Roller Trials and Concept of Roller Testing

UNMAS/GICHD Mine Action Technology Workshop 2010

Erik de Brun
Humanistic Robotics Inc.
September 7, 2010

Mine Rollers

Humanitarian


Source: HALO Trust


Source: Humanitarian Demining R&D Program: Mantis with Pearson Roller


Source: Mine Detection and Detonation System (MDDS) Schiebel Technology, Inc.

Military


Source: Anti-tank mine protection roller - MCRS


Source: OEF SPARK Protection Roller


Source: history.army.mil Vietnam mine roller

Advantages of Rollers in Humanitarian Demining

Advantage	Description
Low Cost	• Low cost when compared with other mechanical equipment • Low ongoing operation and maintenance costs
Simple Operation and Maintenance	• No skilled labor required for operation and maintenance
Efficient for Technical Survey	• A well designed roller in the right environment can increase the efficiency of area reduction / technical survey


Pearson area reduction roller


Rapid Area Preparation Tool (RAPTOR) segmented Roller


Pearson roller on front end loader near Senafe, Eritrea

Why are Rollers Not More Widely Used in Humanitarian Operations

- Rollers are not appropriate for certain environments and missions
- Roller effectiveness is not well understood (anecdotal at best)
- Lack of formal effectiveness data
- Not many rollers available - many are constructed in the field from available materials

Need to understand / quantify performance to take advantage of the benefits of rollers


Source: http://www.missing-lynx.com/library/german/denmine/7.jpg


Source: http://auxgen.tripod.com/page_10.html

What did we do

LABORATORY SCALE TESTING
Focus on roller wheel / mine interaction
→ Clear understanding of the variables that affect roller performance

↓

INITIAL FULL SCALE SYSTEM TESTING
Evaluate roller performance in real world representative conditions
→ Further understanding of performance variables & identified need for refinement of roller testing methodology

↓

CONTINUED FULL SCALE SYSTEM TESTING
Further evaluate performance & refine roller test technique
→ Quantified performance of well designed roller & developed an understanding of roller test technique

Laboratory Scale Testing

What characteristics affect roller performance?

- Tested 3 wheel types: solid, paddle, serrated
- Tested 3 soil types: sand, topsoil, gravel
  - Per CEN Workshop Agreement 15044:2004

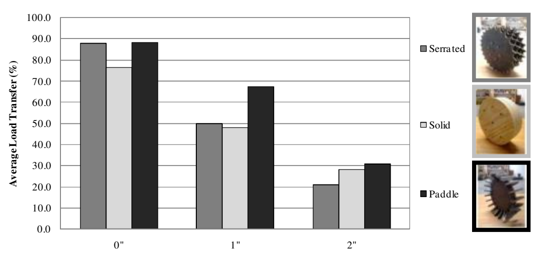



Laboratory Scale Testing

Measured load transfer and inert test mine trigger threshold while varying:

- Wheel type
- Soil condition
- Soil compaction
- Roller Wheel Speed
- Mine/Load Cell Depth
- Applied Load

Scale Test Results



Surface pressure is more effective than ground penetration

Roller Wheel Speed ↑ | ↓ Load Transfer / Mine Trigger

Ground Compaction Level ↑ | ↓ Load Transfer / Mine Trigger

Mine Depth ↑ | ↓ Load Transfer / Mine Trigger

Initial Full Scale Testing



Clearance Effectiveness

- Targets: Inert test mines (T-72A, PMN) and load cells
- Depths: Surface, 2.5, 5.0, 7.5, and 10.0 cm depths
- Conditions: topsoil
- Speed: < 1mph (1.6 kph)
- Experimentation with alternative emplacement

Maneuverability

- Local terrain variation, slopes, and hills

Initial full scale testing conducted in north eastern US (test field and full scale laboratory test area)



Initial Full Scale Testing Conclusions

Key Characteristics of Effectiveness

- Maintain even ground pressure
- Each roller wheel must maintain threshold ground force while allowing independent vertical travel
- Roller wheel width and overlap must be designed to minimize bridging

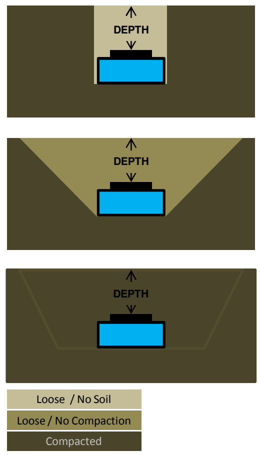


Initial Full Scale Testing Conclusions

Typical ITEP Emplacement

Recent Emplacement

Legacy Emplacement



Roller Test Methodology

- ITEP mechanical equipment evaluation standard very useful for flails and tillers
- Not as relevant for rollers due to critical nature of mine emplacement technique

Typical ITEP emplacement is relevant for flush buried, but at depth the data is not as meaningful for rollers

Continued Full Scale Testing - Performance

Clearance Effectiveness

- Targets: Recently emplaced inert test mines (PMN, T-72A), electronic mine simulants (PMN-2), and load cells
- Depths: Surface, 2.5, 5.0, 7.5, and 10.0 cm depths
- Soil Conditions: topsoil, road gravel, silt gravel mixture based on Yuma, AZ test lane
- Speeds: 1.0, 2.5, 5.0, and 10.0 mph (1.6, 4.0, 8.0, 16.0 kph)
- Collected over 1400 data points

Testing conducted at HRI laboratory test area and at Keweenaw Research Center (KRC) in Michigan

Full Scale Testing Conclusions - Performance

Confirmed scale testing results

- Increasing mine depth, roller speed, and compaction level of mine overburden all lead to a decrease in mine activation

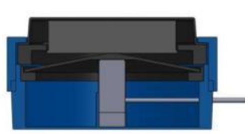
Roller Speed ↑	↓ Mine Trigger
Overburden Compaction ↑	↓ Mine Trigger
Mine Depth ↑	↓ Mine Trigger

Continued Full Scale Testing - Emplacement




Mine Emplacement Technique (Legacy Simulation)

- In order to test legacy conditions need specialized mine simulants
  - Electronic Mine Sensor: real time measurement of pressure plate displacement (PMN-2) [shown above]
  - Mechanical Lock Out: integrated into an inert test mine (T-72A) [shown below]
- To simulate a legacy condition the soil is compacted above and around the mine simulant until uniform heavy compaction is reached

Full Scale Testing Conclusions - Emplacement

- Legacy mine emplacement is the critical test point
  - While holding all test conditions constant and varying only the emplacement technique, we found that for a given roller system weight the mine detonation percentage and pressure plate deflection are lower for legacy mine emplacement

Emplacement	Depth (cm)	Pressure Plate Deflection (cm)
Recent	7.5	0.089
Legacy	7.5	0.038
Recent	10.0	0.069
Legacy	10.0	0.020

Electrical simulant (PMN-2)
7.5 and 10.0 cm depth
Pressure plate deflection versus emplacement

Mechanical Lock-out simulant (modified T-72A)
2.5 and 5.0 cm depth
Mine detonation versus emplacement

Emplacement	Depth (cm)	Detonation %
Recent	2.5	100%
Legacy	2.5	95%
Recent	5.0	100%
Legacy	5.0	33%

Overall Conclusions

- HRI testing has shown that a well designed roller can consistently detonate simulated recently and legacy emplaced mines up to a depth of 10 cm
  - Dependent on mine type and specific ground conditions
  - Need to test at depths below 10 cm
- A legacy mine is more challenging to detonate than one that has been recently emplaced
- Roller performance testing at depths below flush buried that does not include simulated legacy mine emplacement does not fully represent real world conditions
- Comprehensive roller testing can provide a good basis for comparison between roller systems and potentially other mechanical equipment

Video

Acknowledgements

Rich Vanaman - US Army Armaments Research, Development and Engineering Center (ARDEC)

Pehr Lodhammar - Geneva International Center for Humanitarian Demining (GICHD)

Geoff Coley - Defense Research and Development Canada Suffield

Geoff Gwaltney - Michigan Tech Keweenaw Research Center

Patrik Blomander - Swedish EOD and Demining Center (SWEDEC)