Scraper Productivity, Cost, and Size Selection Generator

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In the construction industry we are timelessly looking to increase productivity and find the most cost-efficient way to finish a given project. Like any other sector of the construction industry large earthmoving contractors look to find the most advantageous way to move dirt and at the cheapest cost per cubic yard. To obtain this goal of calculating and imagining the best way to move dirt, I have created a prototype program that analyzes scraper productivity and cost comparisons through excel sheets. These excel sheets allow a contractor to enter information such as cycles times, load calculations, and costs to create a cost and productivity comparison between rental equipment and in-house equipment as well as different models and sizes of scrapers. By inputting data into these excel sheets it aids industry in making key decisions when selecting a fleet of scrapers for their project. The purpose of this project is to analyze the different types of scraper and the best ways to obtain the greatest productivity through them. Then, by incorporating this knowledge into excel sheets that will be able to help the industry make the best decisions when selecting a scraper or an entire fleet for their individual project. These excel sheets will be beneficial in the aspect of comparing different models of scrapers (twin engine and single engine) by their productivity and then cost. The program will then allow the contractor to generate which combination of scrapers will produce the greatest cost and time efficient approach. If successful this program will benefit contractors looking to obtain a better understanding of their fleet and make the right decisions to create the most time and cost-efficient approach.

Key Words: Scraper, Productivity Analysis, Productivity Comparison, Size Selection, Cost Analysis

How project came about

Growing up and being around scrapers my entire life, I became amazed how a piece of machinery could actually move an entire mountain from one place to another. During summer months working for my father's company I found myself running twin engine Caterpillar 627G scrapers building agricultural reservoirs and wondered about how a contractor chooses a certain scraper over another and how their costs differ. Why would a contractor choose a single engine over a twin and so forth? Once at Calpoly, I found myself competing in the ASC heavy civil construction management in Reno. In this competition we were assigned a project and our team had to hard bid the project. In this project we were given a cost sheet for equipment and we were asked what scrapers we would use and why? What size scraper should you choose and how would your costs compare to the others? This immediately made me think back to the question of how they do this in the real world. Many contractors simply use a simple excel sheet to produce productivity for estimating but how are you to know which size to use for that given project. This drive to better understand has pushed me to create a prototype estimating program, through excel, that would allow me to better select the right piece of equipment. Before I was able to create the program though I had to dive deeper into scraper and their capabilities.

Literature Review

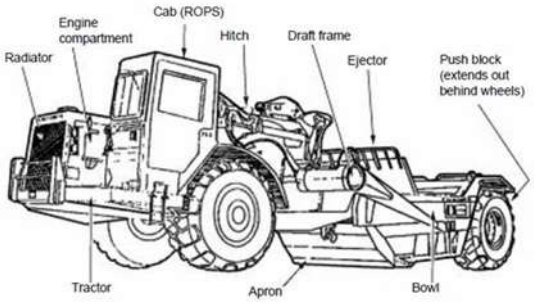
Types

To understand what sizes of scrapers are the best fit for you for your project we must first understand the different types of scrapers, and their advantages and faults. Some types of scrapers work differently for different contractor's due to operating costs, availability of equipment, and job conditions.

The Caterpillar 621, 631, 651 or for short the single engine scrapers are the first group of scrapers that we will talk about and compare. The single engine scrapers are exactly what they seem they are, a single engine scraper. The faults to single engine scrapers are that they do not have enough horsepower to fully load themselves or load each other. This means that a bulldozer will need to be loading each scraper individually which means that you will be paying the operating cost of another man and machine. The advantages of single engine scrapers is that they can carry just as much material as the twin engine scrapers at a lower operating cost (diesel, oil, grease, machine life).

The Caterpillar 627, 637, and 657 are the twin-engine scrapers that I was lucky enough to be operating the entire summer. Unlike their cousins the single engine, the double engine scraper is able to load themselves, depending on the material anywhere from 30 to 50 seconds. The twin engine scraper is also able to "hook up" and push one another through a cut to be loaded, which can cut the filling time in half. The advantages to running twin engine scrapers is that they can boost your production by loading themselves instead of having to wait on dozers to push them through the fill, which is beneficial when there are shortages of equipment. They are also simply faster machines and can reach up to 30+ miles an hour in short periods of time. The disadvantages of running a twin engine is that their operating cost do go way up compared to the single engine. Although when comparing the amount of material, a twin engine can move compared to a single engine scraper the twins operating cost are justified.

The Caterpillar 613, 615, and 623 are paddle wheel scrapers and are specific to finishing touches on a jobsite. The paddle wheels load themselves by using a conveying arrangement to pick up smaller windrows created by the motor grader. Unlike the single and twin-engine scrapers, the paddle wheel can do fine finish work but will not be used to move large amounts of material in large cut and fills.



Sizes

To pick and choose the machine right for the job before us, we must understand the capabilities of our machines and the job at hand. To fully understand this, we need to break up the different sizes of scraper. The twin and single engines scrapers are broken up into three different size groups: 20s, 30s and 50s. These numbers determine the size of the machine, such as the 20's carry 16CY, 30's carry 23CY, and the 50's carry 32CY (Per Caterpillar Handbook).

The numbering after the 20, 30, and 50 determine if the tractor is single engine or twin engine. The single engines will follow with a 1 (621,631,651) while the twin engines will follow with a 7 (627,637,657).

To decide on the machine needed on your particular job we need to look at mainly the amount of material that needs to be moved but also how the machine will handle and how large the haul roads are. For example, "A heavily laden machine, resulting from a long load cycle, may be efficient in terms of real productivity and cost for certain haul cycles, but for other haul cycles may deteriorate productivity and increase cost by increasing tire slip (increased tire wear), burning more fuel, increasing wear on ground engaging tools, and increasing wear on machine structure and powertrain components" (Morey 2007). This means that the haul road and the size of the machine has a large part to do with one another.

Site Conditions

Perhaps one of the largest obstacles to reaching the greatest production on your jobsite are the site conditions. If your jobsite is of small scale and small scale we will have to go with a smaller tractor compared to a site where we are moving millions of yards of material. Size is a huge piece but the main piece that will affect your productivity more than anything will be what type of material is on the site. From personal experience, the best material to load and obtain the greatest productivity is a granular loamy soil, from there either way on the spectrum begins to become harder and harder for the machine to pick up. Examples of this is that a loose sandy material will be harder to pick up and fill up because there is less backpressure on the machine. "The scraper us unable to handle very soft organic soil in swamp locations or the rock which requires blasting and removal" (Sherman 1963). When it comes to the rockier material we need to look at being pushed through the cut by a dozer due to the fact that a scraper will spin its tires therefore destroying their tires (which vary from $10,000-$20,000 apiece). It is also harder to obtain full loads of rockier material. "The variable affecting the profitable excavation of soils by scraper includes the following: loading characteristics, weight to volume relationships, dumping characteristics, rolling resistance and traction. These variable are directly influenced by the following major factors: gradation of the soil particles, moisture content, soil structure, and soil profile" (Sherman 1963). These are all examples of how the material itself can cause a hiccup in your production. By understanding the difference, the materials play on your scraper allows you to make the right decision when deciding which model and size to use on the jobsite.

Steps

The first step was to obtain a better understanding of scrapers and how they operate. I did this by doing some research of my own as well as watching them run on the jobsite I had been working on. This gave me a better understanding how to estimate them and what variables need to be considered. The next step of the project was to create the actual program itself. This included countless hours of excel work. I began by taking a simple scraper productivity generator and added cost and time into it. The overall finished product allowed me to enter job information for a specific project and then the program would select the best choice for you.

Once the prototype program was finished it was time to interview all three companies. The first company I chose was Rege Construction because it was easily accessible and they are a small family owned company that generally only use small scrapers. The next company that I chose was Ghilotti Construction who do much larger earthwork jobs and generally use many different types and sizes. The final company that I interviewed were Granite Construction because they are a large user of scrapers of all sizes. After I was able to complete these interviews I was then able to have a better understanding of how this program worked and if it would benefit the real world. For all three interviews with company's I began by introducing myself and began by asking them a series about scrapers and the differences between them all. This allowed me to have a better understanding of how they worked and if anything would be relevant to my program. I then printed out screen shots of the program that already had a made-up jobsite and scenario and ran the companies through it as if it were their own project. I then asked several questions to have a better understanding of the relevance of the program. This would allow me to see if there would be a possibility in taking the next steps to get the program created and marketed to real world contractors

Rege Construction Inc.

For the interview and presentation for Rege Construction we meet at the home office where Bill Rege the president and Russel Beldon the senior estimator was present. After going through and asking them about general scraper production and estimating I was able to have a better understanding of how someone estimates and selects the right size scraper. For example, Rege explained that their main earthmoving projects are agricultural reservoirs. They stated that they only use 627's due to the fact that when your making such small keyways and levies there's no possible way to fit a larger scraper on the project. The key takeaway that I got from this interview is that when someone is selecting the right scraper for their project, most of the time size and accessibility can play a key factor and lots of times the only reason that you are selecting that size is because you have to. After asking them other various information on scrapers and how they operate and demonstrated the program to them. They thought the program was extremely interesting in showing the side by side comparisons and cost differentiation. After asking them if this is something that they would use however they stated that they only own and use 627s and would not generally use them otherwise. They stated that generally the projects that they do wouldn't necessarily use anything larger

Ghilotti Construction Inc

For the interview with Ghilotti Construction I was able to meet CEO, Brain Ontario and lead earth working foreman, Rich Derico. I was lucky enough to be brought on to one of their projects to take another look at some scraper work that was being done. For the project that they brought me on they were using one 627 scrapers to cut key ways for roads for a new resort/hillside housing. This was a one scraper show with little production. They began by telling me that in some cases scraper production is not always go, go, go. In fact, they stated that unless you were to be moving huge amounts of earth in a repetitive manor it is generally slow going and hard to estimate. They stated that when a contractor is doing small intricate earthmoving work there's so many different reasoning to be considered. For example, the keyways that were being dug did not have a certain depth per plan but to be dug until they were in at least three feet of good hard material. The contractor has an idea of how deep this would be but to some extent it is still a large unknown. The contractors don't have the ability to throw an exact number of cubic yards at something like this. Ghilotti stated that in these instances you have to ball park days instead of going for exact hard counts. Due to the extent of the unknown they said it is hard to estimate and because were not necessarily reaching for high productivity that they had to throw lots of money at bid items like the keyways that they were building. After going on a tour and asking my questions on general scraper knowledge I was able to run them through the program. They thought that it was really neat that I was able to produce something like this myself but they stated that there were also lots of problems with it. For one, my sheets assumed that all different sizes of scrapers would be able to load themselves equally as fast. Well obviously this is not true and this would have skewed my data and otherwise rule my sheet ineffective in producing real world data and comparisons. Another thing that they stated was that even though it was interesting to be able to see the comparisons and differences in the real world it was much less complex in the selection process. Ghilotti stated that in the real world a contractor already knows what size machine they will use. They stated that all scrapers, while all do the same thing, are all used for completely different work. Large 657/651 are so large and cost so much to run and transport that they will not be used on a project unless were talking about moving hundreds of thousands of cubic yards of earth. The smaller the scraper the more intricate work they are able to use and the longer they take. Scrapers all do the same thing, but are all used for different scopes of earthmoving work. Overall Ghilotti thought it was a neat idea but ruled that it would simply be ineffective in the real world. They

stated that all contractors will have a general idea of what scraper is right for the job given the job details and that no scraper project can be bid the same using different scrapers.

Granite Construction inc.

For the interview with granite construction I was able to meet up for lunch with project engineer/estimator Luke Coyne. In the interview I was able to get a better understanding of the estimator's side of things as he had not been in the field a ton with scrapers but more around the office/estimating side of it. After showing Coyne my program, we were again impressed but was quick to point out the flaws that Rege and Ghilotti had before. In an estimator's eyes he said that they already understand the magnitude of earth that is to be moved on the project and have an idea of what machine they will be using. He said that there will never be a project where a 657 should be used and instead they used lots of 627. He said it simply doesn't work that way. All together the same things were brought up in past interviews that scopes of work generally don't intermingle between the different sizes of scraper and this is why there hast been a program like this created yet because it simply doesn't work. Coyne tried to explain it to me like this. Image trying to dig footings for a house using a small mini excavator or a large 349 excavator. There's no way to do it with the larger excavator, its simply too large for the scope of work. Altogether he thought it was a neat project and told me that I should definitely hand down the program to the Calpoly heavy civil team because it would definitely prove useful in the Granite sponsored competitions in Reno if asked to show how one came to deciding which size scraper to use.

Lessons learned during the process

In conclusion I have found that my program would not be beneficial to the construction industry and would not be worth taking the next steps to market it to contractors. I have learned that all sizes of scrapers are used for different aspects or scopes of earthmoving production. The contractor will generally know exactly what size of scraper will be more competitive in the bid process long before the contractors begins to estimate the project. It was found that the program was simply too linear when comparing different scrapers, when in reality there are many different factors that contribute to their selection. Variables such as site logistics, mobilization, scope, and availability are only a few of the factors that are a result of scraper selection. We will never use small scrapers to move millions of yards of dirt and similarly would never use 657s to move ten thousand yards of dirt. This new knowledge has definitely affected the way I think of using scrapers and how they operate in different circumstances.

This type of program could possibly be used in the future for educational purposes in the classroom to educate students how their costs and productivity differ. Although, the program might not meet the exact needs of the industry a student would be able to understand how cost differ between different scrapers per difference per CY and so forth. It would allow them to understand how costs and durations change per size and model and further develop their understanding of large earthmoving projects. Other than in the classroom, this program could be used in comparing and contrasting similar sized scrapers such as twin and single engines of the same size classification. It would also be used to compare similar sized scrapers such as 627 and 637 if the projects parameters and specifications deemed split between the two. However, during my research I found that the contractor will generally use the type of scraper that is available to them at the time of construction. In conclusion field experience remains the greatest attribute in selecting and utilizing size and models of scrapers. This new found information however will benefit myself in my future career endeavors and will help young industry professionals understand logistics of heavy earthmoving projects.

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