Intelligent Compaction for Improved Performance of Rural Roads

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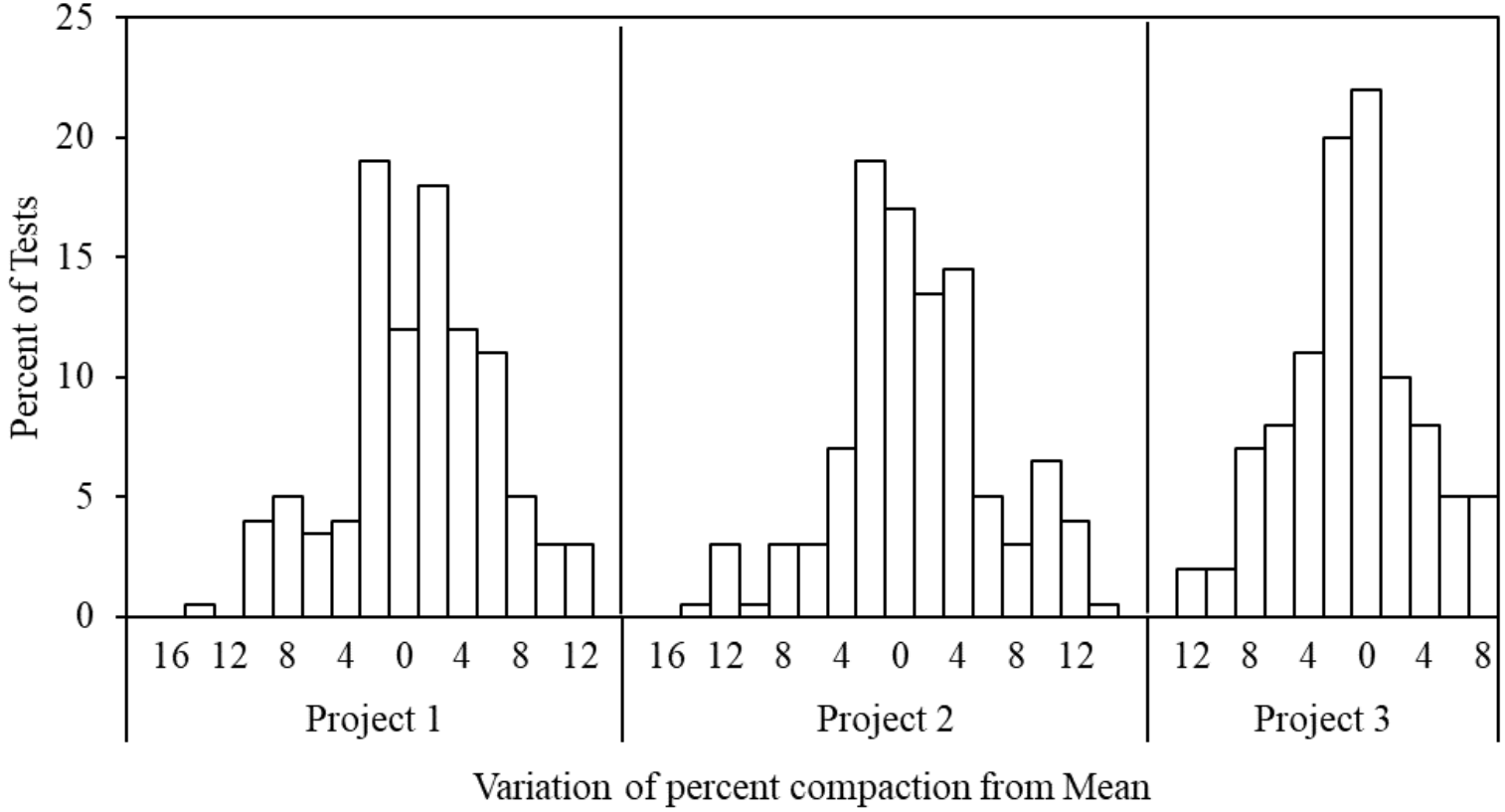
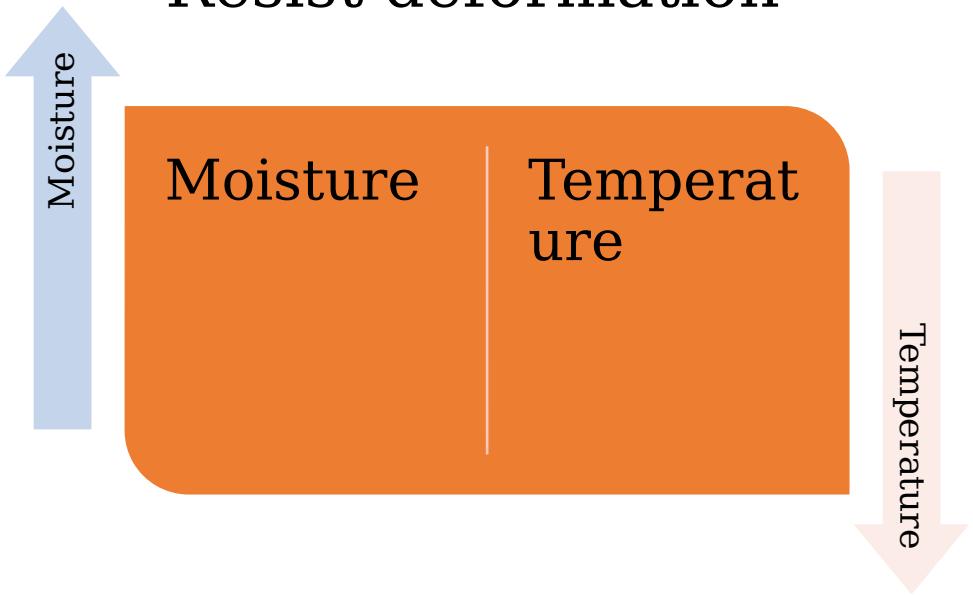
Compaction

- Control
  - Moisture
  - Density
  - Lift



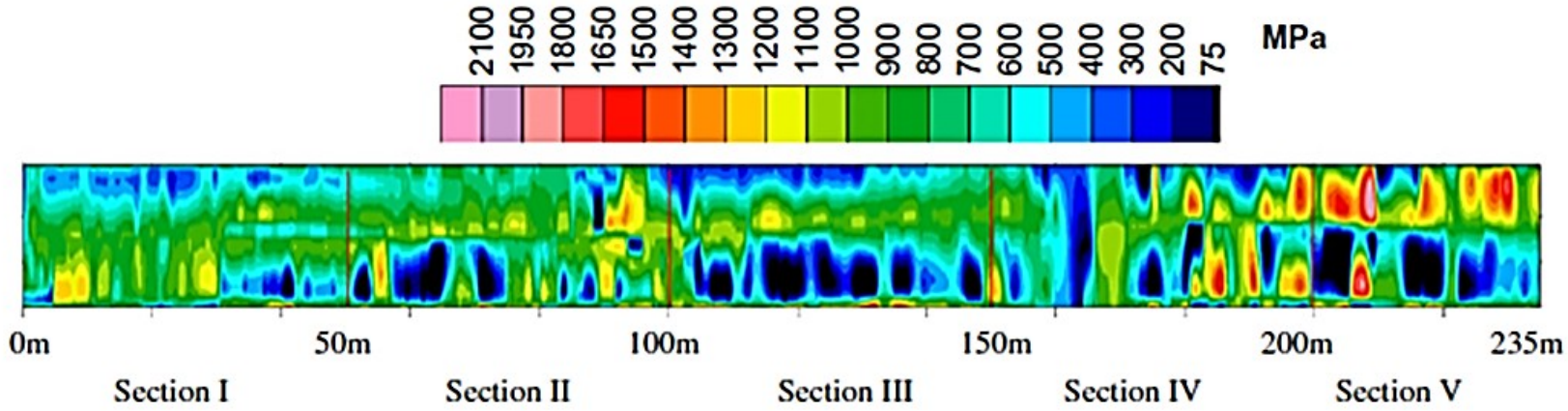
Compaction

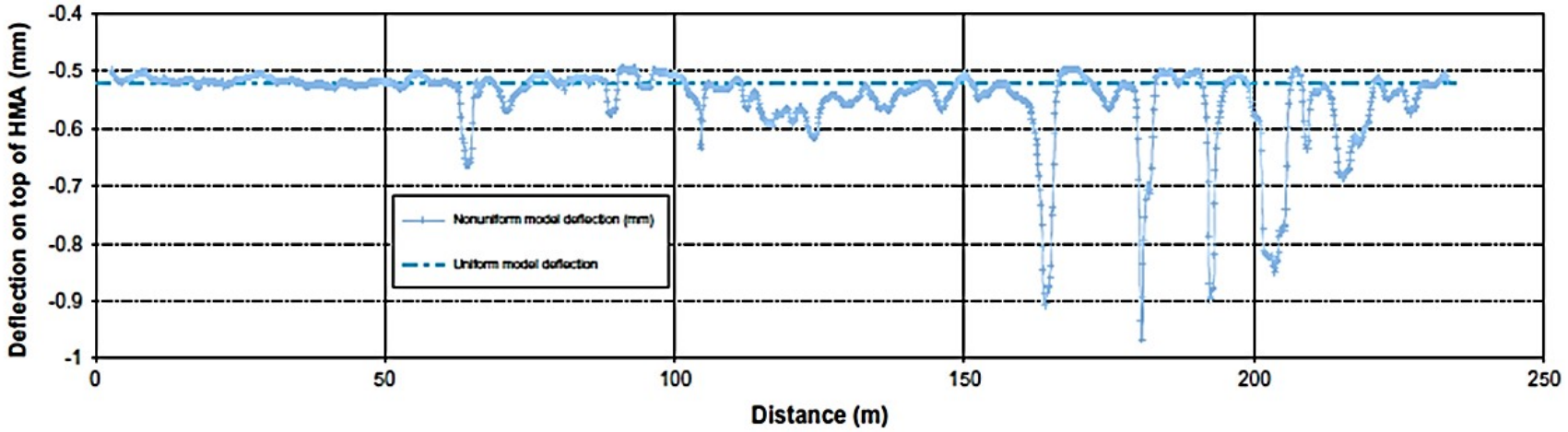
- Density
  - Stress distribution
- Stiffness
  - Resist deformation



- Challenges to achieve density/stiffness
  - Material testing
  - Quality CONTROL
  - Roller parameters
  - Site engineer
  - Operator

Consequences

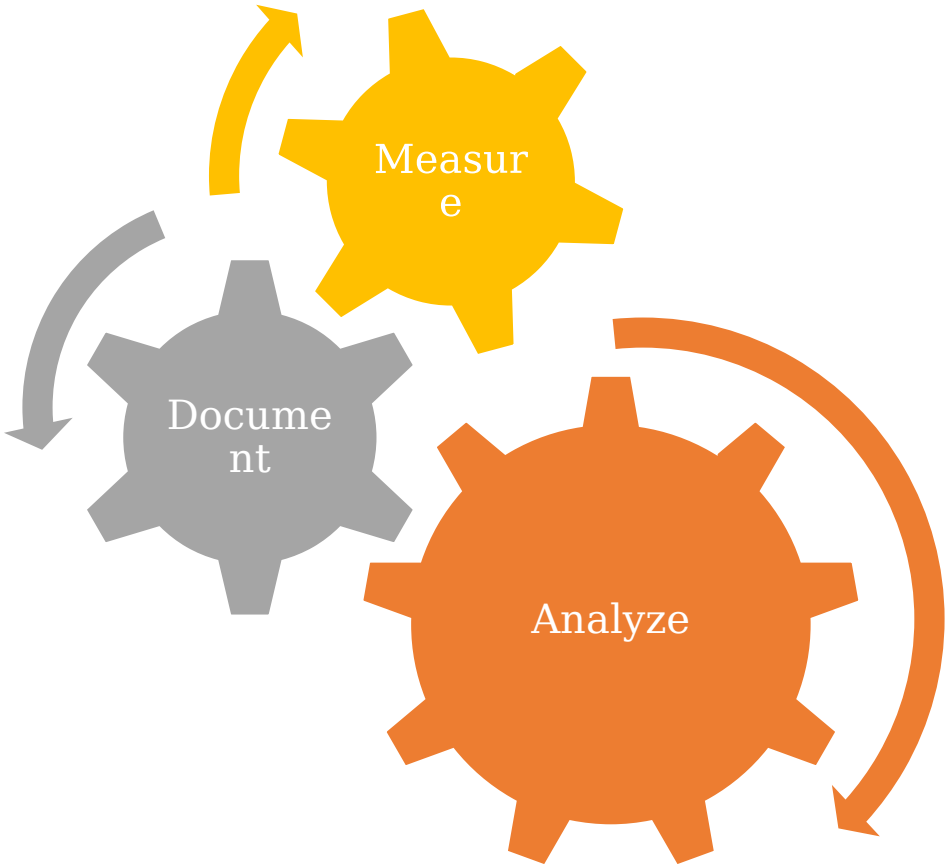




Compaction

- Rural Roads
  - Embankment
  - Subgrade
  - Granular
  - Surface treatment
- Cost of Compaction
  - 600 p/h
  - 5000 per km

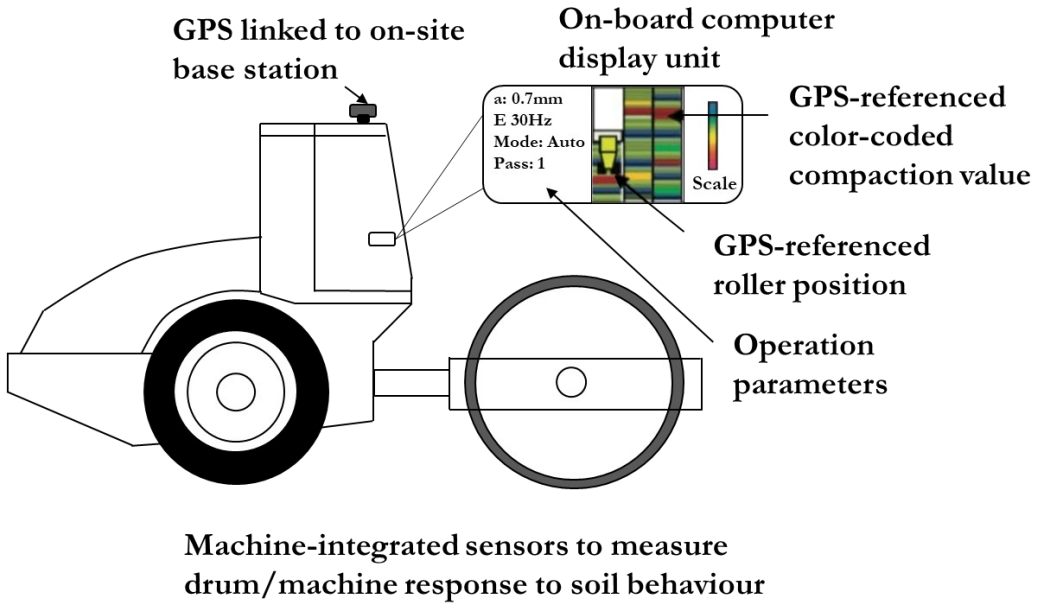
Intelligent Compaction



- Intelligent compaction
  - Continuous assessment of mechanistic material properties (e.g., stiffness, modulus) through roller vibration monitoring;
  - On-the-fly modification of vibration amplitude and frequency;
  - Integrated global positioning system to provide a complete geographic information system–based record of the

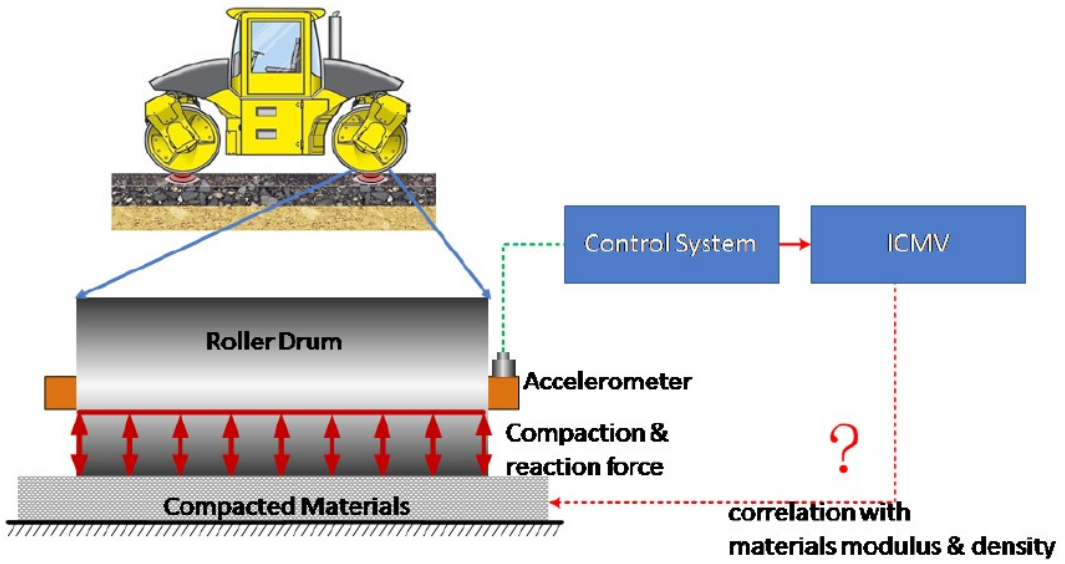
Intelligent Compaction

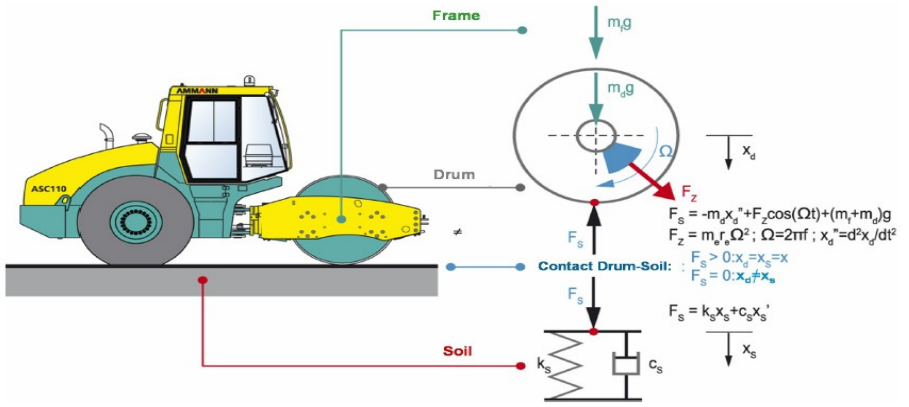
- IC System
  - Accelerometer
  - GPS recorder
  - Data logger
  - Display



Intelligent Compaction

- IC System
  - Compaction
  - Reaction





Intelligent Compaction

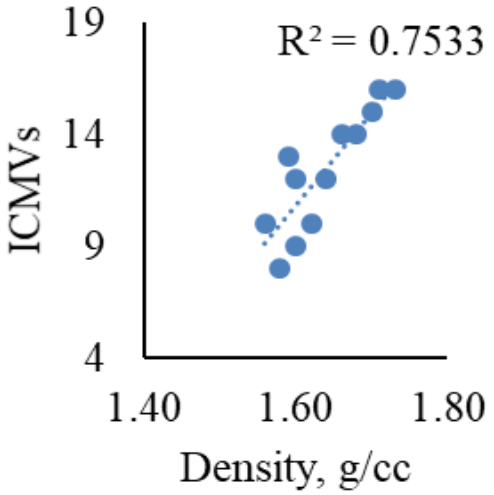
Measurement Value	Manufactures	Relations Used
Compaction Meter Value (CMV)	Dynapac, Caterpillar, Hamm, Volvo	
Compaction Control Value (CCV)	Sakai	CCV=[
Stiffness, K_s	Ammann	
Vibration Modulus, E_{vib}	Bomag	
Machine Drive Power (MDP)	Caterpillar	

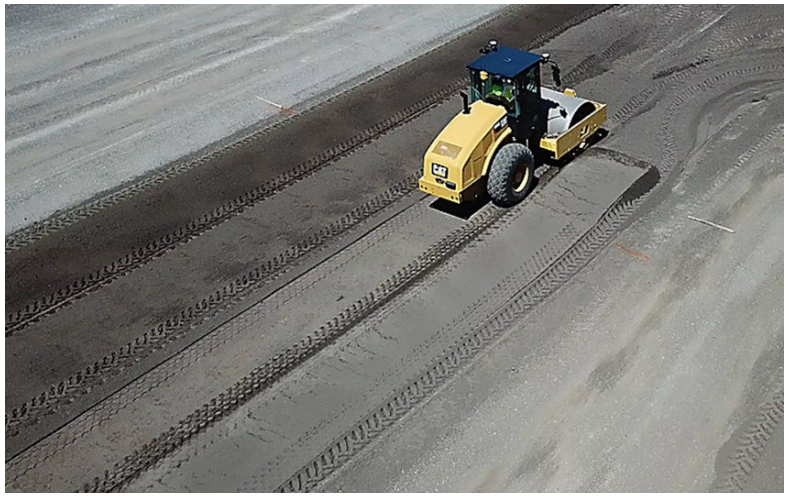
Spectral analysis

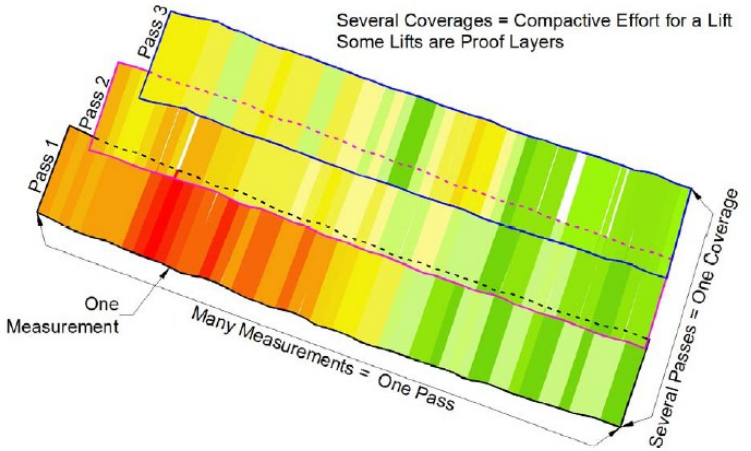
Force displacement

Energy to propel

Intelligent Compaction

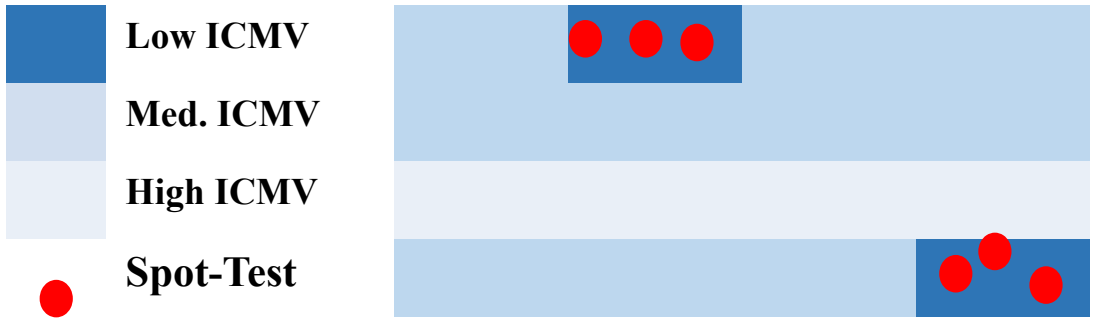


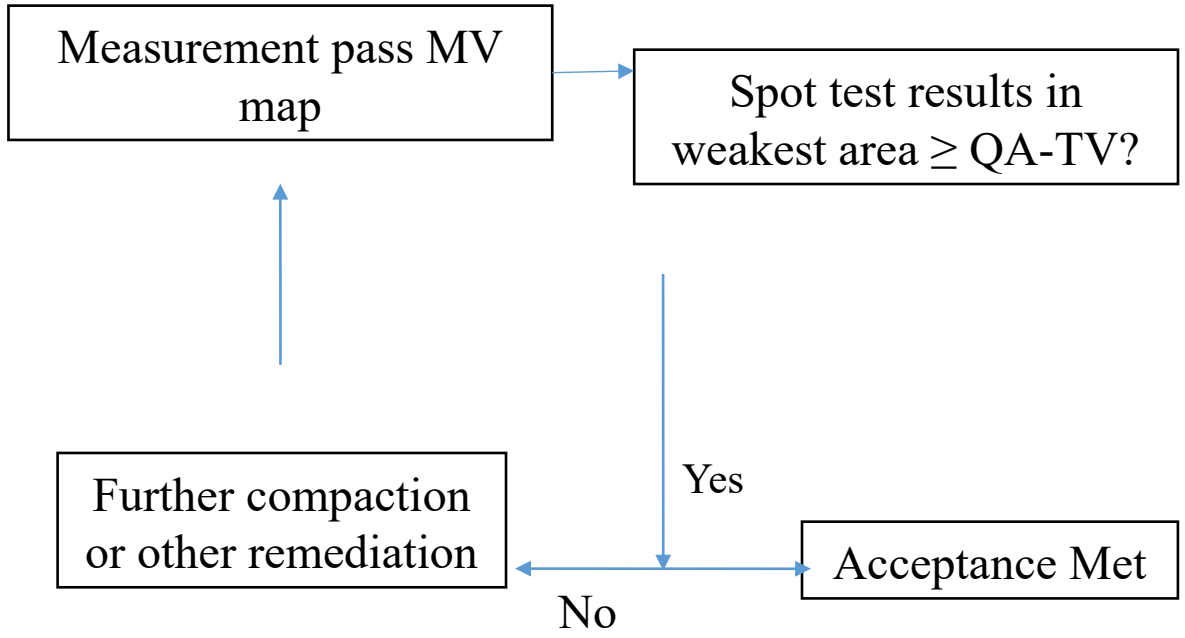




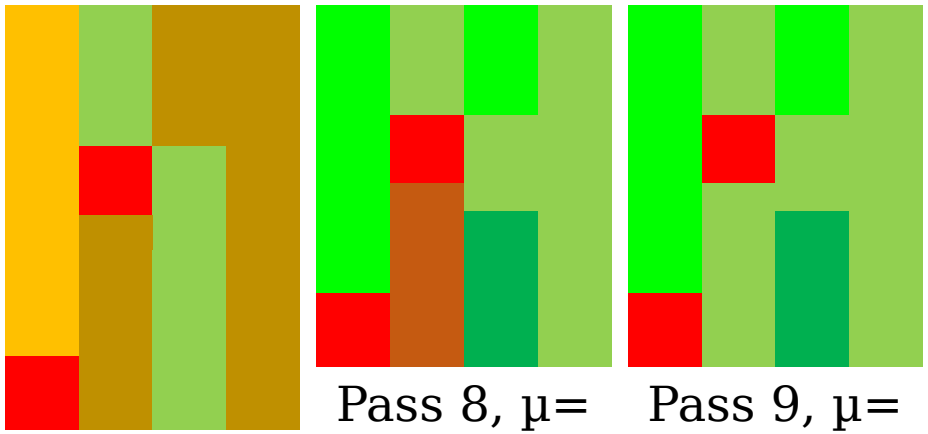
Quality Assurance

- **Option 1**





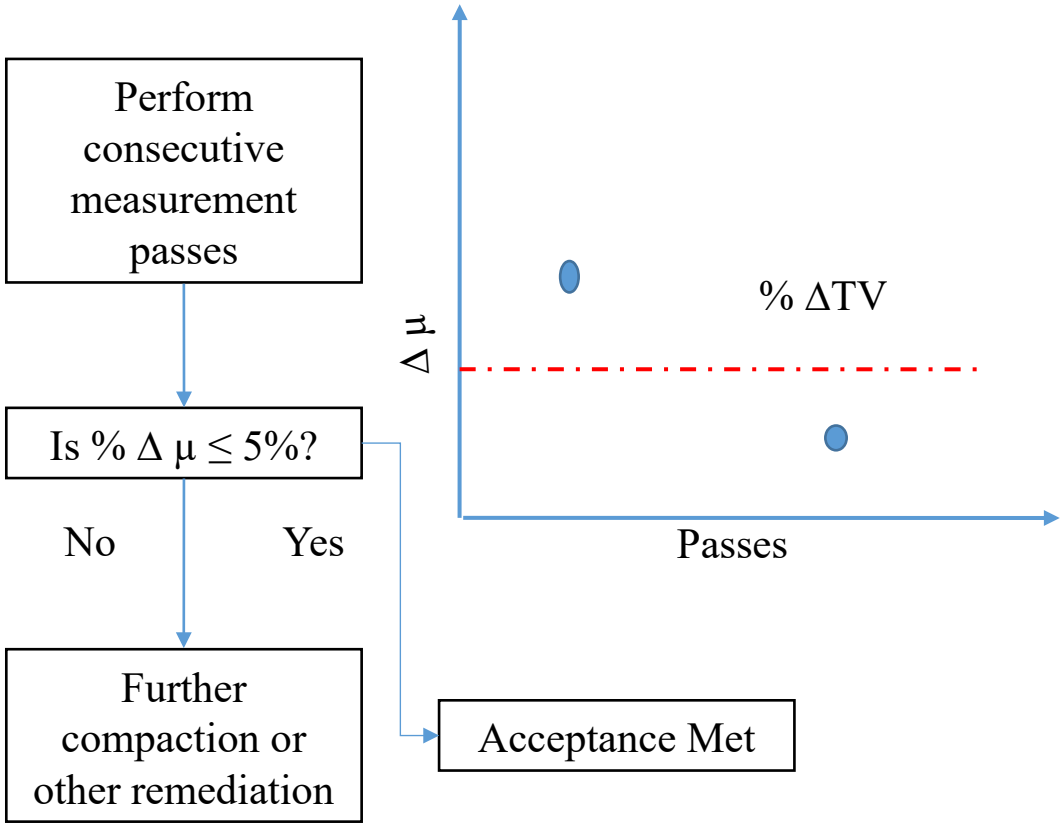
Quality Assurance



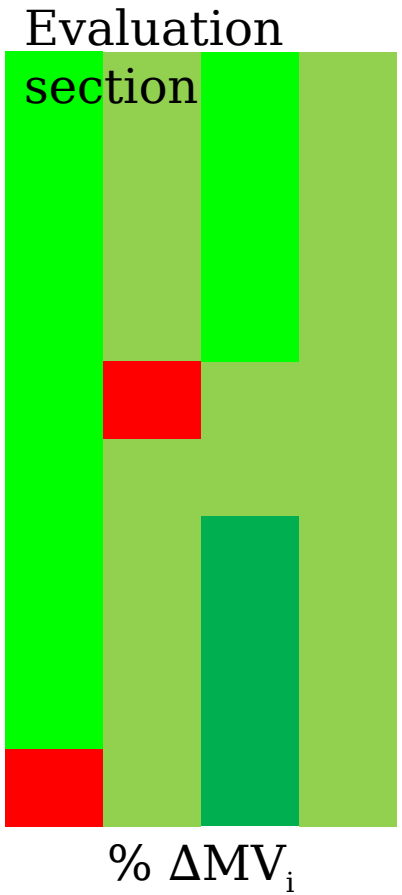
Pass 7, μ= 10

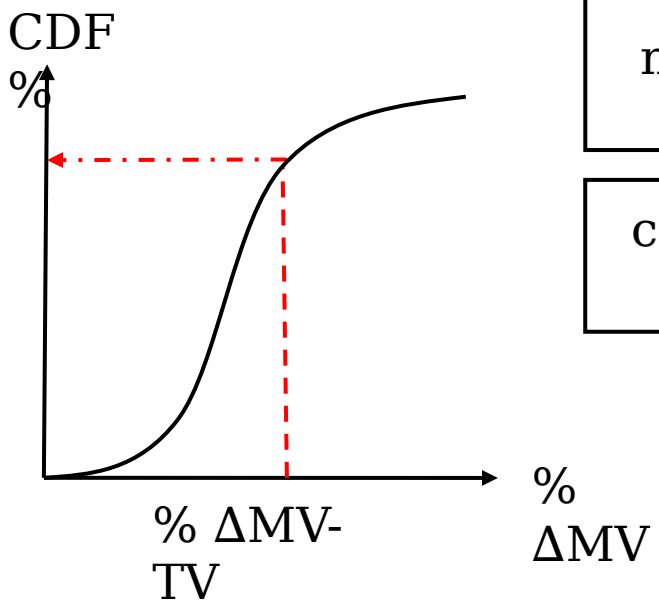
Pass 8, μ= 16

Pass 9, μ= 18

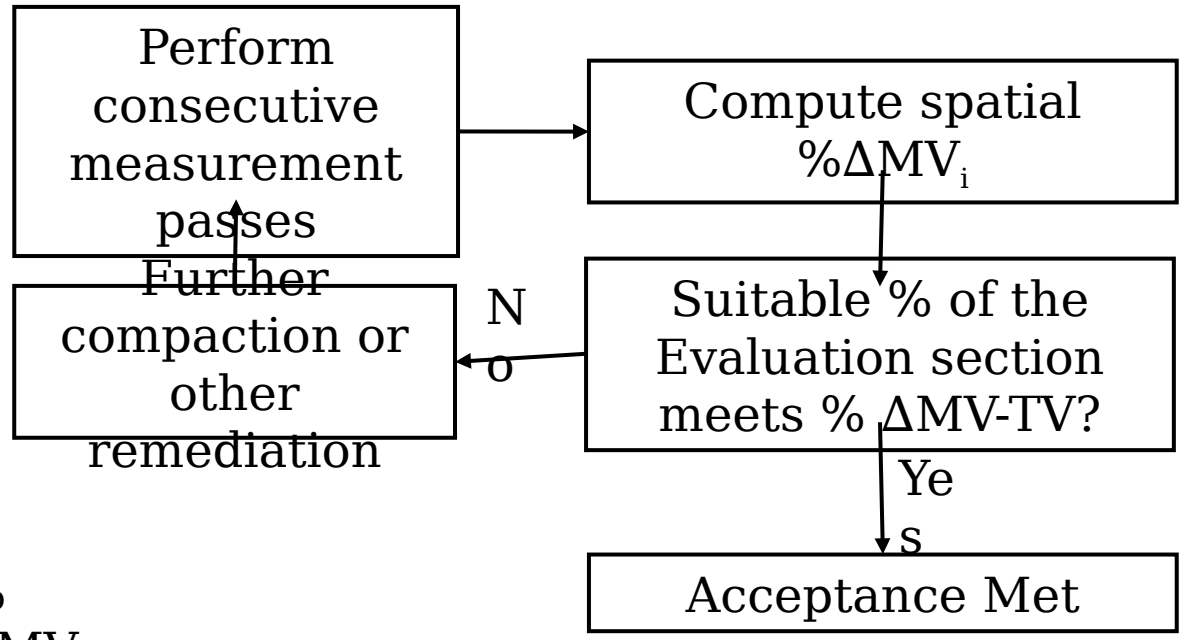


Quality Assurance

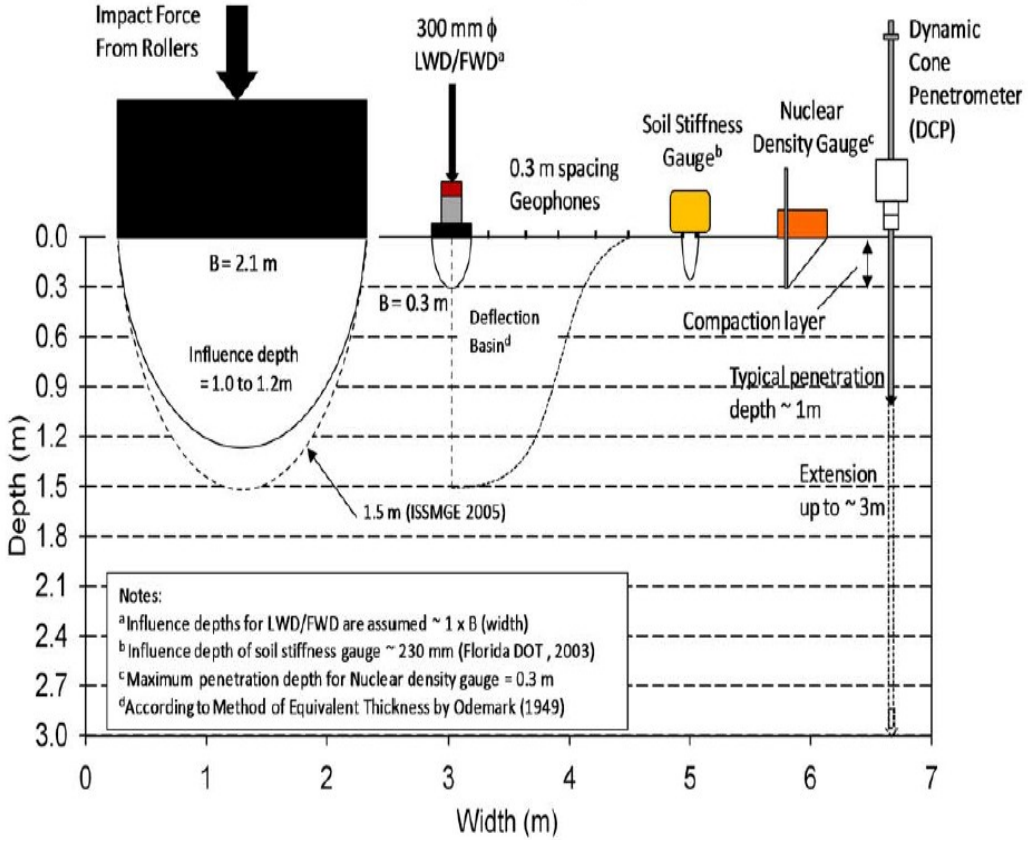




- **Option 3**



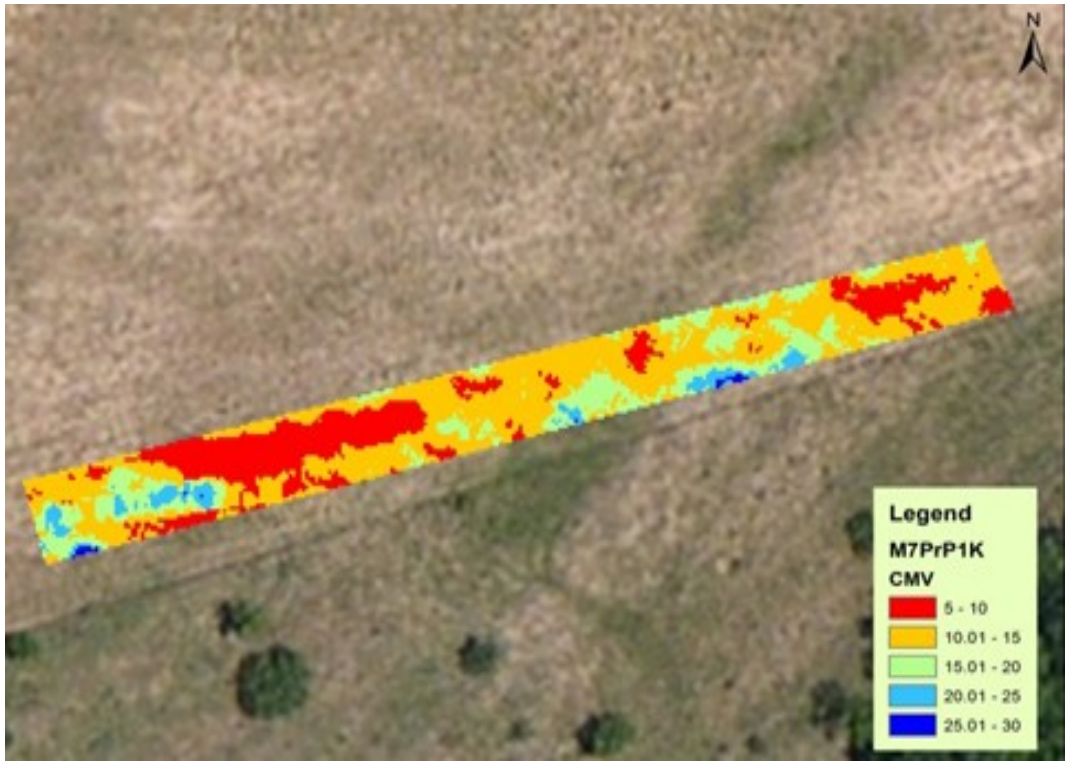
RMV and Spot Measurement Value (SMV)



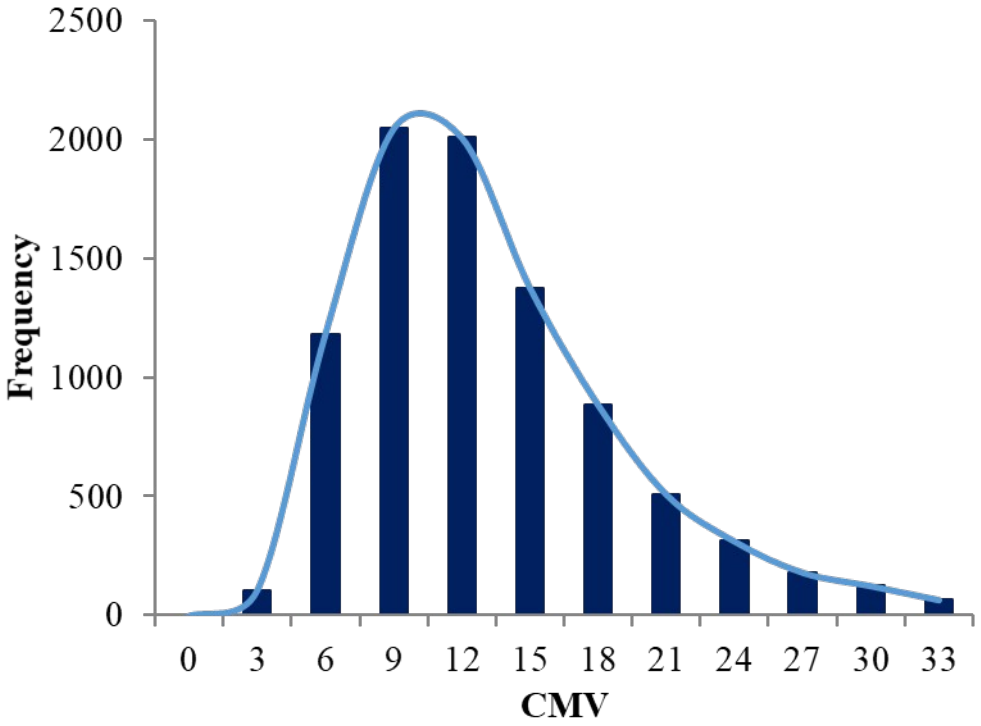
No.	Factors Affecting Association
1	Heterogeneity in underlying layer support conditions
2	High moisture content variation
3	Narrow range of measurements
4	Machine operation setting variation and roller “jumping”
5	Non-uniform drum/soil contact conditions
6	Uncertainty in spatial pairing of point measurements and roller MVs
7	Limited number of measurements
8	Not enough information to interpret the results
9	Intrinsic measurement errors associated with roller MVs and in situ point measurements

Intelligent Compaction

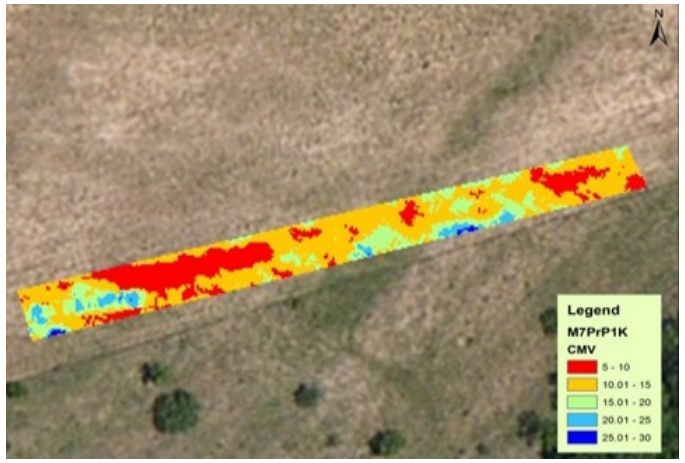
Data Presentation



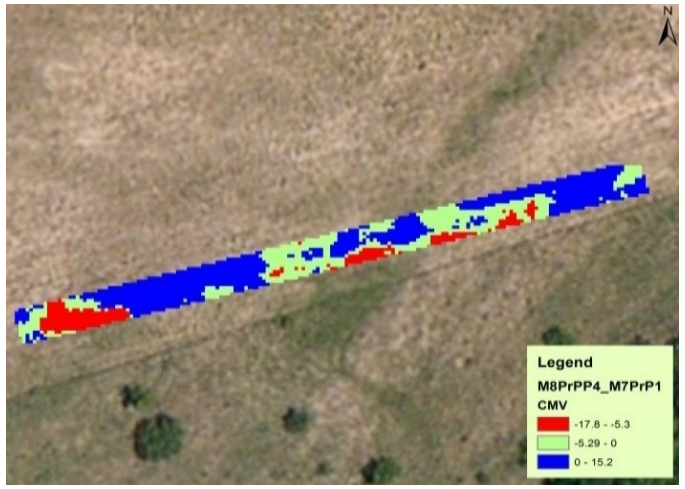
Data Interpretation



Intelligent Compaction



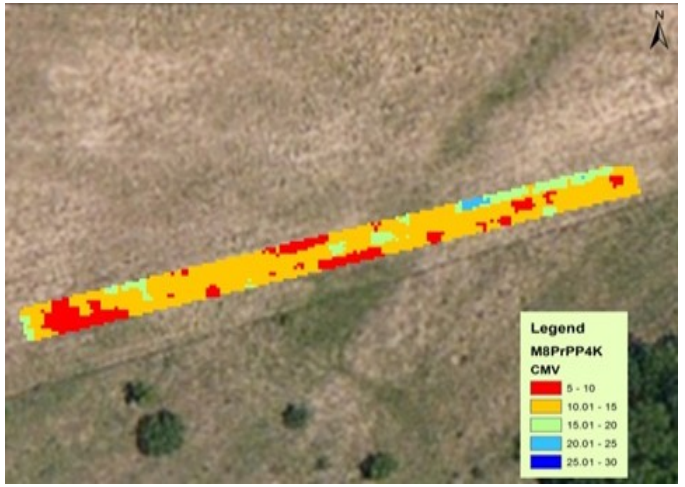
Lift Placement



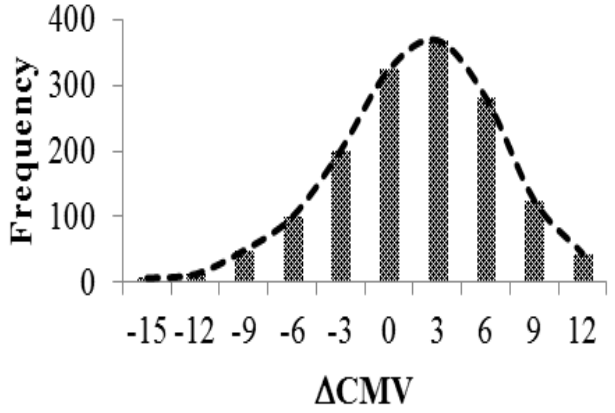
Mapping

BEFORE

AFTER



Completed



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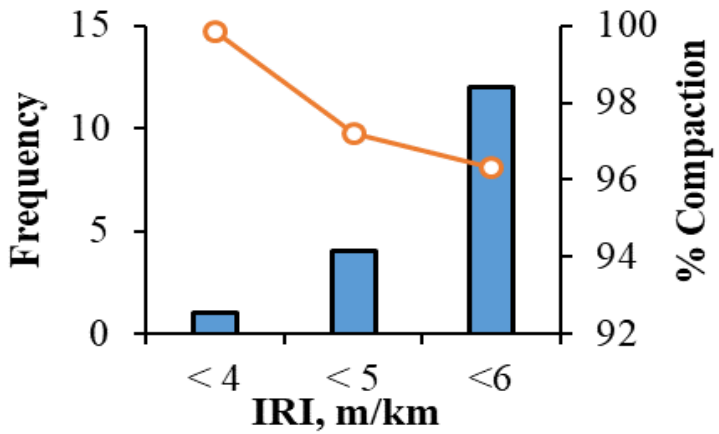

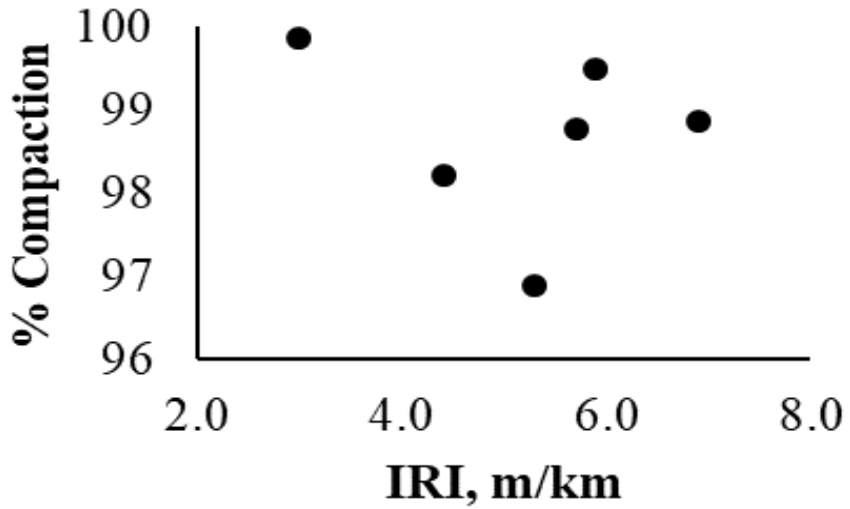

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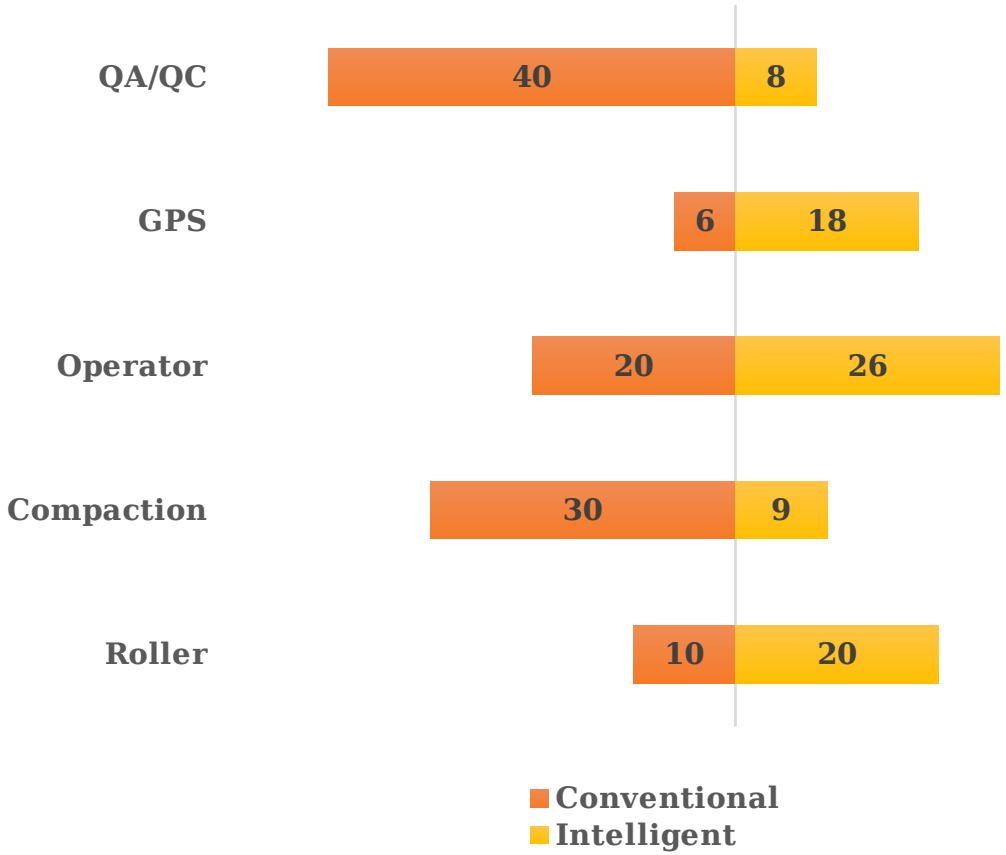

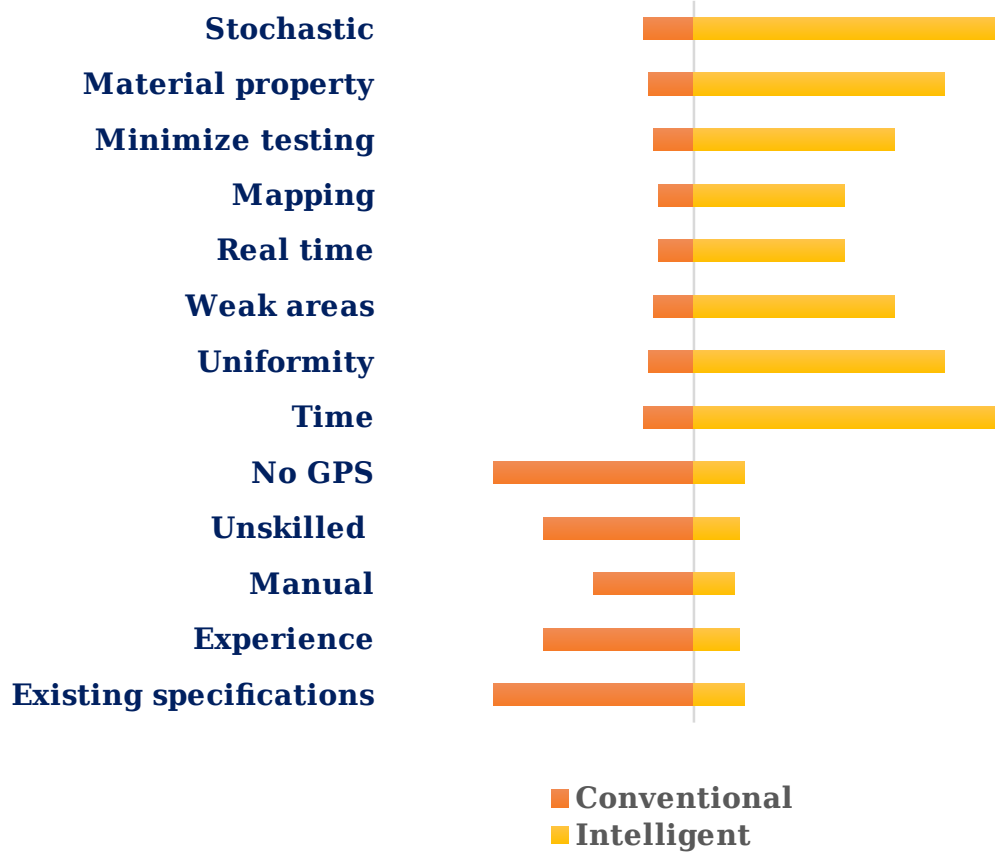

Intelligent Compaction

Conventional

Item	Cost (USD) per unit	Unit	No. of Units	Total cost (USD)
Roller	36	hour	10	360
Operator	30	hour	10	300
GPS	0	hour	10	0
QC/QA	0.04784	m^2	3500	167
			Total	827

Intelligent

Item	Cost (USD) per unit	Unit	No. of Units	Total cost (USD)
Roller	42.61	hour	7.7	328
Operator	36	hour	7.7	277
GPS	0.89	hour	7.7	7
QC/QA	0.004784	m^2	3500	17
			Total	628

(PER LANE KM)

Savan et al. 2019

Intelligent Compaction

Intelligent Compaction

- Quality
  - Monitor
  - Control
- Time & Cost
- Improved Performance
- Reduced Pollution