Optimal Excavator Efficiency on Demolition Sites

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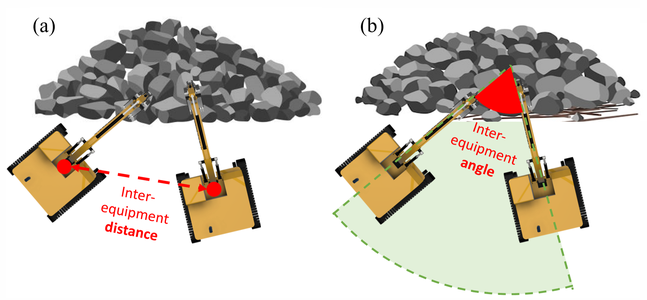
Introduction

- In construction and demolition sites, many measures are in place to ensure that waste is properly sorted in an efficient and accurate process.
- However, the economics industry is rapidly expanding. This, along with growing concerns of environmental sustainability, evokes the analysis of waste sorting in an effort to recycle a greater portion of waste.
- Previously conducted research indicates that a large amount of construction and demolition waste is sent to landfill sites.
- Even though this waste is primarily comprised of recyclable material after being properly processed, much of it gets transferred to landfills.
- Such evaluation inspires the question: To what extent do the number of excavators and excavator orientation contribute to efficiency on a demolition operation?
- The construction and demolition is a thoroughly investigated industry. However, a gap in literature still seems to exist.
- Minimal research has been conducted regarding optimal methods of operating heavy machines in order to effectively sort waste.
- For this reason, this study conducts small-scale experiments in an effort to improve the efficiency of operating vehicles.

Methods

- The study consists of numerous small-scale excavators with their remotes, small colored rocks and misshapen wires to simulate debris, tracking software, and a camera.
- The study measures the distance between excavators during the process, orientation of the machine, number of excavators being used, and the time it takes for a given number of excavators to separate the debris.
- These values are used to determine productivity and variation from expected productivity.
- Expected productivity for each individual is the volume of debris they can separate in an hour. Expected productivity of two and three excavators is calculated by adding each individual productivity together.
- After a trial is run, a ratio is found between the actual productivity and the expected productivity.
- This ratio is analyzed with respect to number of excavators, orientation, and mean distance.
- Orientation is measured through tracking the angles between the excavators at various times and finding the mean for each experiment. The distance is measured by tracking the space between the middles of the excavators. These two measures are depicted by the diagram below.



Results

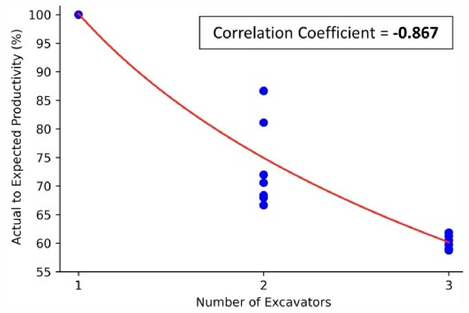


Table A. Depicts number of excavators and ratio of actual to expected productivities.

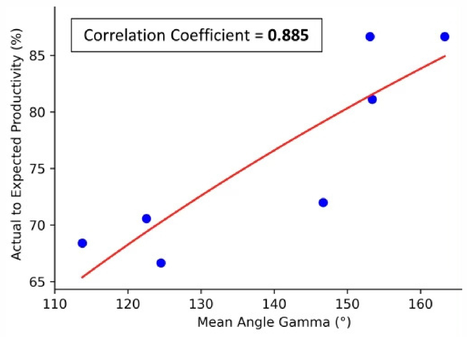


Table B. Depicts mean angle between excavators and ratio of actual to expected productivities.

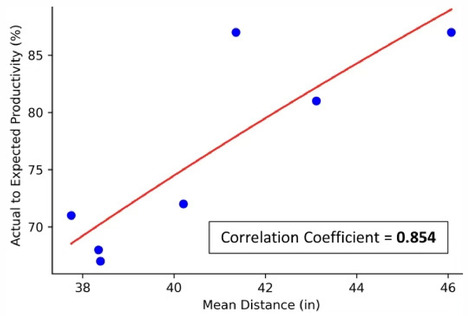


Table C. Depicts mean distance between excavators and ratio of actual to expected productivities.

Discussion

- Data is still being collected and results are still being analyzed, but the following conclusions can be drawn from the collected data.
- Table A suggests that there is a significant negative relationship between number of excavators and ratio of actual to expected productivity. This means that as more excavators are added to the site, the marginal gain in productivity is not directly proportional.
- Even though the overall time decreased, it should have theoretically decreased more.
- Table B depicts a strong positive association between mean angle and ratio of actual to expected productivity. This shows that as excavators move closer to facing each other at a one hundred eighty degree angle, the closer the actual productivity is to what is expected.
- The smaller the angle is between excavators, the smaller the quantity of debris separated per hour for each excavator.
- Table C shows a strong positive correlation between mean distance and ratio of actual to expected productivity. In other words, excavators are more efficient while they are further apart.
- There is an indirectly proportional relationship between distance and productivity.
- We hypothesize that these results may be due to the spatial orientation of excavators.
- As more excavators are added and closer together excavators get to each other, the higher chance they have of interfering with each other and slowing down in productivity.
- This is important for demolition companies to take into account because adding more excavators may not be worth the additional finances.
- Additionally, it is important to know that it is most optimal for excavators to begin far away from each other with the widest angle possible.
- However, a limitation to this experiment is that the expected productivity may be slightly smaller than what it should. This is because individual productivities were recorded months before trials with multiple excavators were performed. This means that each individual's productivity is likely higher now. If this is the case, it would only strengthen the aforementioned findings.
- Based on these findings, companies may find it useful to know a simple approach to calculating exactly how many excavators should be used for optimal operation. Although we established correlations, we did not come up with any specific measures.

Refrences

[1] Bhandari, MG, et al. Building Demolition, citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=b42cffa5a2ad63a31fcf99869e7cb8ef72b44374. Accessed 17 Nov. 2023.

[2] Maciejewski, J., et al. "Study on the Efficiency of the Digging Process Using the Model of Excavator Bucket." Journal of Terramechanics, Pergamon, 25 Jan. 2004, www.sciencedirect.com/science/article/abs/pii/S0022489803000600.