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Magnetic Fragment Collection

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Introduction

In a typical manual mine clearance operation, deminers often spend nearly all of their time finding metal fragments in the search for anti-personnel mines. Often there is too much metal to be able to use metal detectors: then the deminers have to probe an entire minefield by hand, every 25 - 50 mm apart, or even dig through thousands of square metres of ground by hand.

In response to a request from the Mine Action Programme in Afghanistan (MAPA) we conducted a trial to test the effectiveness of a magnet for removing steel fragments from the ground. The magnet was to be attached to a back-hoe bucket on a machine similar to those being used in Khandahar for excavating residential areas and irrigation canals.

Figure 1: Backhoe used in Khandahar, Afghanistan for excavating residential areas. Dirt spread by the bucket is inspected visually for mines and small UXO devices. The operator is shielded by steel plate around the cab, and 25mm thick polycarbonate windows. A second operator watches from a nearby vantage point and alerts the operator by radio.

The proposed method of using the backhoe was to scrape the ground with the bucket teeth as shown in figure 2. This would loosen the otherwise hard ground and possible expose mines as well. Previous experience has shown that this procedure is safe when earlier technical surveys have shown there are no anti-tank mines or large UXO present. Occasionally one or more teeth have been blown off the bucket by AP mine explosions.

By using an electro-magnet, the fragments could be dropped on a collection pile. Electro-magnet attachments for commercial excavators are available commercially (see, for example, UNO Corporation, Tokyo, Japan).

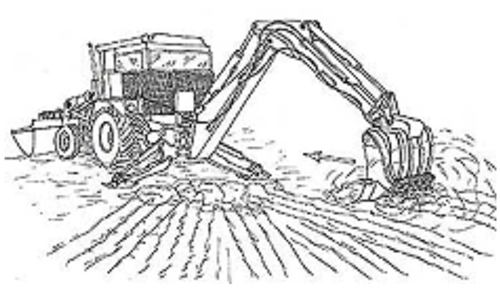

Figure 2: Proposed method for using magnet in Afghanistan. An electro-magnet is attached to the rear surface of the bucket.

Test Equipment

We constructed a permanent magnet for our tests. This consisted of 8 commercially available ferrite slab magnets mounted as shown in figure 3

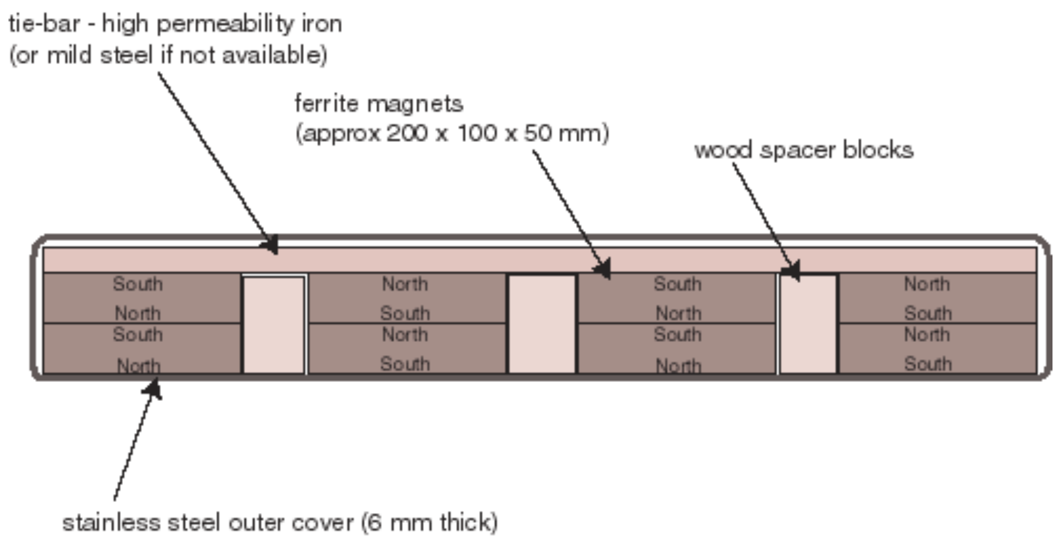

Figure 3. Magnet assembly used for trial consisted of 8 ferrite slab magnets mounted in a 6 mm thick stainless steel case.

Figure 4 shows the magnet attached to the bucket. The angle of the magnet is important - it provides clearance between the ground and the rear of the magnet to prevent fragments from being wiped off the face of the magnet.

Trial

The trial was carried out on May 3rd 1998 at the Bindoon Army Demolition Range approximately 120 km North East of Perth in warm and dry conditions (approx. 32°C). We used a tracked back-hoe excavator supplied by the Australian Defence Force.

The ground consisted of very

hard, compacted laterite clay and gravel. A large number of artillery shells and other explosive devices have been detonated during the last 20 years so the ground is impregnated with steel fragments. Every year or so, shell craters are filled and the ground is re-graded by bulldozers so the fragments are mixed with the top 2 metres of earth.

The trial was conducted at the end of a long, hot dry summer, making the ground very hard. A cold chisel could be driven no more than 20 mm into the ground with a hammer.

The bucket teeth were scraped over the ground to break up the surface layer to a depth of about 80 mm. The magnet on the bucket collected steel and iron fragments. Every two or three strokes of the bucket, the fragments were reoved by hand and collected in a collection pile.

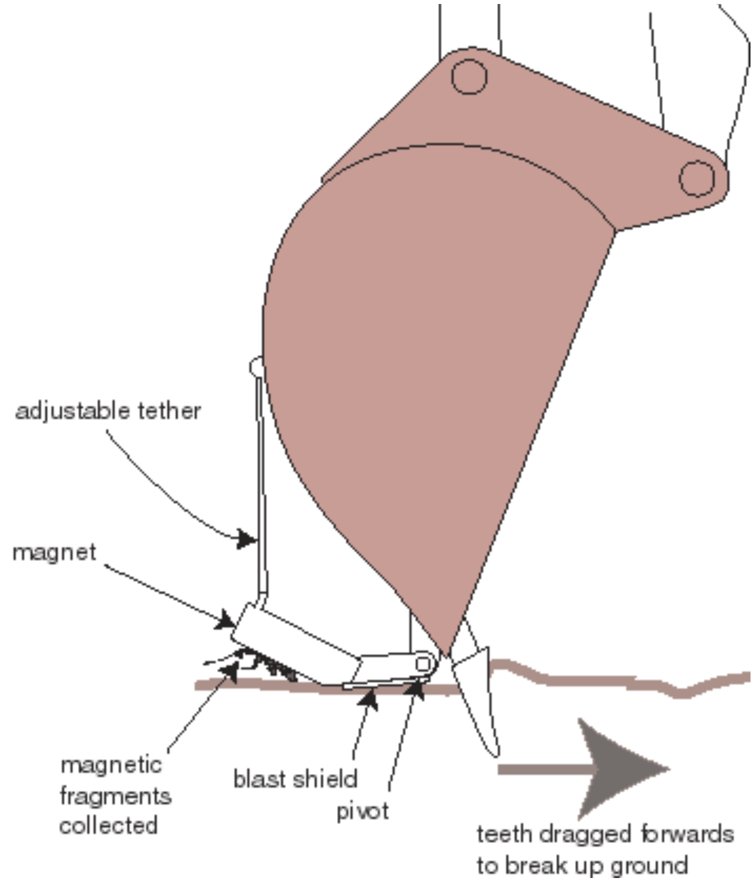

Figure 4. Arrangement of magnet on bucket.

Figure 5: Close-up of bucket with

Figure 7: Removing collected fragments by hand. The stainless steel case made this relatively easy.

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magnet collecting fragments. Note the steel frame for attaching the magnet. This provides a means of attaching the magnet for trial purposes only. We were asked to minimize any welds as the bucket had to be returned to the owner.

Figure 8: Material collected by magnetic removal included microscopic steel fragments, up to half kilo steel fragments, large thin sheets and barbed wire.

Photograph 8 shows material recovered from about 5 square metres of ground (approx 6 kg fragments, required about 10 minutes work by excavator).

Results

The test demonstrated that the excavator would easily break up the surface layer of hard ground with embedded explosion fragments (mainly steel), and the magnet removed nearly all (>95% estimate) of the metal fragments contained in the broken layer of earth. This was a much greater proportion than we expected.

Figure 6: Fragments tend to collect along edges of slab magnets. Note long piece of steel pipe hanging from magnet at left-hand end.

The operator had some difficulty keeping the bucket at the right angle relative to the ground, partly because the magnet was out of sight most of the time. Because of this, some fragments were wiped off the magnet at the inner-most end of each stroke.

For this reason, the verification areas (1 square metre) was marked out near the outer edge of the working area. These were then carefully inspected by hand to locate any metal fragments missed by the magnet. This was time-consuming and rewarding because very few pieces of non-magnetic metal were found.

Because the ground was deeply contaminated with metal fragments as a result of several years of tests with large ordnance explosions and demolition tests, it was not feasible to use a metal detector to verify clearance. Many metal fragments are buried in the ground to a depth of at least two metres.

Conclusions and Design Implications

Some lessons can be learned for designing a practical device for recovering metal fragments before manual demining.

1. The magnet needs to be allowed to pivot with a skid to keep the bottom of the magnet at the

right angle and height from the ground. The operator needs a reasonably clear view of the bucket teeth and magnet.

3. The magnet needs to be retractable so that the bucket can be used for other tasks without having to remove the magnet.

4. The bucket teeth should be narrower than the ones we used to reduce the amount of material pushed forward by the teeth.

There are other ways in which magnets could be used for similar purposes. Flails loosen the surface layer of the ground, and magnets attached to the underside of the flail vehicle could collect fragments as the vehicle passes over the loosened ground. This could significantly reduce the time required for manual verification after the flails have been used.

We were surprised that the degree of fragment removal was so great. We had expected most of the fragments to have been removed from the surface of the ground with perhaps 50% or less at a depth of 80 mm (the length of the bucket teeth). Instead we found that all loose magnetic material had been removed from the areas we inspected. Magnetic material which was still firmly attached to the ground was, of course, not collected.

We would expect less effective removal in wet conditions when the clay becomes sticky.

We had expected to be able to transfer this technology in prototype form to Khandahar, Afghanistan. However, the MAPA Regional Manager was asked to leave Afghanistan shortly after we completed these tests. Currently, MAPA technical advisers have tightly resirticted access to Afghanistan and little more can be done until more access is negotiated with the current administration in Afghanistan.

Acknowledgements

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