DEMICHAIN: A New Concept of Mechanical Demining

Rene Joeckle
Association de Recherches de Techniques Innovantes en Démimage Humanitaire

Follow this and additional works at: http://commons.lib.jmu.edu/cisr-journal

Part of the Defense and Security Studies Commons, Emergency and Disaster Management Commons, Other Public Affairs, Public Policy and Public Administration Commons, and the Peace and Conflict Studies Commons

Recommended Citation

This Article is brought to you for free and open access by the Center for International Stabilization and Recovery at JMU Scholarly Commons. It has been accepted for inclusion in Journal of Conventional Weapons Destruction by an authorized editor of JMU Scholarly Commons. For more information, please contact dc_admin@jmu.edu.
DEMICHAIN: A New Concept of Mechanical Demining

DEMICHAIN, in which a horizontal web of heavy chains hung several metres above a surface to be cleared, is dropped in a free fall and delivers a mechanical impulse over the whole surface hit by the chains. A pressure wave expands in the soil and is expected to trigger the active landmines. A description of the device is given, as well as comparisons to other demining devices. The author offers that DEMICHAIN provides numerous advantages to current mechanical-demining techniques, though it requires further testing before it can be used in real-life situations.

by René Joeckle [Association de Recherche de Techniques Innovantes en Déminage humanitaire]

Most mechanical-demining devices, such as flails and tillers, penetrate soil to a certain depth and can trigger or demolish explosive devices encountered. A lot of energy and specialized tools and devices are needed for this task. Triggering the explosion of an active mine, however, is an alternative method. Rollers work in this way, but the required pressure makes it necessary to have heavy rollers and large engine power to drive them.

A drawback of these mechanical devices results from the fast decrease of stress generated with depth. A landmine with a small pressure plate can therefore remain dangerous if deeply buried. In order to remedy this problem, Association de Recherche de Techniques Innovantes en Déminage proposes the DEMICHAIN. This tool is not yet in use in minefields, and careful tests are needed before using it on mine-affected ground, yet its potential advantages warrant a study of its expected effectiveness.

Description of DEMICHAIN

DEMICHAIN means “DEMIning with CHAINs.” Jacques Demichelis invented this idea and developed it within the framework of ARTID. Still in the testing phase of development, the DEMICHAIN consists of a horizontal web of heavy chains hung several metres above the ground, which, when dropped in a free fall, delivers a mechanical impulse over the ground hit by the chains. A pressure wave is generated in the soil, which triggers active landmines. In addition to other mechanical-clearance devices.

The main characteristic of this demining method, as compared to rollers and flails, is that the forces are vertical and uniformly distributed over a large surface. The dimensions of this area are more than 10 times larger than the normal clearance depth requirement of 20 centimetres (0.78 inch). It is assumed, therefore, that the phenomenon is one-dimensional (i.e., the stress variation is significant only in the direction of the depth).

A theoretical description can be made, assuming the soil is elastic and hit by a uniformly distributed mass moving with a velocity V0 of about 8 metres per second. After a few micro-seconds, it can be assumed that the surface of the soil moves with a velocity of V0 and is compressed. This elastic strain generates a vertical stress and results in a pressure wave, which expands at the velocity of sound. The theoretical value of this stress, σ0, on the surface at the very beginning of the impact is given by the Timoshenko expression:

\[ \sigma_0 = \rho c V_0 \]

where \( \rho \) is the mass density and \( c \) the velocity of sound in the soil. This latter variable varies strongly with the water content of the soil—between 160 and 1000 metres/second (525 to 3,280 feet/second). Even with the lowest value, the stress for an initial velocity of about 9 m/s generates a vertical pressure (4.106 Pa) that is higher than the pressure that triggers a landmine.

Other theoretical considerations yield the following conclusions:

- The initial stress level depends only on the velocity of the chains when they hit the ground.
- The duration of the pressure pulse (in the millisecond range) is proportional to the weight of chains per unit area.

How Will DEMICHAIN Work?

The demining process occurs during a fraction of a second over an area of several square metres; however, it must be followed by a change to the positioning of the chain web. This is completed in a cycle of three to four phases:

1. The chain web is released and falls freely, whereinupon it impacts the ground and detonates all the active mines present.
2. The crane or hydraulic arm recovers the chain web.
3. The chain web is lifted to the required height.
4. The DEMICHAIN is moved to the next demining location. 5

The demining operation consists of a succession of cycles, either in front of the machine, as for flails and rollers, or by creating a broader zone through a combination of linear movement and rotation of the crane.

The chains are vertical and can work on uneven ground. A large area is simultaneously under stress and the resulting forces decrease slowly with depth, in contrast with other mechanical-clearance devices.

The main characteristic of this demining method, as compared to rollers and flails, is that the forces are vertical and uniformly distributed over a large surface. The dimensions of this area are more than 10 times larger than the normal clearance depth requirement of 20 centimetres (0.78 inch). It is assumed, therefore, that the phenomenon is one-dimensional (i.e., the stress variation is significant only in the direction of the depth).

A theoretical description can be made, assuming the soil is elastic and hit by a uniformly distributed mass moving with a velocity V0 of about 8 metres per second. After a few micro-seconds, it can be assumed that the surface of the soil moves with a velocity of V0 and is compressed. This elastic strain generates a vertical stress and results in a pressure wave, which expands at the velocity of sound. The theoretical value of this stress, σ0, on the surface at the very beginning of the impact is given by the Timoshenko expression:

\[ \sigma_0 = \rho c V_0 \]

where \( \rho \) is the mass density and \( c \) the velocity of sound in the soil. This latter variable varies strongly with the water content of the soil—between 160 and 1000 metres/second (525 to 3,280 feet/second). Even with the lowest value, the stress for an initial velocity of about 9 m/s generates a vertical pressure (4.106 Pa) that is higher than the pressure that triggers a landmine.

Other theoretical considerations yield the following conclusions:

- The initial stress level depends only on the velocity of the chains when they hit the ground.
- The duration of the pressure pulse (in the millisecond range) is proportional to the weight of chains per unit area.

How Will DEMICHAIN Work?

The demining process occurs during a fraction of a second over an area of several square metres; however, it must be followed by a change to the positioning of the chain web. This is completed in a cycle of three to four phases:

1. The chain web is released and falls freely, whereinupon it impacts the ground and detonates all the active mines present.
2. The crane or hydraulic arm recovers the chain web.
3. The chain web is lifted to the required height.
4. The DEMICHAIN is moved to the next demining location.

The demining operation consists of a succession of cycles, either in front of the machine, as for flails and rollers, or by creating a broader zone through a combination of linear movement and rotation of the crane.

For safety, the surface must be impacted several times. Movement of the DEMICHAIN must therefore be adjusted as a function of this requirement and the dimensions of the chain web.

Two types of lifting devices can be used:

- A conventional hydraulic arm, with which the second phase requires a skilled operator and a certain amount of time. This type of machine is widely used in mine-affected countries and on mine-clearing sites. The DEMICHAIN device then consists simply of the chain web.

The "light" or "agricultural" device

In addition, the chain web is cheap and rugged and could be built locally. Its geometry could be adapted to the place to be demined, for instance a road or a trail, with ditches and banks. It is a tool that could be fitted to many lifting machines. This concept is within the reach of demining organizations that cannot afford specialized machines. It is also well adapted to dealing with problems such as small areas or uneven parts of large areas.

ARTID’s Study

Methodology

DEMICHAIN, being a new concept, must be well understood before being used on live areas. Taking advantage of the characteristics of DEMICHAIN (one-dimensional effect), ARTID is performing a study of the forces developed by the free fall of a web of chains on buried force detectors.

Prototype

The "heavy" device with 3,100 kilogrammes (6,866 pounds) of chains on a 2.5 by 2.8 square metres (27 by 30 square feet) is handled by a hydraulic arm of a conventional tractor and adapted to performing measurements. See Figure 4.

A crane equipped with a free-fall winch, for instance a dragline. In this case, the second phase is shortened and the device can be easily remote controlled.

Comparison

DEMICHAIN offers several advantages over flail and roller machines. The chains are vertical and can work on uneven ground. Ground obstructed by stones, small rocks, banks, ditches, small fences or barbed wire, for instance, cannot be cleared by flails or rollers but could be demined with DEMICHAIN. In addition, the chain web is cheap and rugged and could be built locally. Its geometry could be adapted to the place to be demined, for instance a road or a trail, with ditches and banks. It is a tool that could be fitted to many lifting machines. This concept is within the reach of demining organizations that cannot afford specialized machines. It is also well adapted to dealing with problems such as small areas or uneven parts of large areas.

Table: Triggering pressure of several anti-personnel landmines.

<table>
<thead>
<tr>
<th>APL</th>
<th>Area of the pressure plate</th>
<th>Triggering force</th>
<th>Triggering pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 72</td>
<td>44 cm²</td>
<td>5 – 10 kg</td>
<td>2,9 – 3,4 Pa</td>
</tr>
<tr>
<td>M1 AP DV 59</td>
<td>3 cm²</td>
<td>5 kg</td>
<td>17 – 20 Pa</td>
</tr>
<tr>
<td>VS-50</td>
<td>19 cm²</td>
<td>10 kg</td>
<td>5,10 – 6,6 Pa</td>
</tr>
<tr>
<td>PMN</td>
<td>80 cm²</td>
<td>8 – 25 kg</td>
<td>3,0 – 3,8 Pa</td>
</tr>
<tr>
<td>M14</td>
<td>18 cm²</td>
<td>9 – 16 kg</td>
<td>9,10 – 10,4 Pa</td>
</tr>
<tr>
<td>PMA 1</td>
<td>42 cm²</td>
<td>&gt; 5 kg</td>
<td>3,0 – 3,4 Pa</td>
</tr>
</tbody>
</table>

Table 1: Triggering pressure of several anti-personnel landmines.
Where Could This Tool be Useful?

The deminer’s toolbox can be completed by adding to it a DEMICHAIN for dealing with following problems:

- Area reduction, as the DEMICHAIN is very versatile and does not destroy the surface of the ground.
- Diminuting of readables and difficult ground, for example, maquis.1
- As an accessory of other mechanical demining techniques, for operating at the sides of the main surface.
- As a ground-preparation tool for small tasks or for small organisations.
- For quality control of mechanically demined areas.

Another potentially interesting application, which has not yet been completely investigated, is the ability to generate the required force at great depths. This is an interesting feature for sandy areas like deserts, where the burial depth can vary due to the movement of the sand. Moreover, there is no wear of the device on the chains by the sand as there is with flails.

Tests with Real Landmines

As soon as the current study is completed, tests on real landmines will be required before the device can be used on real fields. Testing can be performed, for instance, at the CTRO in Ranspach-le-Bas; Claude Hartmann, Robert Goepfert for work with the “light” prototype in Ranspach-le-Bas; Claude Hartmann, Robert Goepfert for work with the “light” prototype in Ranspach-le-Bas; see Etablissements, page 114.

The author would like to thank all the members of the ARTID who helped in the testing and who were party to the fruitful discussions, namely Christian Baran for the electronics; John Crawford for a good English translation; Robert Guoefri for work with the “light” prototype in Bonapace-le-Bas; Claude Hartmann for building the prototypes; and Bernard Gautier, Jean-Pierre Hancy, and Danielle Samirant for their participation in the tests. The author is also especially thankful to Jacques Demichelis for his idea and interesting suggestions.

The necessary funding Etablissement Technique de Bourges in France has shown an interest recently in testing the DEMICHAIN.

ARTID’s mission is to perform research into new ways to help eradicate anti-personnel mines. We encourage other organisations to review our results and develop, test and use the DEMICHAIN in order to eradicate AP mines faster. The DEMICHAIN concept and the results of the study are published at http://www.artid.org and the concept is not patented.

See Endnotes, page 114

I Movie moved by the British film The Killing Fields (1984), a drama about the Khmer Rouge regime in Cambodia and its landmine fields, in 2006 Vikas Reddy and his fellow Cornell engineering students formed a new organisation, Cornell Minesweeper, to develop a new type of demining machine. The organisation is dedicated to the design and fabrication of cost-effective autonomous robotic vehicles capable of accurately detecting anti-personnel landmines and facilitating their clearance.

“That movie shocked me,” says Reddy, who is currently a senior mechanical and aeronautical engineering student. “It made me want to do something about the landmine problem, so I started reading anything (I could) related to it.” Finally, in the full semester of his junior year, Reddy got together with other engineering students and formally started Cornell Minesweeper.

Initial Research

The team looked at the products already on the market before it began its work into small, inexpensive robots. The products they found were large and expensive—nothing like the robots they envisioned.

Current robotic clearance systems by companies such as MineWolf Systems use remotely operated, armored vehicles to clear landmines by direct detonation on contact using flails or tillers. Mine-detection Systems use remotely operated, armored vehicles to clear landmines by direct detonation on contact using flails or tillers. The products they found were large and expensive—nothing like the robots they envisioned.

Current robotic clearance systems by companies such as MineWolf Systems use remotely operated, armored vehicles to clear landmines by direct detonation on contact using flails or tillers. The products they found were large and expensive—nothing like the robots they envisioned.

The team looked at the products already on the market before it began its work into small, inexpensive robots. The products they found were large and expensive—nothing like the robots they envisioned.

Current robotic clearance systems by companies such as MineWolf Systems use remotely operated, armored vehicles to clear landmines by direct detonation on contact using flails or tillers. The products they found were large and expensive—nothing like the robots they envisioned.