NanoJelly Concrete Admixture: Comprehensive Research Summary

Executive Summary

NanoJelly, an innovative concrete admixture, has undergone rigorous testing to assess its impact on concrete performance. This document summarizes the key findings from ASTM C494 standardized testing, specialized pumping efficiency and viscosity studies, and rebound reduction tests. Results demonstrate that **NanoJelly** improves workability, significantly reduces pumping pressures, increases viscosity, enhances concrete strength, and dramatically reduces rebound in shotcrete/gunite applications. These findings also suggest promising potential for precast concrete manufacturing and 3D concrete printing applications.

1. Strength Enhancement

1.1 Compressive Strength (ASTM C39)

Age (days)	Reference (psi)	NanoJelly (psi)	Change
3	3106	3282	+6%
7	4260	4767	+12%
28	5210	5502	+6%

Key Takeaway: NanoJelly improves compressive strength, with a notable 12% increase at 7 days.

1.2 Flexural Strength (ASTM C78)

Age (days)	Reference (psi)	NanoJelly (psi)	Change
3	626	746	+20%
7	739	861	+17%
28	886	975	+10%

Key Takeaway: NanoJelly enhances flexural strength, particularly in early stages with a 20% improvement at 3 days.

2. Workability and Shrinkage

2.1 Slump

- **Reference Mix:** 3.5 inches
- **NanoJelly Mix:** 4.0 inches

Key Takeaway: NanoJelly increases slump by 0.5 inches without additional water, improving workability.

2.2 Shrinkage (ASTM C157 Modified)

Age (days)	Reference (% Change)	NanoJelly (% Change)
7	-0.0040	-0.0023
14	-0.0203	-0.0233
21	-0.0323	-0.0350
28	-0.0413	-0.0413

Key Takeaway: NanoJelly matches the reference mix in long-term shrinkage performance.

3. Viscosity Study

3.1 Viscosity Measurements Over Time

Time (minutes)	REF Viscosity	NNC Viscosity	Difference
8	1800	2500	+39%
10	1660	2640	+59%
12	1480	2660	+80%
15	1620	2629	+62%
20	1690	2670	+58%

Time (minutes)	REF Viscosity	NNC Viscosity	Difference
25	1840	2800	+52%
30	2140	2830	+32%

Key Takeaways:

- **NanoJelly** consistently increases concrete viscosity throughout increasing time periods.
- The most significant viscosity increase is observed at 12 minutes, with an 80% higher viscosity compared to the reference mix.
- **NanoJelly** maintains a higher viscosity even after 30 minutes, indicating prolonged workability.

3.2 Viscosity Trend Analysis

- **Initial Viscosity: NanoJelly** starts with a 39% higher viscosity at 8 minutes.
- **Peak Difference:** The largest viscosity difference occurs at 12 minutes.
- **Sustained Effect: NanoJelly** maintains at least 32% higher viscosity throughout the 30-minute period.
- **Reference Mix Behavior:** The reference mix shows more fluctuation in viscosity over time.
- **NanoJelly Mix Behavior:** The **NanoJelly-**enhanced mix demonstrates more consistent viscosity, with less variation over time.

Key Takeaway: NanoJelly significantly increases and stabilizes concrete viscosity, which can contribute to improved cohesion, reduced segregation, and better pumpability.

4. Pumping Efficiency Study

This study measured pump pressure gauge readings at different input pressures (5, 10, 15 psi) over time intervals from 15 to 150 seconds.

4.1 Comprehensive Pump Pressure Readings

Time (seconds)	Reference 5 psi	NanoJelly 5 psi	Reference 10 psi	NanoJelly 10 psi	Reference 15 psi	NanoJelly 15 psi
15	2.8	1.4	2.8	1.6	4.0	2.9
30	2.9	1.5	3.2	1.6	3.9	2.5
45	3.0	1.3	3.0	1.5	4.7	2.2
60	3.0	1.6	2.8	1.3	4.1	2.6
90	2.7	1.5	3.6	1.2	4.1	2.9
120	2.6	1.3	3.1	1.3	4.2	2.8
150	2.6	1.0	2.9	1.2	3.1	0.0

4.2 Analysis of Pump Pressure Readings

1. **At 5 psi input pressure:**
    - **NanoJelly** consistently maintains lower pressure readings throughout the 150-second test period.
    - The pressure reduction ranges from 38% to 62%, with the most significant reduction at the 150-second mark.
2. **At 10 psi input pressure:**
    - **NanoJelly** shows consistently lower pressure readings, with the gap widening over time.
    - The pressure reduction ranges from 43% to 67%, with the most significant reduction at the 90-second mark.
3. **At 15 psi input pressure:**
    - **NanoJelly** demonstrates significantly lower pressure readings throughout the test period.
    - The pressure reduction ranges from 28% to 53% up to the 120-second mark.
    - Crucially, at 150 seconds, the **NanoJelly** mix shows a pressure reading of 0, indicating that the entire concrete sample had been pumped through the system.
    - This complete evacuation of the **NanoJelly** mix**,** while the reference mix still shows residual pressure, demonstrates a remarkable improvement in pumping efficiency.

Key Takeaways:

- **NanoJelly** significantly reduces pump pressures across all input pressure levels and throughout the entire pumping duration.
- **NanoJelly's** pressure reduction benefits are sustained over time, with some variations in effectiveness at different time points.
- This complete evacuation indicates potential for:
    1. Faster pumping operations
    2. Reduced risk of blockages
    3. Easier cleaning and maintenance of pumping equipment
    4. Potential for pumping larger volumes of concrete in a given time frame
- The consistent pressure reduction and improved flow characteristics across different input pressures and time intervals suggest significantly improved pumpability and potential energy savings in concrete pumping operations.

5. Rebound Reduction in Shotcrete/Gunite Applications

5.1 Rebound Data

Mix Type	**Rebound (%)**
Reference	11.94
NanoJelly	1.79

Key Takeaway: NanoJelly reduces rebound by 85% compared to the reference mix.

5.2 Implications for Shotcrete Applications

- **Material Efficiency:** Significant reduction in wasted material, leading to cost savings.
- **Improved Application Quality:** Less rebound results in more consistent application and better bonding to the substrate.
- **Reduced Cleanup:** Less material loss means reduced cleanup time and associated costs.
- **Safety Improvements:** Reduced rebound can lead to improved working conditions and potentially reduced respiratory hazards for workers.

6. Implications for Precast Applications

NanoJelly's unique properties offer several potential benefits for precast concrete manufacturing:

- **Faster Production Cycles:** The enhanced early strength development (12% higher at 7 days) could allow for earlier demolding and faster turnover of forms.
- **Improved Surface Finish:** Higher viscosity and better cohesion may result in fewer surface defects and reduced need for patching or repair.
- **Reduced Formwork Pressure:** The increased viscosity could potentially lead to reduced lateral pressure on formwork, allowing for lighter form designs or faster casting rates.
- **Enhanced Durability:** Improved strength and potentially denser microstructure may contribute to longer-lasting precast elements.

7. Potential in 3D Concrete Printing Applications

The characteristics of **NanoJelly-**enhanced concrete align well with the requirements of 3D concrete printing:

- **Optimal Viscosity:** The higher and more stable viscosity is crucial for 3D printing, as it helps maintain shape after extrusion without sagging or deformation.
- **Improved Pumpability:** Reduced pumping pressures could translate to more precise control over extrusion rates and potentially allow for longer pumping distances in large-scale printing operations**.**
- **Layer Adhesion:** The enhanced early strength development could improve bonding between printed layers, a critical factor in 3D printed concrete structures.
- **Extended Working Time:** The sustained higher viscosity over time could potentially extend the printing window, allowing for larger continuous prints.
- **Reduced Shrinkage:** The matching shrinkage performance with traditional concrete is beneficial in maintaining dimensional accuracy of printed structures.

8. Implications for Ready-Mix Concrete Applications

The unique properties of **NanoJelly** offer several significant advantages for ready-mix concrete operations:

- **Enhanced Mix Stability During Transport**:
  - The increased viscosity (up to 80% higher) helps maintain mix homogeneity during transit, reducing the risk of segregation and bleeding.
  - This can lead to more consistent concrete quality from batch plant to job site, potentially reducing rejected loads and improving customer satisfaction.
- **Improved Pumpability**:
  - Reduced pump pressures (28% to 50% lower) can significantly ease the pumping process, beneficial for high-rise construction or long-distance pumping.

    - Lower pumping pressures may allow for the use of smaller pumps or reduce wear on existing equipment, potentially lowering operational costs.

- **Extended Working Time**:
    - The sustained higher viscosity over time (32% higher even after 30 minutes) can provide a longer window for placement and finishing.
    - This is particularly valuable for projects with complex placing requirements or in challenging weather conditions.

- **Flexibility in Mix Design**:
    - The ability to increase workability without additional water (0.5-inch slump increase) offers more flexibility in mix designs.
    - This can be crucial for meeting diverse project specifications while maintaining strength and durability requirements.

- **Strength Enhancement**:
    - Early strength gains (12% higher at 7 days) can accelerate construction schedules, a significant advantage in fast-paced construction markets.
    - Improved flexural strength (up to 20% higher) is particularly beneficial for pavements and slabs, common applications in commercial and infrastructure projects.

- **Adaptability to Various Applications**:
    - The versatility of **NanoJelly** to be integrated into any mix design ensures no additional headaches or operational confusion.

- **Quality Control and Consistency**:
    - More stable viscosity and improved mix cohesion can lead to more predictable and consistent concrete performance, potentially reducing variability in quality control tests.

- **Cost-Efficiency**:
    - The markedly improved performance enhancements that NanoJelly provides enhance ROI, especially due to how little is needed to see benefits.

- **Market Differentiation**:
    - Offering **NanoJelly**-enhanced mixes could provide a competitive edge in innovative construction markets, particularly for projects demanding high-performance concrete or specialized applications.

Key Takeaway for Ready-Mix Operations: **NanoJelly** has the potential to enhance the quality, consistency, and versatility of ready-mix concrete while potentially improving operational efficiency and aligning with sustainability goals. These benefits could offer ready-mix producers an opportunity to differentiate their products and potentially capture high-value market segments across various construction sectors.

9. Practical Implications

- **Faster Construction:** Enhanced early strength allows for earlier form removal and load application.
- **Cost Savings:** Reduced pumping pressures lead to lower energy consumption and less wear on equipment.
- **Improved Workability:** Increased slump without additional water facilitates easier placement and finishing.
- **Enhanced Mix Stability:** Higher and more consistent viscosity suggests improved resistance to segregation and bleeding, particularly beneficial in pumping and placement operations.
- **Extended Working Time:** The sustained higher viscosity indicates a longer window for placement and finishing, potentially reducing issues with cold joints or incomplete consolidation.
- **Versatility Across Applications:** From traditional ready mix operations to shotcrete/gunite, precast, and 3D printing, **NanoJelly** demonstrates potential benefits across various concrete applications.
- **Sustainability Improvements:** Reduced fuel use for pumping, shooting and finishing, as well as lowered material waste in shotcrete applications and potential for optimized mix designs, **NanoJelly** is a plug and play solution to improving concrete's sustainability.

10. Conclusion

NanoJelly demonstrates significant benefits as a concrete admixture across a wide range of applications:

- Improves workability and viscosity without compromising long-term shrinkage performance.
- Substantially reduces pumping pressures, leading to energy savings and reduced equipment wear.
- Dramatically reduces rebound in shotcrete and gunite applications, improving efficiency and quality.
- Enhances both compressive and flexural strength, particularly in early stages.
- Offers promising characteristics for precast concrete manufacturing, potentially improving production efficiency and product quality.
- Aligns well with the demanding requirements of consistent high quality 3D concrete printing, potentially enabling advancements in this emerging technology.

These attributes position **NanoJelly** as a versatile and valuable addition to concrete mixes, offering potential improvements in construction efficiency, cost-effectiveness, sustainability, and overall concrete performance across traditional and innovative concrete applications.