Width Control:** Even after cracking, steel fibers can keep crack widths very small.
 - **Potential for Compressive Strength Increase:** By confining the matrix, they can sometimes lead to a modest increase in compressive strength.
- Secondary Benefits:
 - Can contribute to controlling shrinkage cracking, though their primary role is in the hardened state.
- Considerations with Stainless Steel Fibers:
 - **Cost:** Stainless steel fibers are significantly more expensive than synthetic fibers and even carbon steel fibers.
 - **Dispersion:** Micro steel fibers can be prone to clumping if not added and mixed correctly. Specialized mixing techniques might be needed.
 - **Workability:** Will further reduce flowability and increase viscosity significantly. High superplasticizer dosages will be essential.
 - **Weight:** Steel fibers will increase the density of the CLC. For a 70 pcf target, the amount of steel fiber you can add without exceeding this density (after accounting for foam) will be limited.
 - Density of steel \sim 490 pcf (7850 kg/m³).
 - Even a 1% volume fraction of steel fibers in the CLC would add ~4.9 pcf to the density, which is substantial.
 - **Foam Interaction:** The aggressive mixing potentially needed for steel fiber dispersion, and the fibers themselves, could be detrimental to the pre-formed foam bubbles. This is a major concern.
 - **Pumpability:** High fiber contents, especially steel, can make CLC very difficult to pump.
 - **Corrosion:** Stainless steel mitigates corrosion, but the grade of stainless steel matters for very aggressive environments.

Overall Effect of the Triple Hybrid System (Acrylic + PVA + Micro Stainless Steel):

- **Potential for Very High Performance CLC:** If successfully implemented, this system could yield CLC with:
 - Excellent plastic shrinkage control (acrylics).
 - Good post-crack ductility from PVA fibers.
 - Significant increases in flexural strength, tensile strength, toughness, and impact resistance from the steel fibers.

• Extreme Challenges:

- **Workability Nightmare:** Managing the rheology of a slurry containing three types of fibers, especially steel, while trying to incorporate delicate foam will be exceptionally difficult.
- **Foam Stability:** The biggest hurdle. The mixing energy and physical presence of steel fibers pose a huge risk to the pre-formed foam.
- \circ **Dispersion:** Achieving uniform dispersion of all three fiber types without defects.
- **Cost Prohibitive:** This would be a very expensive CLC mix.
- **Density Control:** Very hard to maintain a target density like 70 pcf with a significant volume of steel fibers. You'd likely end up with a much denser material if you add enough steel to make a major mechanical difference.

Recommendations:

- 1. Start Simpler: Before attempting a triple-hybrid system, master the incorporation of:
 - Acrylics alone.
 - PVAs alone.
 - Then, perhaps a dual acrylic/PVA system.
- 2. Focus on the Base Slurry: The key will be creating a very robust, yet fluid enough, base slurry (with high superplasticizer dosage) that can tolerate fiber addition *before* foam is introduced.
- 3. **Foam Introduction:** The method of foam introduction and mixing will need to be very gentle yet effective after fibers are in.
- 4. **Realistic Expectations for CLC with Steel Fibers:** If significant steel fiber content is desired for mechanical properties, you might be moving away from "Cellular Lightweight Concrete" (where low density via foam is key) and more towards a "Fiber-Reinforced Lightweight Aggregate Concrete" or a "Fiber-Reinforced Mortar/Concrete" where the "lightweight" aspect might come from lightweight aggregates rather than a very high volume of foam.
- 5. **Purpose-Driven Design:** What specific performance characteristic are you trying to achieve that warrants such complexity?
 - If it's primarily very high flexural/tensile strength, then steel fibers are key, but you might sacrifice the "cellular" aspect or low density.
 - If it's balanced toughness and crack control at a specific low density, a well-designed acrylic/PVA system might be more achievable.

This triple-hybrid system is theoretically interesting for pushing performance boundaries but would be extremely challenging to implement successfully in a practical CLC application while maintaining a low target density. The interaction with the foam is the most critical and difficult part to manage.

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