

Users Background and Perception of Robotic Demolition Equipment

Matthew Jones

California Polytechnic State University
San Luis Obispo, California

Robotic demolition equipment or demolition robots are robots that resemble excavators without the cab, that can be controlled by an operator at a safe distance. This equipment can access hazardous environments and provides versatility in the demolition methods possible. Robots have become a popular choice for contractors looking for a competitive advantage. Currently there is little research about the demolition robot market and how the industry views the technology. This research first seeks to answer background questions on the users and their experience with demolition robots. The research also answers perception questions such as the benefits, drawbacks, and reasons for adopting demolition robots to their company. The research shows that contractors most often use the robots on commercial or industrial projects, companies own five or less robots on average and view the initial price as the largest drawback. Contractors view safety as the most important benefit and view both safety and a competitive advantage as the main reasons for adopting the technology. The research is useful to see how the industry views the technology and will be of interest to current and prospective users of demolition robots.

Key Words: Demolition Robot, Safety, Equipment, Remote-control

Introduction

Robotic demolition equipment is an increasingly common sight at demolition projects nationwide. These robots excel in working in dangerous situations and have changed what is possible in demolition. This research asks the users of robotic demolition equipment a series of questions to understand their background and perceptions of robotic demolition equipment in the fall of 2020. A survey sent to users of robotic demolition across the United States was used to identify common characteristics about the users and their view on robotic demolition equipment. The results are able to show what the industry currently thinks about the reason for adoption, benefits, drawbacks, time, and cost implications of robotic demolition equipment. The research provides contractors a better idea of what their industry peers think about demolition robots and can be a resource for prospective users to understand the technology.

Literature Review

What is Robotic Demolition Equipment

Robotic demolition equipment has been around since the 1970s however the technology is starting to become a popular solution for contractors seeking solutions to their aging workforce (Cottom, 2019). The demolition industry faced with stricter regulations and a shrinking labor force has turned eyes towards compact remote-controlled demolition equipment. The equipment can take on jobs that are labor intensive, risky, and time restrictive (Cottom, 2019). Compared to using hand tools, robots can help complete a job faster and safer.

Demolition robots or robotic demolition equipment are two terms that refer to the same type of equipment. Demolition robots are mobile robots that leverage a variety of end-of-arm tools such as breakers, crushers, buckets, and drills that are used to break material on a jobsite (Robotic Industries Association). Most demolition robots resemble a small excavator without the cab that can fit through doorways and other small spaces normal machines would be too large to fit (Robotic Industries Association). Because of their design, the equipment can work in areas that would be too dangerous for laborers, such as nuclear contaminated sites and airless environments (Cottom, 2019). The work can be done safely and efficiently with a remote-control box allowing the operator to stay out of harm's way (Brokk 2016). An example of a demolition robot would be the Brokk 500 as seen in figure 1. The Brokk 500 is an electric powered robot that weighs 6 tons, has a control range of 300 meters and is compatible with numerous end of arms tools. The robot resembles an excavator with tracks, stabilizers, and an arm with interchangeable tools.



Figure 1. Brokk 500

History

In 1979 the Robotics Industries Association defined a robot as “a reprogrammable multifunctional manipulator designed to move materials, parts, tools, or specialized devices through various programmed motions for the performance of a variety of tasks.” Robots have developed further technologically however the definition remains relevant. Adding on to that robotics incorporates the

background, knowledge, and creativity of mechanical, electrical, computer, industrial, and manufacturing engineering (Jackson, 1990). Robots began to gain attention in the 1970s and that is when the idea of a robot was first applied to the demolition industry.

In the 1970s Lars and Per-Martin Holmgren owned a metal processing plant in Sweden. The task of cleaning the furnaces was hot and dangerous work so the Holgren brothers saw an opportunity to improve the safety and efficiency of demolition. After piecing together a prototype, the brothers became the first to develop a remote-controlled demolition machine. The ability to control the machine out of harm's way, protected workers from hazardous environments and reduced the time to complete the cleaning of slag at the metal processing plant. (History, 2020) The brothers named their company Brokk and began producing the Brokk 250, the first commercially available demolition robot. In the last 50 years Brokk has continued to innovate and is still an industry leader. The other worldwide leader is Husqvarna who also produces a range of models of robotic demolition equipment.

Robot Market

Robotic demolition equipment is currently the most used robot in the entire construction industry. Demolition robots currently account for 90 percent of the total construction robot market. Demolition, unlike construction requires less precision and is more easily adaptable to robotics. Wise Guy reports calculates the overall construction robot market to be worth \$321 million by 2022 with a global compound annual growth of 8.7% between 2016 and 2020 (Robotic Industries Association).

Interview

Jim Thompson, the Director of Operations at Sunesis Environmental, was interviewed as the first step in the research. Jim purchased and has overseen the use of two Brokk demolition robots on projects around the Cincinnati, Ohio area. Currently the machines are being used to demolish Kirwan and Blanding Towers at the University of Kentucky. The robots are assisting crews in demolishing the building one floor at a time. The robots can be suspended from above and work in areas too dangerous for other equipment. Jim said that the robots are essential to keeping crews safe and out of harms way. He says that the ability to remote control equipment is “innovative” and that the equipment is easy to operate. He notes that there is a shortage of operators and that operating a robot is “easier on the body of operators.”

Jim was vital in the development of this project. Jim's insights into demolition robots were used to craft survey questions that were sent to other companies. His answers to questions such as benefits, drawbacks, and reasons for adopting for the technology influenced the answer choices in the survey.

Methodology

The primary data for this research was collected via a survey targeted at demolition contractors and subcontractors who use robotic demolition equipment. The survey population was identified in three different ways: (i) members of the National Demolition Association (NDA); (ii) a list of subcontractors and contractors found from trade magazines, news articles, and targeted Google searches; (iii) contacts provided by other participants in the survey. After identifying companies that use robotic demolition equipment using the three ways listed above, each company was contacted. All contacted companies are based in the United States of America with no preference on geographical location when selecting the targeted companies. The first contact with a company was via publicly

available phone numbers and emails. The survey was sent via email to each company's preferred email. There is no way of knowing what role the respondents have in the industry however, the aim was to reach project managers and executives who work with robotic demolition equipment. The first employee contacted at each company was encouraged to forward the survey link to the person at their company most suited to answer the questions. The companies were also told to only complete one survey per company.

The survey was sent to 88 unique companies scattered throughout the country. A typical response rate for a construction industry questionnaire can be found using similar research. Panthi (2007) received a 19.4% response rate and Ahmed and Azhar (2004) received 30.4% of surveys sent out. There were 20 companies out of 88 that responded completely to this survey. That is a response rate of 22.7%. Baker (1998) reported that a statistically reliable conclusion can be obtained from a sample size of 20. Baker says that low or high response rates do not guarantee the survey results will be representative of the entire population (Baker, 1998)

The survey probes the perceptions of users of robotic demolition equipment and consists of 15 questions. The questions can be broken down into two groups: Background and Perceptions. The background portion has the goal of understanding information about the respondent and their knowledge of robotic demolition equipment. The second section, Perceptions, asked companies to answer questions about their experience related to robotic demolition equipment. The goal was to discover what the industry thinks about the technology in 2020.

Survey Results/ Analysis

Background

The title page of the survey was used to inform the respondents of what type of robotic demolition equipment the survey includes. This page included robotic demolition equipment defined as “an unmanned remote-controlled machine used for demolition purposes. The largest manufacturers of this equipment are Brokk and Husqvarna.”

The first question in the survey asked “What is the primary role of your company?”. This question had the options of contractor, subcontractor, supplier, and other. More than one response was allowed on this question and the results show subcontractor was the most common response at 65% followed by 60% contractor and 5% other. The respondents in this survey are mainly employees of demolition contractors or subcontractors. The other response was one rental company that participated.

Q2 What type of demolition projects do you use Robotic Demolition Equipment

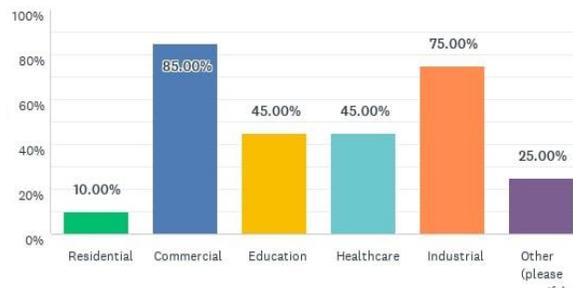


Figure 2. Question 2

The second question probed the sector of demolition that the companies use robotic demolition equipment. As seen in figure 1 the most common response was commercial with 85% or 17/20 responses. The next most common would be industrial with 75% of respondents having used robotic demolition equipment. The other responses included heavy civil and nuclear contaminated sites. The robots are being used in all primary sectors of construction however the most work is in large scale commercial and industrial projects. These results suggest that the companies surveyed are using the robots in environments otherwise too dangerous for humans. This explains the high percent of companies working on industrial jobs and the nuclear contaminated responses.

A question on the size of companies showed that 40% of companies are small (11-50 employees) and 40% are medium (51-250). 10% of companies were smaller than 10 employees and 10% were larger than 250 employees. The results of this question may be skewed by ease of communicating with companies. Larger companies, who usually use demolition robots, had a much lower response rate because of the inability to get past the front desk.

The fourth question asked “what decade your company first heard of robotic demolition equipment.” 20 percent of companies heard of the technology before 1990, 25% during the 1990s, 35 percent during the 2000s, and 20 percent after 2010. Next it would be interesting to know when companies first purchased a robot since the industry appears to have heard about the technology at differing times. This question showed that 0 percent of companies purchased a robot before 1990, 35% during the 1990s, 30 percent during the 2000s and 35 percent after 2010. These results show no adoption before 1990 even if the companies had heard of demolition robots. As time passed the companies slowly adopted the technology with no decade showing substantially more adoption than another.

Brokk and Husqvarna lead the North American demolition robot market. Brokk, the industry leader, was used by 90% of the companies, followed by Husqvarna at 30% and 5% other. During conversations with these companies the proximity to a repair center and experience helped decide on which company to use. Both companies sell and repair in the United States however Brokk is the industry leader. All of the companies use demolition robots, so it is important to know how many robots each company has. The results show that 80% of companies have 0-5 machines, 15% have 6-10, and 5% have more than 16. This shows that there either is not the demand for more machines or maybe there is room for expansion for the demolition robotics industry. During conversations with participants there was a common idea that there is a limited amount of jobs for robotic demolition equipment. There is a market however not every demolition job requires a robot.

Perceptions

The perception section of the survey consisted of seven questions that aim to answer important questions of why companies use the equipment and identifies the most popular benefits, drawbacks, and reasons for adoption. This section is particularly interesting if you may be considering adopting demolition robots yourself. This is a glimpse into the perceptions of users and leaves room for further research to understand why companies responded in these ways.

The next four questions asked questions with the possible answers being yes, no, and it depends. This format allowed the companies to answer in the middle and opens questions for future research. The first question asks, “do you think robotic demolition equipment reduces the equipment cost on a project?”. From my research the initial price of the equipment is a downside, but it seems the equipment cost on a project is reduced. The responses on the question were split, 50% saying yes, the equipment cost is reduced and the other 50% saying it depends. To my surprise there were no “no” responses. The next question asked, “Do you think robotic demolition equipment reduces the total project cost.” 70% of respondents said yes the total project cost is reduced and 30% believed it depends. Once again there were no “no” responses. This is interesting and shows a primary reason companies may consider purchasing demolition robots. The next question asked if demolition robots reduce the total project duration. Completing a project faster and safer is a primary reason for using the technology and the results show this. 80% of respondents thought “yes” the project duration is reduced and 20% thought “it depends”. The last question of this section asked if you see owning a demolition robot as a competitive advantage. 95% of respondents said that it is a competitive advantage and 5% selected it depends. These four questions give a basic insight into why companies are choosing to use this technology. There were 0 companies that responded no to any of these questions. It appears cost and project duration are impacted in a positive way however the “it depends” responses need investigated.

The next three questions used a ranking system to answer the questions of most common benefits, drawbacks, and reasons for adoptions. The respondents were asked to rank out of 6 options. This means that the highest possible score is 6 if every respondent chose that answer as their number one option. This information is especially useful in understanding the industries perceptions, essentially the rest of the research was leading up to these insights.

Q12 Common Benefits of Robotic Demolition Equipment

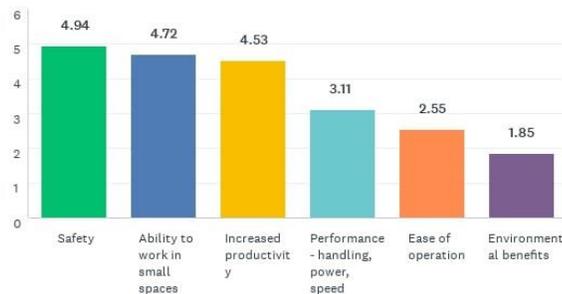


Figure 3. Question 12

The most common benefit according to the survey is safety. This was expected considering the equipment was developed to work in spaces too dangerous for humans. The ability to work out of harm's way cannot be understated as the most important benefit. The next highest rated benefit would be the ability to work in small spaces. Demolition robots can do the work of many men and fit in spaces no other machine can fit. This leads us to the next important benefit of increased productivity. It is much faster to use a robot than to use hand tools. This fact is clearly recognized by the industry. It is worth noting that none of the options here are the clear leader. Looking at the results shows a general disagreement within the industry on this question. Even the lowest rank choice, environmental benefits, was the highest ranked choice for one participant but was also the last choice for 13 participants.

Q13 Common drawbacks of Robotic Demolition Equipment



Figure 4. Question 13

Unlike the benefits chart, the drawbacks chart shows a clear leader. The most common drawback with 5.58/ 6 possible points was the initial price. This should not be a surprise considering purchasing a new or used demolition robot is a large investment. MSRP for Brokk's from 2010 shows small robots starting at \$100,000 and going up to around \$300,000 for the higher end models (Standard Machine and Equipment Prices, 2010). It can be expected that these prices are even higher in 2020. The next most highly rated drawback was the repair costs. During my time speaking with some of the respondents I was told multiple times repairs can be expensive and time consuming considering the machines must be sent to a specialized repair center. The next most important drawback was that the machines are idle and do not have enough demand. This is interesting and may be a point of concern for companies looking into purchasing robotic demolition equipment.

Q14 Motivations for adoption of Robotic Demolition Equipment

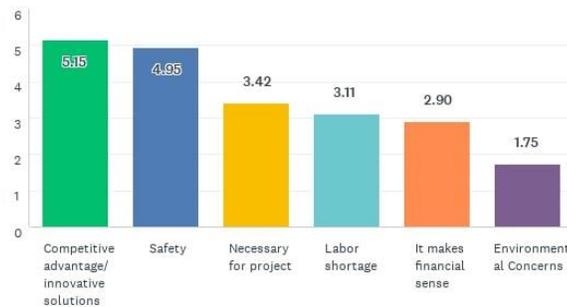


Figure 5. Question 14

Demolition robots, although invented nearly 50 years ago continue to grow in popularity and use. Companies seeking to grow have turned to robots as a competitive advantage. Earlier in the survey it was shown that 95% of survey participants viewed the robots as a competitive advantage. Competitive advantage is also the most highly rated response for the motivation to adopt demolition robots. Safety also proved to be important earlier in the survey and that also was an important motivation for adoption of the technology. It is shocking however that the competitive advantage outweighs the motivation provided by safety. Safety is an important concern on any jobsite and thankfully was viewed that way when considering purchasing equipment. Another surprising result of this question is the last place response of environmental concerns. Demolition robots are usually electric powered (not always) and are much cleaner compared to diesel equipment. The results suggest that even though demolition robots do have environmental benefits, the industry does not view environmental concerns as a primary reason for adoption.

Future Research

This research answers many “what or when” questions. For example, what are the drawbacks or when did companies first purchase demolition robots. There is a need for future research into the why. Unfortunately, this research was unable to dive into this topic at that deep of a level. For example, it is important to know why “it depends” if the equipment cost is reduced on a project when using demolition robots. Another example of future research may be a deeper dive into the safety aspect of demolition robots. Safety is clearly a significant reason why companies use demolition robots, so it is important to understand the factors that play into that.

Conclusion

This research has examined the demolition robot industry and the users of the technology at a basic level. It has identified the background of the users as well as perceptions such as benefits, drawbacks, and reasons for adopting the technology. The answers to these questions provide useful insights into the collective mind of the industry. This data cannot be used to prove any individual point, however using a wider lens come conclusions can be drawn. The industry overwhelmingly believes that owning demolition robots is a competitive advantage and that there are time and cost benefits. Also, it can be seen that companies are using demolition robots for its ability to protect workers from

dangerous situations. This research can be used by prospective users and current users of the technology to understand what the industry is thinking in the fall of 2020.

Works Cited

- Ahmed, S. M., and Azhar, S. (2004). "Risk Management in the Florida Construction Industry". Proceedings of the 2nd Latin American and Caribbean Conference for Engineering and Technology, Miami, Florida
- Baker, S. W. (1997). Risk Management in Major Projects. Ph.D. Thesis, University of Edinburgh, UK.
- Brokk Celebrates 40 Years of Manufacturing Remote-controlled Demolition Machines. (2016, March 08). Retrieved November 14, 2020, from <https://www.forconstructionpros.com/equipment/earthmoving-compact/mini-excavators/press-release/12168446/brokk-inc-brokk-celebrates-40-years-of-manufacturing-remotecontrolled-demolition-machines>
- [Brokk 500 Demolition Machine Image]. (2018, November 27). Retrieved November 13, 2020, from <https://www.brokk.com/us/press-release/brokk-features-powerful-brokk-500-demolition-machine/>
- Cottom, T. (Ed.). (2019, June 14). Robot invasion: Why remote-controlled machines are the future of demolition. Retrieved November 14, 2020, from <https://www.cdrecycler.com/article/remote-controlled-demolition-robot/>
- History. (2020, May 28). Retrieved November 14, 2020, from <https://www.brokk.com/about-brokk/history/>
- Jackson, J. R. (1990). Robotics in the Construction Industry (master's thesis). University of Florida, Summer. doi:https://archive.org/stream/roboticsinconst00jack/roboticsinconst00jack_djvu.txt
- Panthi, K.; Ahmed, S.M.; and Azhar, S. (2007). "Risk Matrix as a Guide to Develop Risk Response Strategies". Proceedings of 43rd ASC National Annual Conference, April 12-14, Flagstaff, Arizona
- Robotic Industries Association. (n.d.). Retrieved November 12, 2020, from <https://www.robotics.org/service-robots/demolition-robots>
- Standard Machine and Equipment Prices (North America) [PDF]. (2010, January 10). Monroe, WA: Brokk Inc.