Predicting Smoothness Growth





Rice County Highway 12 Project Data



- Two 4.5 m lifts (75 mm / 50 mm) on reclaimed granular base
- 24 lane kilometerss



2006 IRI PAY FACTOR - EQUATION B

- Two Lift Projects
- Calculated for each 100 meter segment
- \$600 (IRI x 10) = Pay Factor (incentive / disincentive)
- Maximum Pay Factor = \$270 if .50 m / km (12.0 NAASRA) or less
- Bump (+6mm) = \$675 deduct
- Corrective Action = \$675 deduct and Fix



Reclaimed Granular Sub-base



- Blended, pulverized bituminous material and existing granular base
- Shaped by motor grader with GPS control
- Profile (slope) held very close to 2% from centerline
- Ride van took IRI measurement



Sub-base Stability



- Generally wellcompacted, stable subbase
- Some wet, yielding spots
- Additional grading and compaction done in some areas



Eastbound Lane, 3.6 miles / 5.8 Km (1/10 mile segments)

- 1 236" 11 - 219" 21 - 216" 31 - 220" 2 - 272″ 12 - 203" 22 - 208" 32 - 237" 3 - 243" 13 - 215" 23 - 195" 33 - 218" 4 - 222" 14 - 145" 24 - 203" 34 - 181" 5 - 262" 15 - 206" 25 - 228" 35 - 202" 6 - 222″ 16 - 207" 26 - 180" 36 - 145" 7 - 219″ 17 - 228" 27 - 193" 8 - 176″ 18 - 235" 28 - 227" 9 - 238" 19 - 299" 29 - 288" 10 - 262" 20 - 268" 30 - 226"
- AVG: 221 inches / mile 3.5 m / km 91.5 NAASRA

soft sub-base areas



First Lift Paving Process



- Windrow paving with 3.0 meter track paver
- 4.6 m wide x 75 mm depth
- Continuous paving at 8-9 mpm
- 315-360 tonnes/hour



First Lift Grade / Slope



- First shift westbound using Sonic Averaging Ski on centerline side
- Slope control (2%) shoulder side



First Lift Grade / Slope



- All other shifts using 9-meter multiarticulated averaging ski on centerline side
- Sonic grade sensor
- Slope control (2%) shoulder side



Good Results - First Lift



- Well-trained crew
- Balanced production plant - trucking - paving speed
- Good mat quality in general
- No significant density issues
- Some mat problems noted



Waiting for Mix



- Occasional stops
- Usually under 5 minutes
- Usually related to traffic control
- Can cause heat loss, compaction variation, bump
- Worked with crew on paving speed



Low on Mix in Hopper Insert



- Windrow management issue
- Mix segregation in hopper
- Head of material drops in auger chamber



Mat Defects



Segregation

Dip

- Hand work needed
- Worked with dump man on windrow management
- Worked with paver operator to stop before running out of mix



Intersection Tie-ins



- Overlapped approach on slope side caused bumps
- Worked with approach crew on leaving proper joint to match
- Note: small roller still working



Rolling onto Mainline Mat



- Approach roller stopped on hot mainline mat
- Operator given instructions to roll parallel to joint



Mat Deformation - Soft Sub-base



- Compaction found soft spots in subbase
- Mat cracked and deformed
- Deformed areas cut out and patched prior to top lift
- Can be an issue on any reclamation project



Smoothness Growth - First Lift

1st Lift	Incorrections
<u>IRI</u>	Improvement
80″	66%
83″	69 %
70″	71%
78″	65%
92″	65%
60″	73%
79″	64%
69″	61%
90″	62%
74″	72%
57″	74%
94″	54%
58″	73%
	1st Lift <u>IRI</u> 80" 83" 70" 78" 92" 60" 79" 69" 90" 74" 57" 94" 58"



Smoothness Growth - First Lift

Base	1st Lift	Improvement	
<u>IRI</u>	IRI	Improvement	
145″	69″	52%	
206″	80″	61%	
207″	57″	72%	
228″	66″	71%	
235″	68″	71%	
299 ″	71″	76%	Soft Subbase
268″	91″	66%	Soft Subbase
216″	52″	76%	
208″	48″	77%	
195″	58″	70%	
203″	52″	74%	
228″	74″	68%	
180″	56″	69%	



Smoothness Growth - First Lift

Base	1st Lift	
IRI	<u>IRI</u>	Improvement
193″	74″	62%
227″	75″	67%
288″	78″	73%
226″	72″	68%
220″	63″	71%
237″	77″	68%
218″	74″	66%
181″	73″	60%
202″	81″	60%
<u>145″</u>	<u>69″</u>	<u>52%</u>
221″	73″	67% Average
3.5 m	1.16 m	o, lo ruorago
91.5 NAASRA	29.5 NAA	SRA



Top Lift Paving - Cruise Control



- Balanced production
- Uniform Speed
- Continuous paving
- No big mistakes
- Crew monitoring the paving process
- Paving grade / grade, ski / ski



Grade Control - Centerline Side



- 9-meter multiarticulated drag ski
- Use when grade reference is outside paving width
- Provides superior averaging / smoothness
- Also provides good joint match



Grade Sensor at Tow Point



- Produces small tow point movement
- Screed change is slow and spread out
- Mounting hardware installed on tow arm
- Use mechanical or sonic sensor



Grade Control - Shoulder Side



- 9-meter Fore and Aft leveler
- Use when grade reference is inside paving width
- Input from top lift mat and first lift
- Provides good averaging / smoothness



Compaction Process



- Initial phase roller stop / reverse on cold mat
- Compactor speed matching paving speed, staying in same temperature zone



Compaction Process



- Pneumatic roller (intermediate) kept back on cooler mat
- Tires skirts used to keep heat on tires
- Operator stayed on mat, kept tires hot



Compaction Process



- Some mix sticking on tires -- Level III mix
- Some effect on smoothness
- Bigger problem when using stickier Level IV and Level V mixes



Mix Sampling



- Always pull from shoulder when permitted
- Minimize effect of handwork on driving lane



Smoothness Growth - Top Lift

1st Lift IRI	Top Lift IRI	Improvement	Total Improvement	
<u>90"</u>	20"	<u>52%</u>	Q10/	
00	30	JZ /0	04 /0	
83″	37″	54%	86%	
70″	49″	30%	80%	
78″	42″	46%	81%	
92″	56 ″	39 %	79 %	super elevation
60″	36″	40%	84%	
79″	32″	5 9 %	85%	
69″	29″	58%	84%	
90″	43″	52%	82%	
74″	53″	28%	80%	
57″	37″	35%	83%	
94″	41″	56%	80%	
58″	31″	47%	86%	



Smoothness Growth - Top Lift

1st Lift	Top Lift		Total
<u>IRI</u>	<u>IRI</u>	Improvement	Improvement
69″	43″	38%	70%
80″	43″	46%	79%
57″	71″	-24	65% patched area
66 ″	63″	5%	72% patched area
68″	38″	44%	84%
71″	49″	31%	84% patched area
91″	66 ″	27%	75% patched area
52″	34″	35%	84%
48″	39″	19%	81%
58″	39″	33%	80%
52″	35″	33%	83%
74″	45″	39%	80%
56″	38″	32%	79 %



Smoothness Growth - Top Lift

1st Lift <u>IRI</u>	Top Lift <u>IRI</u>	Improvement	Total <u>Improvement</u>	t
74" 75" 78" 72" 63" 77" 74" 73" 81" 69"	43" 42" 38" 37" 30" 30" 40" 37" 44" 39"	42% 44% 51% 49% 52% 61% 46% 49% 46% 43%	78% 81% 87% 84% 86% 87% 82% 80% 78% 73%	
73″″ 1.16 m 29 naasra	42″ 0.67 m 16.5 naasi	40% Ra	81%	Average



Smoothness Study



North Dakota State Hwy 12



- Widening to 5.5 m, driving lane plus shoulder
- Blended, stabilized subbase
- 39.5 lane kilometers
- Paving completed
 September October
 2005



Continuous Paving at Constant Speed



- Transfer device separates truck from paver
- Paving speed based on 400 tonnes per hour from plant; 5.6 meter paving width; 76 mm paving depth
- Paving speed: 9 mpm



Averaging Ski Centerline Side



- 12-meter, multi-foot ski
- Installed new springs to improve float
- Reference outside paving width
- Center of ski in line with tow point
- Reduce grade deviations by a factor of eight



Fore and Aft Leveler on Shoulder Side



- 3-meter, articulated ski in front of screed
- Stringline over the screed
- Aft beam rides on mat
- Reference inside the paving width
- Correct profile built in base lift
- Replaces slope control



Improvement by IRI Category





Improvement by IRI Category





The Averaging Ski Debate





Non-Contact SAS

Articulated Drag Ski



IRI Comparison

Average IRI by Jobsite





Confidence Level - Predictability





Why Choose Non-Contact Ski?



- Get the data
- Know the project requirements
- It's not always the money



SAS – When Time Is Most Important



- Any shift with time limit
- Usually night shift
- Multiple re-starts for lane matching
- SAS saves 10-15 minutes per re-start compared to drag ski



SAS – When There Are Obstacles



- Grade reference has catch basins, etc.
- No grade reference outside paving width, i.e. paving next to barrier



SAS – Decent Grade Reference



- Need to measure surface of the grade to be paved
- IRI under 100" per mile / 1.6 m per Km is suitable for SAS

IRI of milled surface averaged 43" / mile
Profile checked at correct slopes
IRI of top lift averaged 35" / mile



Drag Ski – Need Maximum Averaging



- Grade reference average over 100 inches per mile / 1.6 m per Km IRI
- 9-meter Outboard Leveler when grade reference is external to paving width
- Reduces grade deviations by a factor of 8 at center of ski



Drag Ski – Time Less Important



- Long pulls
- Few re-starts
- Mostly long day shifts



What is achievable on typical two-lift project?

.9-1.1 m/km	.89 m/km	.86 m/km	.65 m
<u>25 NAASRA</u>	<u>21 NAASRA</u>	<u>17 NAASRA</u>	<u>14 NAASRA</u>
100%	90%	75%	50%

These scores are attainable, but with a lot of

IFS



IF – Fundamentals Are Done Correctly



- Good transverse joints
- Feeder system adjusted for smooth, continuous mix flow



IF – Paving Is Continuous



- Any type Material Transfer Device is adequate
- Requires pre-project planning
- Caterpillar Production Calculator or other estimating software



IF – Big Mistakes Are Avoided



- Big spills
- Long Paver Stops
- Rollers parking on hot mat
- Voids and hand work



IF – Averaging Skis Used



- Preferably two skis
- Preferably two drag skis



IF – Slope Is Not Used



- Some public works departments require slope on first lift – ask engineer for waiver
- Some contractors like slope because it's easy
- Slope changes are relatively fast with big tow point movement – bad for smoothness



PREDICTING SMOOTHNESS GROWTH

CATERPILLAR®

© CATERPILLAR 2011

