

SPE-187498

**Low Density Proppant in Slickwater Applications
Improves Reservoir Contact and Fracture
Complexity - A Permian Basin Case History**

Kale Jackson, Endurance Resources; Olatunji Orekha, CARBO Ceramics



Outline

Introduction

Ultra Lightweight Ceramic (ULWC) Proppant

1. Physical properties
2. Laboratory testing

Proppant Transport Evaluation

1. Stokes Law calculations
2. Slot Experiment and Results

ULWC field application – Permian Basin Case History

1. Operational considerations
2. Well performance

Summary and Conclusions

Introduction

Background - Slickwater Fracturing (SWF) on the rise in recent years

Drivers for design evolution include

1. Proppant pack damage minimization
2. Formation complexity
3. Environmental concerns.
4. **Cost**

Limitation of SWF - Proppant carrying capacity

Design requirements for successful SWF

1. Large water volume requirement
2. Limited max proppant concentration (0.25 – 2.00 PPA)
3. **Smaller mesh size proppant (100 – Mesh & 40/70)**

Ultra Lightweight Ceramic (ULWC) proppant

ULWC design goals

1. Low density proppant
2. Increased fracture coverage (same mass ULWC, lbm)
3. Reductions in pump time, water + chemical usage (with same volume ULWC, cu. ft)

Table 1 – Physical characteristics of ULWC and sand

Property	ULWC	Sand	IDC
ASG	2.0	2.65	3.25
BD (g/cc)	1.15	1.56	1.88
BD (lbm/ft ³)	72	97	117
Roundness	0.9	0.6 – 0.7	0.9
Sphericity	0.9	0.6 – 0.7	0.9

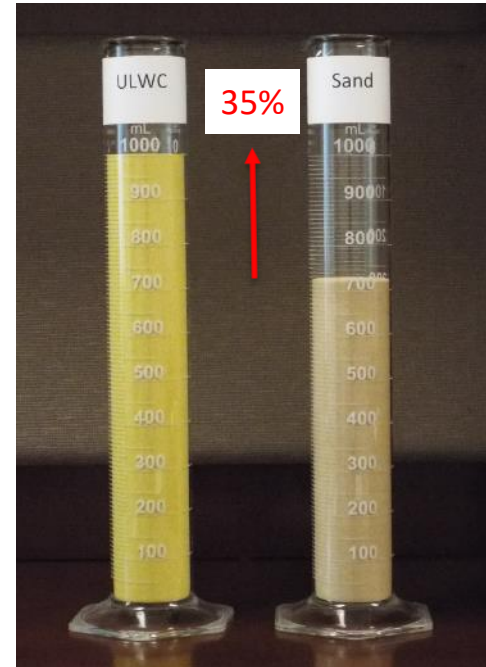


Fig. 1 – Equal mass of ULWC and sand

Long Term Conductivity Comparison of ULWC with Sand

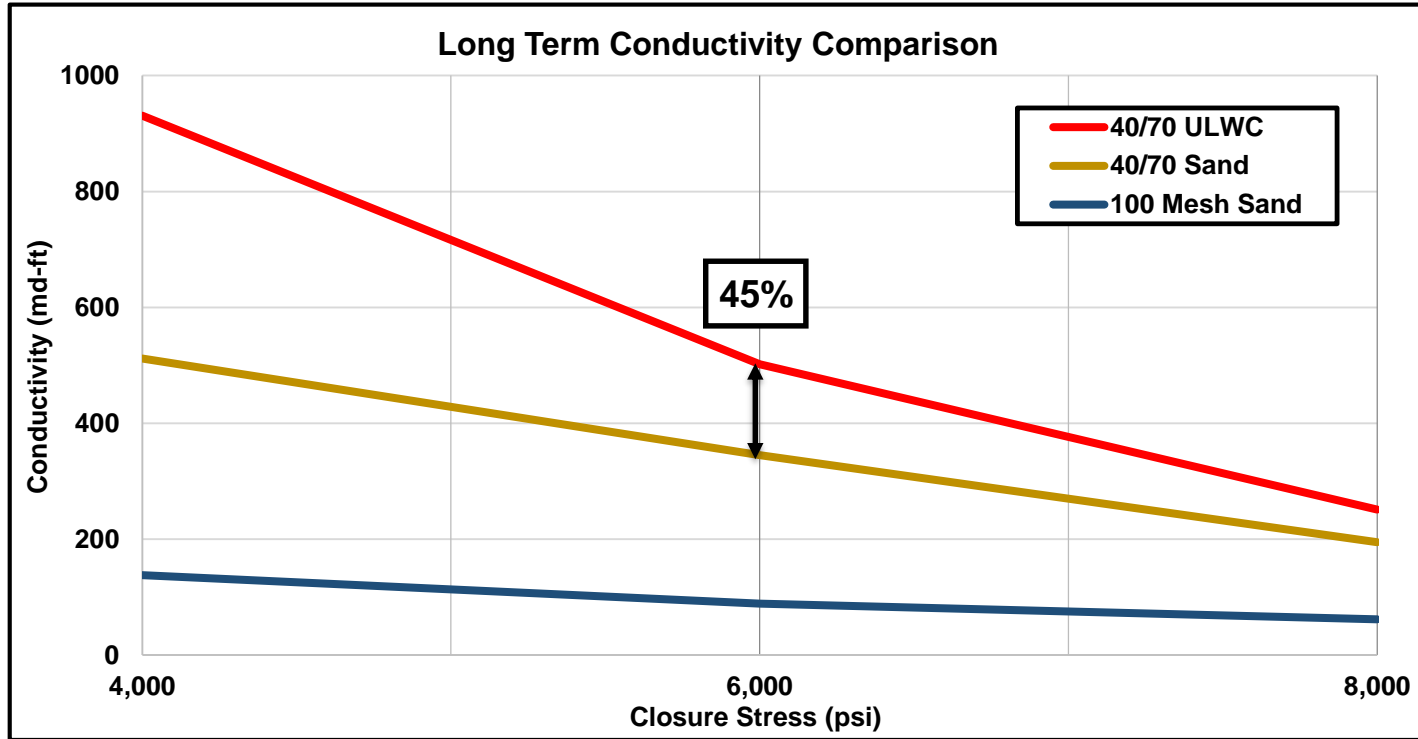


Fig. 2 - Long Term Conductivity Comparison of ULWC with 100-Mesh sand and 40/70 Frac Sand

Proppant Transport – Static Conditions

$$V_s = \frac{g(\rho_p - \rho_{fluid})d_p^2}{18\mu_{fluid}}$$

(Fresh water, 1 cp)

Stoke's Law

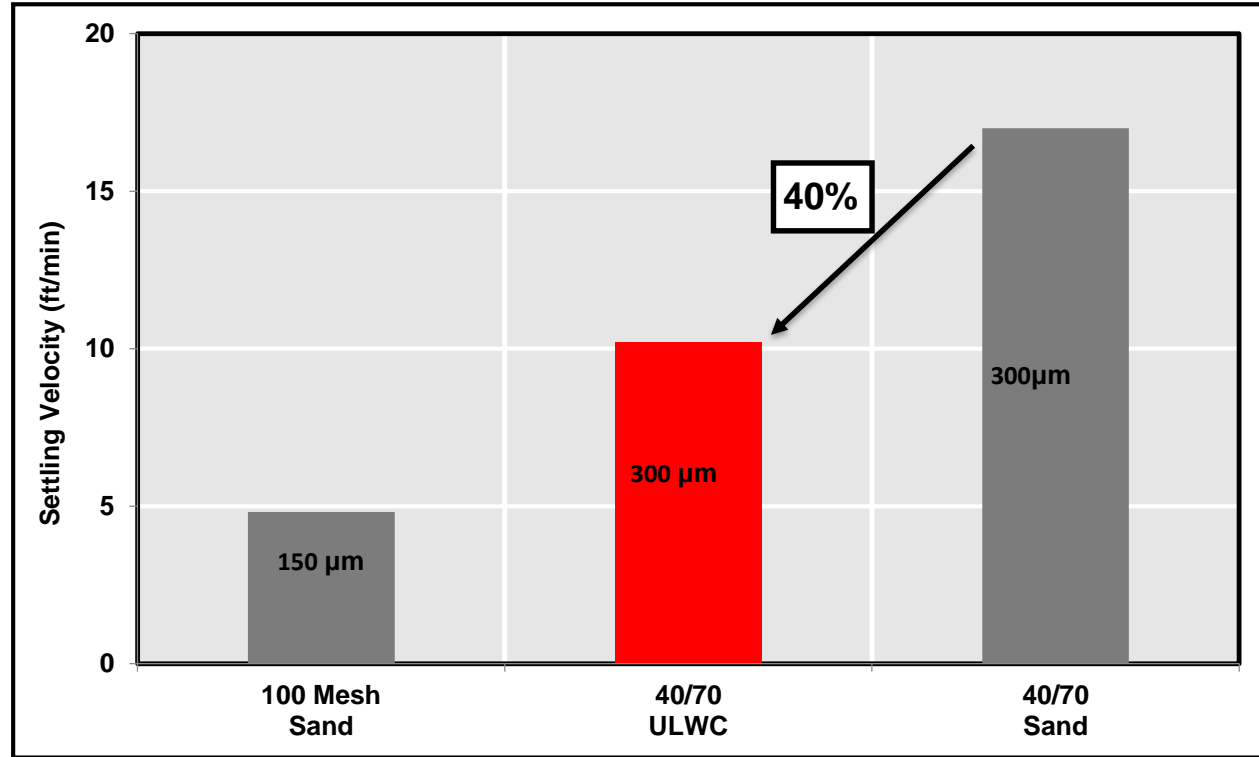


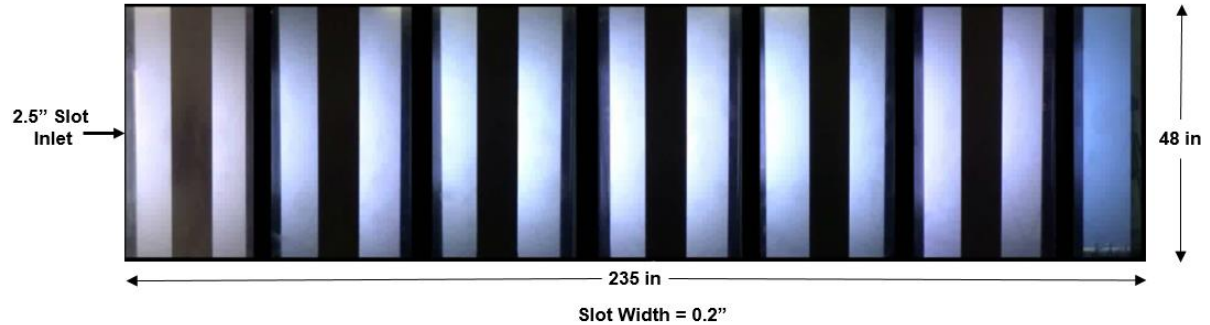
Fig. 3 – Settling velocity comparison of 40/70 ULWC with 100-Mesh sand and 40/70 sand

Proppant Transport – Dynamic conditions

Slot testing used to evaluate transportability under pumping conditions

Major test apparatus

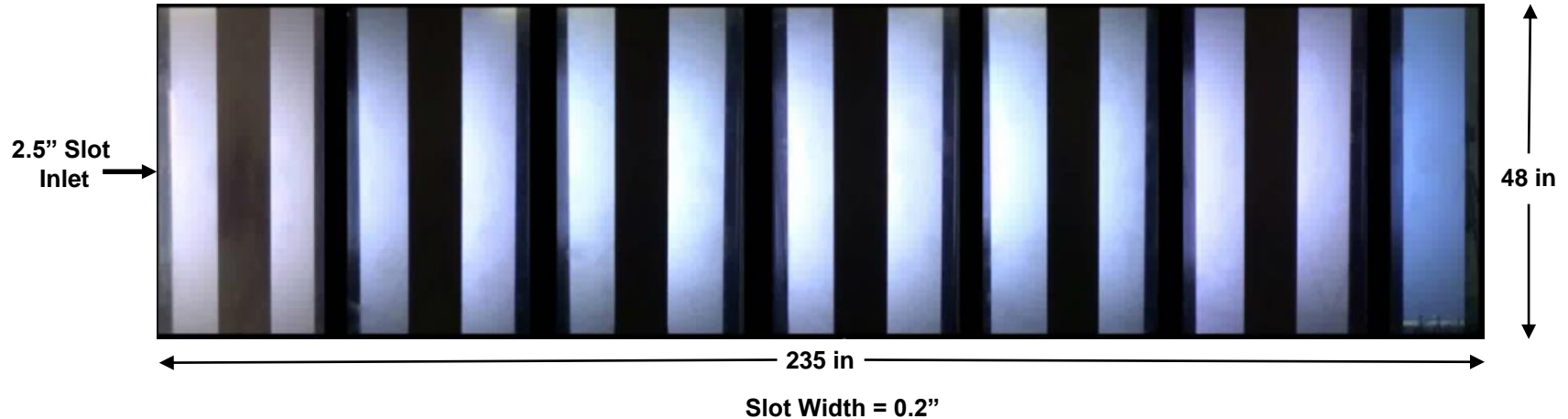
1. Water pumps, reservoirs
2. Flowlines, flowmeters
3. Pressure transducers
4. Catch tanks
5. Digital cameras



4 different test scenarios (Similar volume)

1. Test 1 - 40/70 Sand
2. Test 2 - 40/70 ULWC
3. Test 3 - 50:50 (by volume) mixture of Sand and ULWC
4. Test 4 - Alternating stages (Sand:ULWC:Sand:ULWC)

Proppant Transport – Slot Flow



Performance indicators

1. Proppant profile/geometry in slot
2. Water requirement
3. Far-field sample size

Test Conditions

1. Freshwater system (ambient T, P)
2. Slurry rate 10.5 gpm
3. Slurry concentration 2 PPA
4. Equivalent proppant volumes

Slot Testing Results - Tests 1 & 2

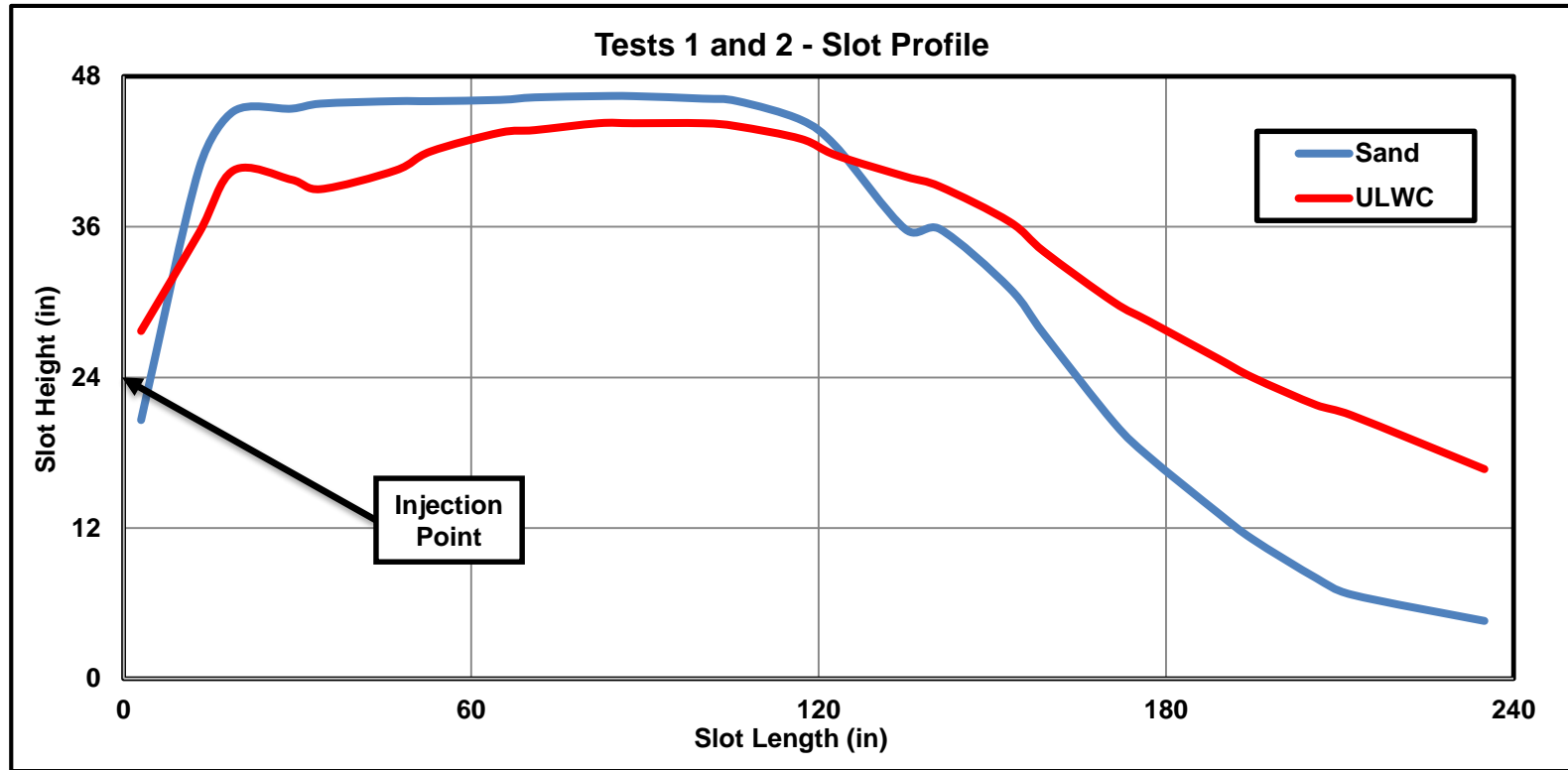


Fig. 4 - Slot Profile for Tests 1 & 2

Slot Testing Results - Tests 3 & 4

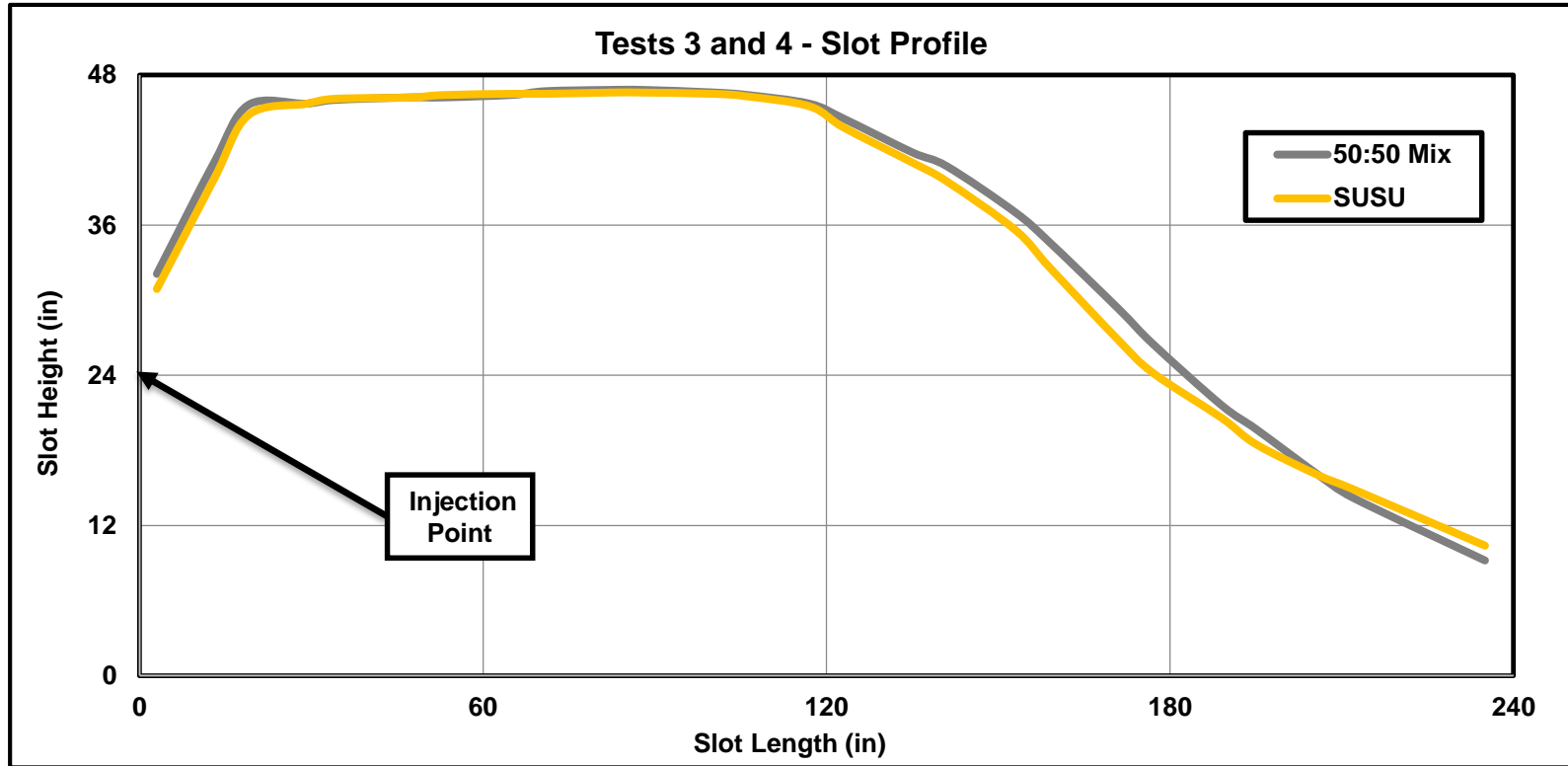


Fig. 6 - Slot Profile for Tests 3 & 4

Proppant Transport Evaluation – Test 4

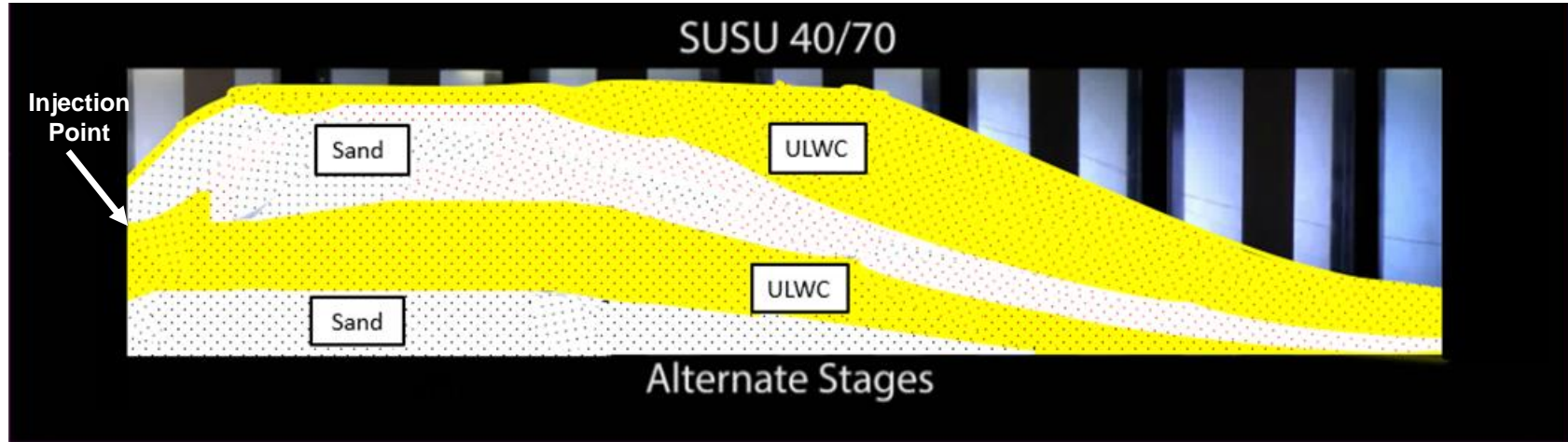


Fig. 8 - Slot sections schematic during Test 4, showing the geometry of Sand and ULWC

- Sand settled early in the near-field
- ULWC “launches” over settled sand
- Conductivity channels in settled sections

Slot Testing Results – Overall Profile

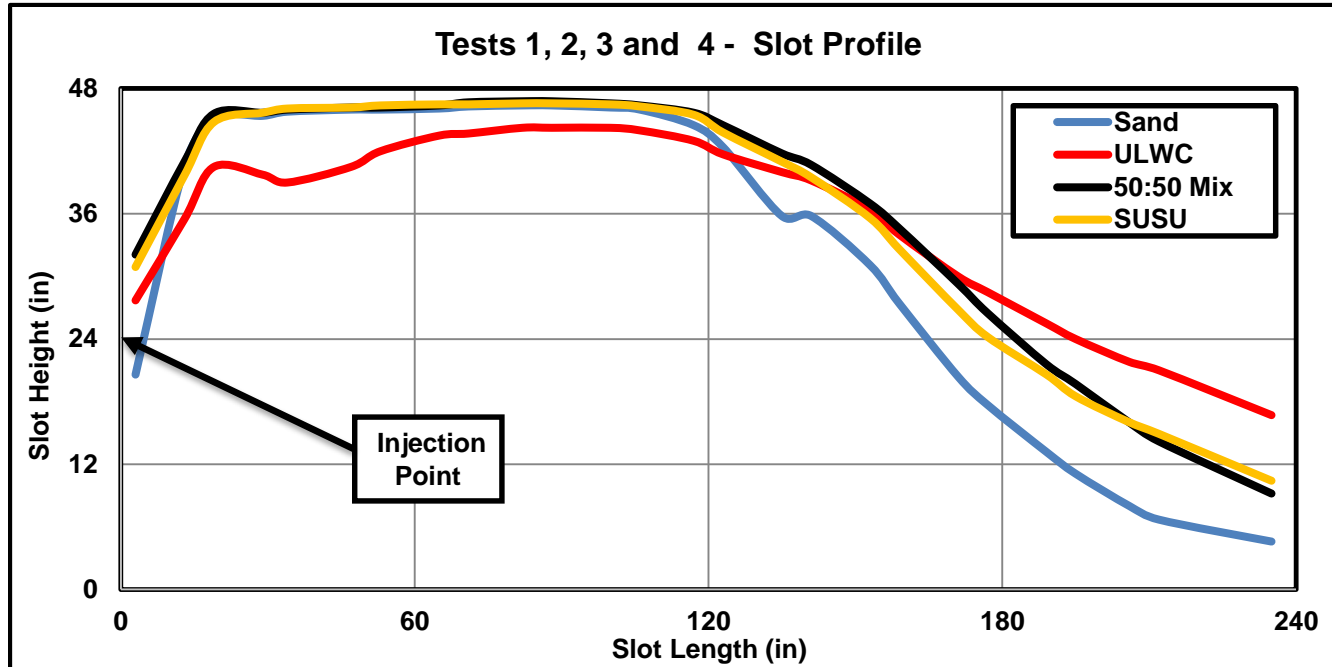


Fig. 7 – Overall slot Profile for Tests 1,2,3 & 4

- 100% ULWC has 4x the far-field height of sand
- Mix and S-U-S-U : 2x height of sand in the far-field

Slot Testing Results - Summary

Table 2 – Slot Flow Results

Test	Sample	*Mass Pumped (lb)	*Areal Coverage (sq. ft)	Water Usage (gals)	**ULWC discharged (lb)	**Sand discharged (lb)
1	ULWC	74.4	58.1	37.20	3.82	-
2	Frac Sand	98.6	55.8	51.20	-	1.21
3	50:50 Mix	86.5	57.1	46.40	2.62	-
4	S-U-S-U	86.5	56.3	46.10	1.44	0.65

1. Equivalent proppant volume in Tests 1 & 2 with ~30% less fluid (ULWC)
2. ~ 3X ULWC sample in far field
3. Similar fluid & geometry utilization in Tests 3 & 4

Permian Basin Case History – Well A

- “Wildcat” well located in the 2nd Bone Spring
- 100 ft gross thickness
- Previous success with 100 – Mesh and 40/70 sand
- Design goal – fracture length

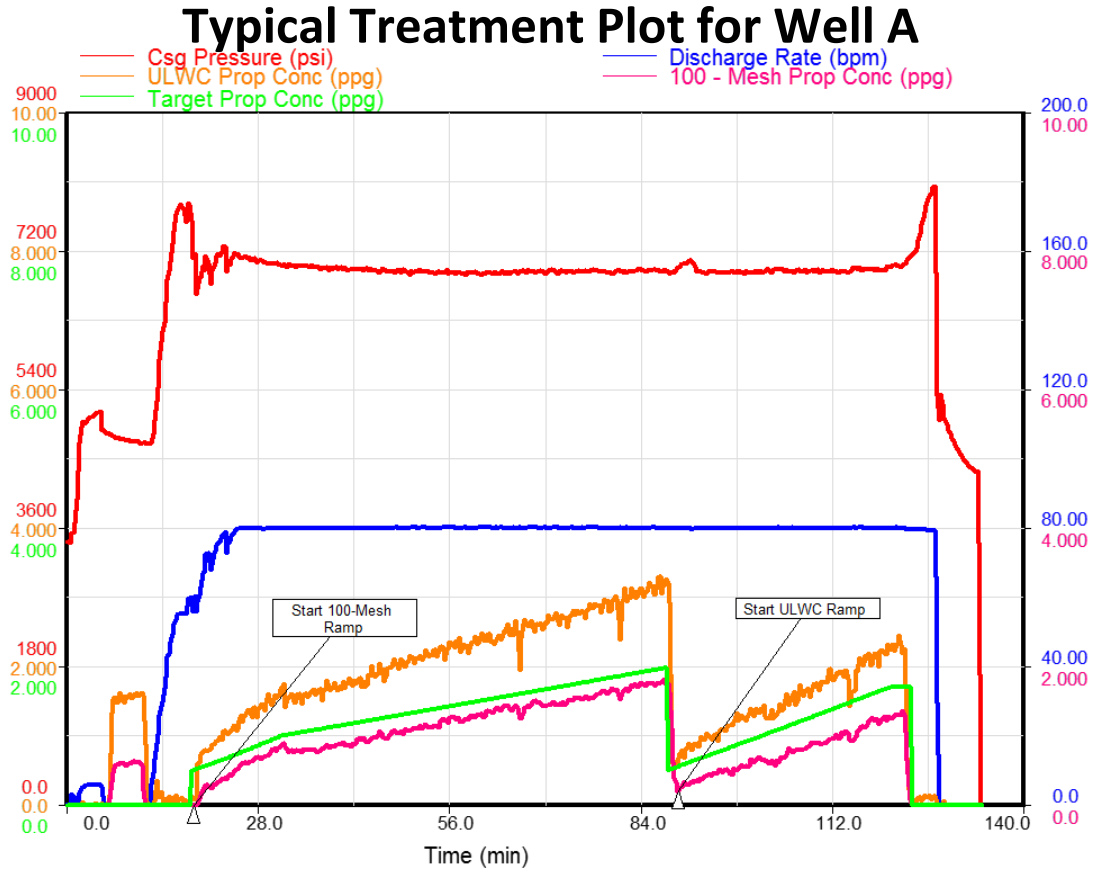


Fig. 9 – Typical treatment plot for Well A, showing a lead-in with 100-Mesh sand and a tail-in with ULWC

Paper # 187498 • Low Density Proppant in Slickwater Applications Improves Reservoir Contact and Fracture Complexity –

A Permian Basin Case Study • Olatunji Oreka

Well A – Well Performance

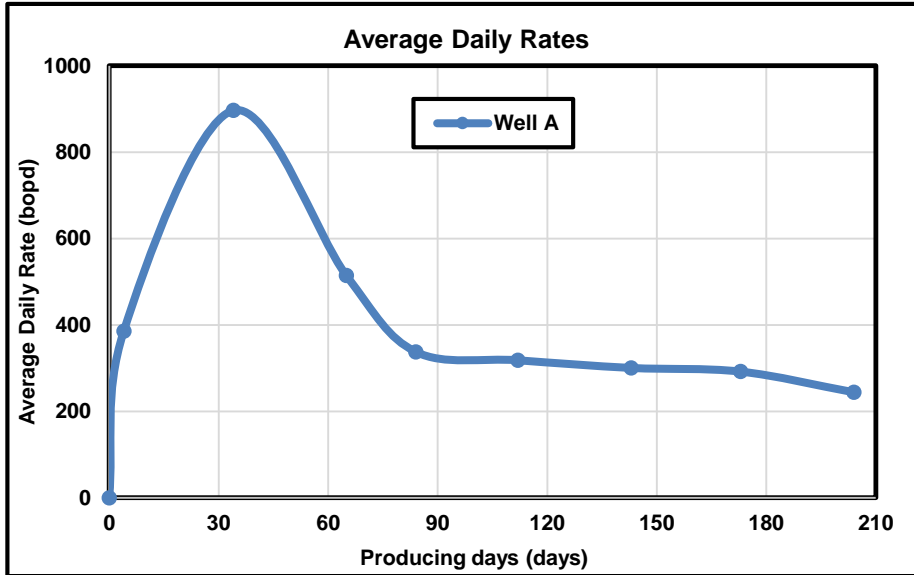


Fig. 10a - Average daily rate plot

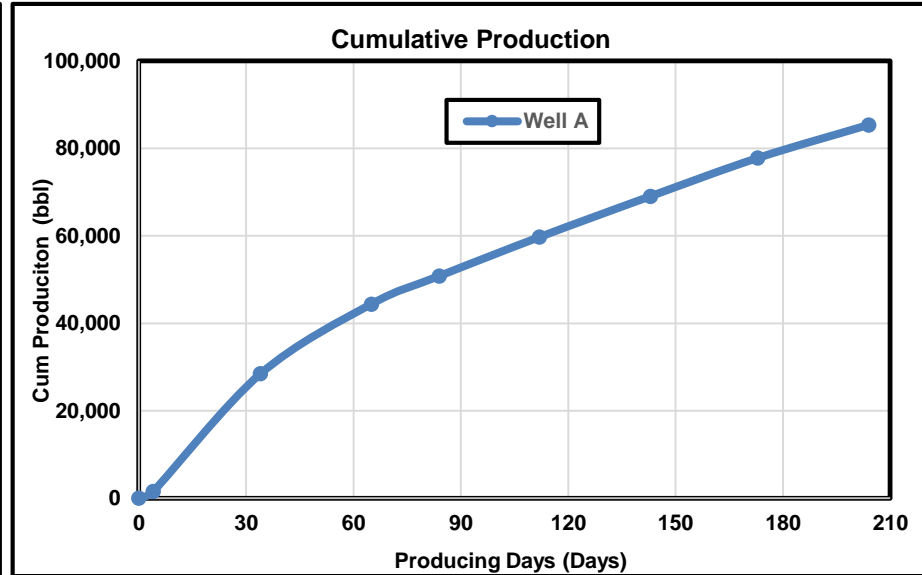


Fig. 10b - Cumulative production plot

Summary and Conclusions

- SWF has become very popular
- Proppant transport is problematic in SWF
- A new low density (2.0 ASG), high transport proppant has been developed
- 25% lighter than sand with higher conductivity
- Slot flow testing confirms improved transport, leading to increased fracture geometry
- First deployment in Permian well was successful
- Several novel applications available

SPE Liquids-Rich Basins Conference—North America

13-14 September 2017

The Petroleum Club
MIDLAND, TEXAS, USA

Acknowledgements / Thank You / Questions

The authors want to thank:

CARBO Ceramics

Endurance Resources LLC

FracTech Laboratories, UK

Southwestern Energy

