Heavy Equipment as a Topics Course at Cal Poly San Luis Obispo Construction Management Curriculum

Samuel G. Duner
California Polytechnic State University
San Luis Obispo-California

In the construction industry it has been said that no project is the same. That each project awarded to a contractor will have new and unique details that were not faced in the previous projects. However, all the management skills acquired by the project team will be used to complete the current project. One of those skills that seems to be underutilized and does not receive enough emphasis, is the management of heavy equipment. The purpose of this paper will be to highlight details of heavy equipment management that need to be emphasized in the Cal Poly construction management curriculum, and the level of interest student have in heavy equipment management. The literature review conducted for this paper stresses the need for a topics course with an emphasis on heavy equipment management. Literature review was collected by surveying all the construction management students with the major. The survey was included 10 question on heavy equipment management. Second a project, planned and built by four Cal Poly construction management students. The heavy civil project completed by the four construction management student was an asphalt replace that took place in Templeton California. The project tested their knowledge of construction management and the use of heavy equipment management.

Key Words: Heavy Equipment, Equipment Management, Performance Standards for Equipment, Cycle time for Equipment, Equipment Safety

Introduction

There are three main disciplines of construction that Cal Poly, San Luis Obispo exposes each construction management student to. These disciplines include, commercial construction, residential construction, and heavy civil construction. Besides estimating, scheduling, budgeting, safety, and other aspects of construction management that the three disciplines share, there seems to be one shared aspect that does not get the necessary attention it deserves. That particular shared aspect is heavy equipment management.

In all three construction disciplines most construction managers will be task at one point in their careers with a project from the ground up. Those projects will have to use some form of heavy equipment. In most cases the equipment will include excavators, scrapers, dozers and front loaders, backhoes, and compactors. Heavy equipment is not only confined to earth moving equipment, but any piece of equipment on the job site that requires an operator. These types of machines might include, pile drivers, reach forklifts, cranes, and large trucks All these pieces of equipment play a large role in a construction project and the better understanding a construction manager has of the equipment the more efficient, safe, and on time a project will be.

Most of the Heavy equipment will be used primarily during the beginning stages of a residential or commercial ground up project, equipment will always be used on a heavy civil project. On these types of projects safety is of the upmost importance. If a company can't maintain a good safety record they will be less likely to get work. It was found that, "fatalities involving ground workers being struck by a vehicle or equipment accounted for 73% of transportation-related work zone incident, with half occurring when a construction vehicle is backing up" (McCann, 2006, p. 512). It was also found that smaller equipment tends to have lower visibility well larger equipment have large blind areas in front and opposite the operators' seat (McCann, 2006). The Bureau of Labor Statistics census of

fatal occupational injuries found that out of 253 fatal heavy equipment cases 63% were heavy equipment operators and laborers. Out of the 63% of fatal that involved operators and laborers trucks and backhoes were involved in half (McCann, 2006) This study made it very clear that when safety concerning heavy equipment needs to be taken more seriously. It also leads to the conclusion that managers aren't properly stressing safety to their laborer. It is either because they are not properly educated in safety procedures when it comes to heavy equipment or they believe that the labor knows what that they are doing. It raises a concern that safety is not being stressed enough and that educating managers on proper safety techniques is lacking.

Construction companies are constantly trying to remain on time and within budget. One cause that can greatly affect both time and money is heavy equipment down time. If the project schedule is a major concern to a project a lot of time can be made up in the beginning of the project. It was found that, "Downtime durations consist of three major components, including (1) administrative time: time required for communication floe from user to manufacture, time required for commercial formalities and hours needed to repeat a machine failure and give work directions for maintenance; (2) Supply time: time when repair is delayed due to non-availability of spare parts and materials necessary to preform maintained. (3) active repair: time when technicians are working on the equipment to actually commission it including both preventive and corrective maintenance (Sambasivan & Soon, 2006, p.3). These three aspects of down can plague a construction project. It has been stressed countless time how important a project schedule is. In all the construction management courses at Cal Poly all the professor talk about the importance of proper planning. However, the professors rarely talk about project times for equipment and maintenance and most student don't concern themselves with in. In other research it was established that down time is interdependent. Downtime is simulated by reinforcing cycles. Theses cycles include schedule disruption and acceleration, operator schedule pressure creep, and mechanics' schedule pressure creep (Hadikusumo, 2009). At Cal Poly the construction management department has one class that discusses cycle time for certain pieces of equipment. The course never dives further into operators and mechanics schedules. Those issues are left for on the job learning. However, it would benefit student to learn this material befoer reaching a job site to reduce the learning curve.

Methodology

Data was collected in many different ways for this paper. The first method of data collection was a survey. The survey was sent to all Cal Poly construction management majors. The survey consisted of nine question that aimed to gauge the level of confidence each student had with management skills required for heavy equipment, and what areas of heavy equipment they were most interested. The tenth question was reserved for comments by the students for other areas of heavy equipment construction they thought would benefit the topics course. Extensive literature review was done on safety, machine downtime, machine cycle time, and machine financials. The final way literature review was conducted was through a project completed in Construction Management 421-service learning. This project was unique compared to the other project options provided. This particular project required proper coordination, estimation and hand on use of heavy equipment.

Survey

The survey was created for Construction management majors only. It was believed that any construction management minors or other majors would not be an appropriate group to survey because of their lack of jobsite experience compared to construction management majors. The survey included the following questions: (1) What year in school are you? (2) How many internships have you had? (3) What type of construction was your internship? (4) Are you interested in learning about heavy equipment? (5) How often did you see heavy equipment (equipment that is ridden and requires an operator) on your job site? (6) How comfortable are you when it comes to identifying certain pieces and sizes of heavy equipment? This can range from Dozers, Backhoes, Cranes, Excavators, Scrapers, Rollers, Pavers, Size of blades, size of buckets, weight caring capacity. (7) How confident are you in your abilities to estimate what types of heavy equipment you will need for a certain project? For example, how many trucks will it take to haul of excess material, how many buckets will it take to excavate a footing, how many scraper passes are required to achieve the proper rough grade, et... (8) Do you think having a better understanding of heavy equipment would benefit your CM education? (9) What sub-topic of heavy civil

construction interest you most or would benefit your CM education? (10) What other areas of heavy civil construction do you think would help improve you Cal Poly CM education?

Results

Question three was the question that placed the students into their respected discipline. Figure 1 explains that most students in the major choose Commercial Construction as their preferred discipline of construction

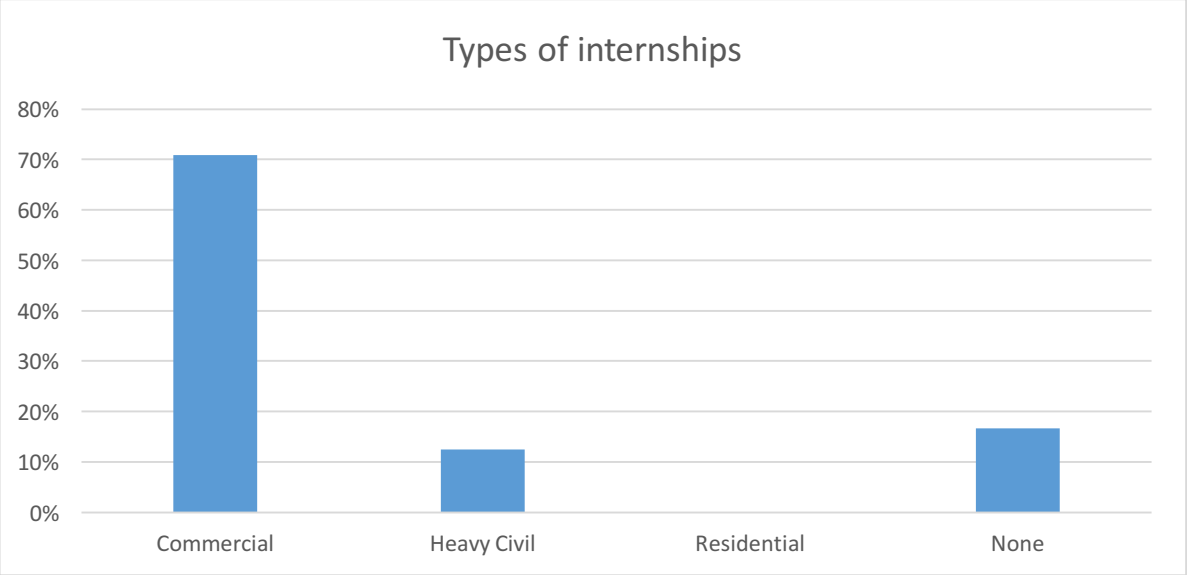

Figure.1 Types of Internships Cal Poly Construction Management Majors have worked in

Question 4 was meant to gauge the if the student were interested in learning more about heavy equipment management. The feedback was extremely positive which resulted in 100% of the students expressing an interest in learning more about heavy equipment.

The follow up question was focused on determining the frequency the students say heavy equipment. The survey explained that heavy equipment was defined as any equipment on a jobsite that was ridden and required an operator. The consensus was that if student did have frequent exposure to heavy equipment a course relating to the topic would only benefit there education. Fortunately, the majority of the student were exposed to heavy equipment daily well working. Figure 2 highlights the results.

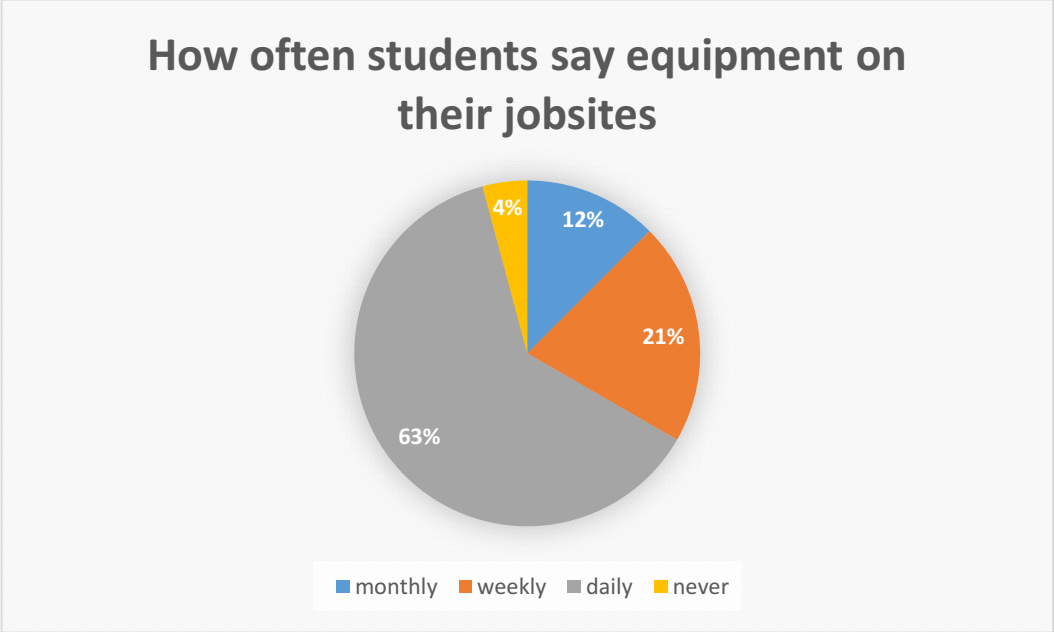

Figure 2. The frequency students saw heavy equipment being operated on their jobsites

The next two question asked in the survey were meant to better understand the level of comfortability the student had with identifying types of equipment and how comfortable student were when it came to estimating what pieces of equipment might need on a project. Most students were more comfortable then previously predicted when it came to identifying equipment. The question was phrased in a way that didn't not ask student if they were comfortable when identifying sizes of equipment. It was not ask of the student if they could identify a D9 Dozer or a Cat 657 scraper. It was simply ask if they were able to identify heavy equipment. Student answered varied with this question, the spread from very comfortable to not comfortable was even. The question that asked if students were comfortable with estimating equipment need for a project was skewed in the direction of less comfortable. A good majority of the students that completed the survey felt that they did not felt less than comfortable when it came to estimating heavy equipment. This question narrowed the parameter compared to the previous one. In the sub text there were examples of typical heavy equipment management that would be utilized on most projects. Examples included cycle time for truck hauling and delivering materials to a project site or how many buckets load will it take to did a typical footing. It was felt that these examples applied to all three disciplines of construction, and that most students should know by the time they have completed their construction management degree at Cal Poly. It is important to note that most of the students that took the survey were third years and above. The results for these two questions are shown in figures 3 and 4.

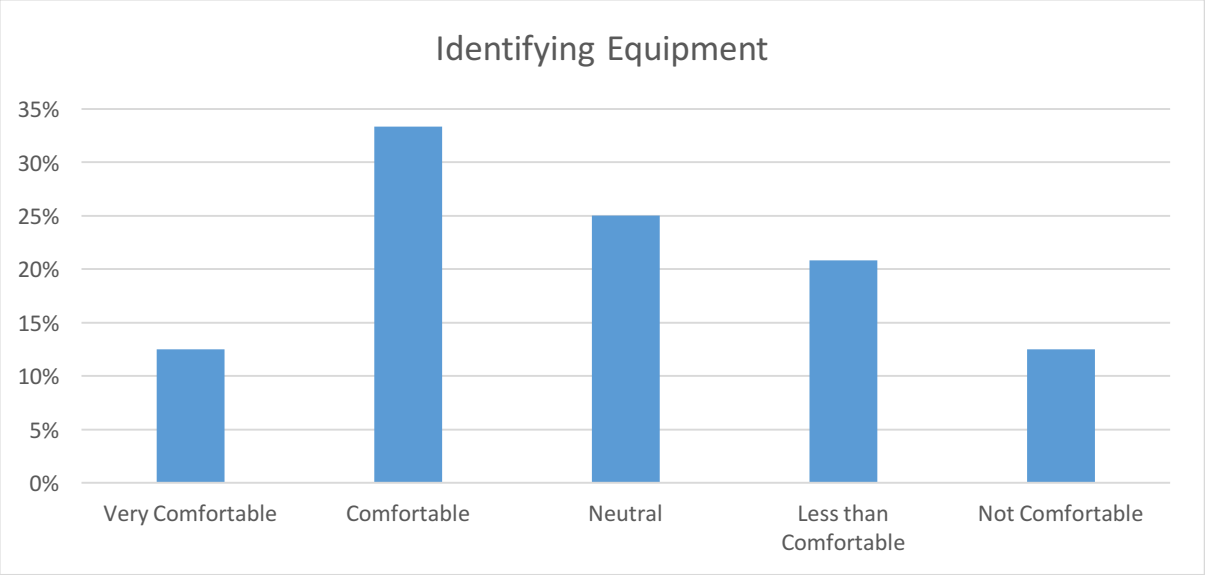

Figure.3 How comfortable students felt identifying heavy equipment

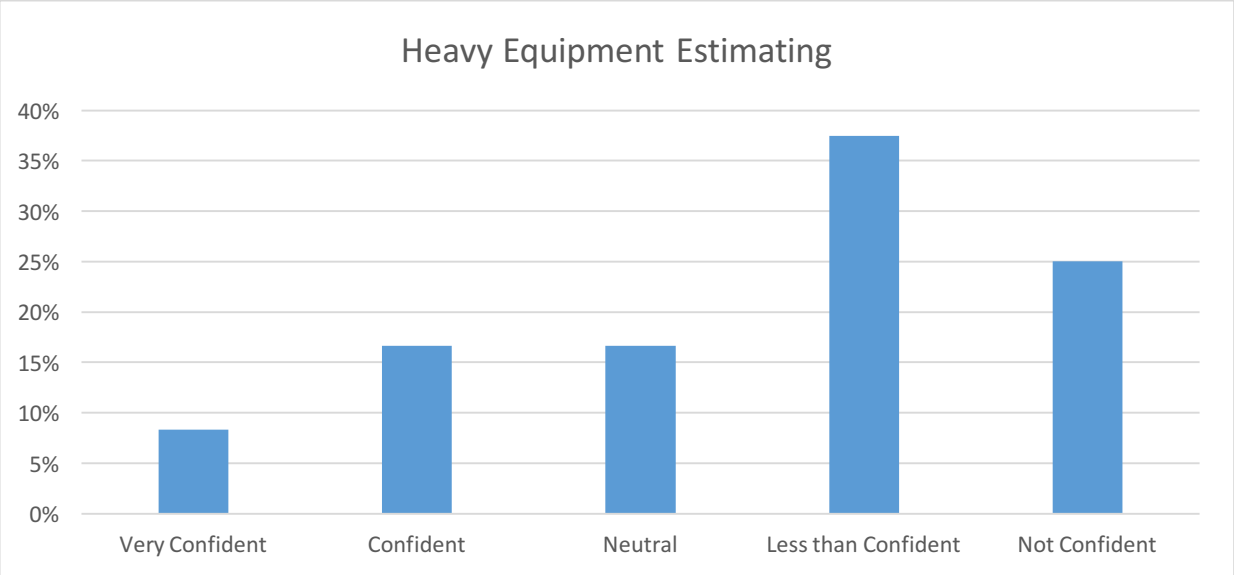

Figure.4 The confidence level student had when asked to estimate for heavy equipment

Question eight asked the students surveyed if they thought receiving more education on the topic on heavy equipment management would improve their education. Out of the totaled surveyed 96% believed that it would have a positive impact on their education. The following question was formulated to gain an understanding of which aspects of a class of this nature peaked their interest. The three sub topic options that were most desirable with the students were; hand on operation experience, coordination of equipment while on site, and equipment safety. The hope was to show the construction management faculty that a hands on operation experience should be incorporated into the class. A good majority of students within the major have little to no experience driving equipment. This would not only increase attendance in the course, but would also give the students a better understanding of an operator's day to day life. It was an added bonus that students also took an interest in safety of heavy equipment. The two sub topics correlate very well together. Figure 5 shows a graphical representation of the levels of sub topic interests.

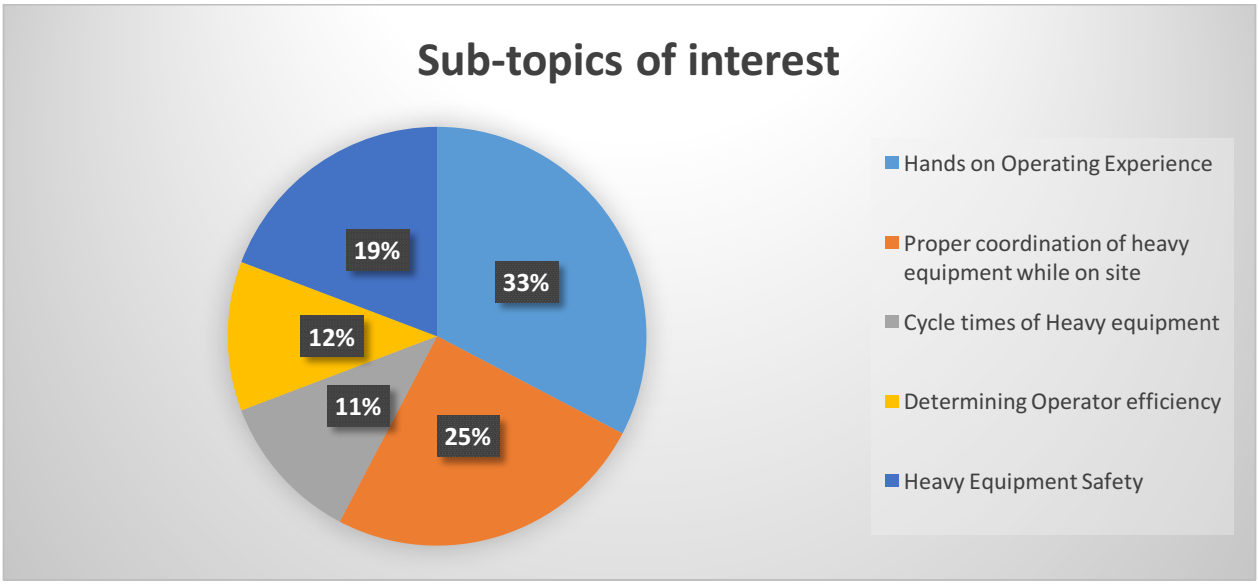

Figure 5. Heavy equipment sub topics of interest students expressed

The final question of the survey was open and asked the students what other areas of heavy equipment management they felt would benefit the class. The three suggestion that were the most comparable were; demolition of large building, heavy equipment placement on commercial jobsites, and field trips.

Asphalt Replace Project

At Cal Poly the construction management department offers a course called CM 420-Service learning. This class provides a great opportunity to give back to the local community. It also allows students to go out into the field and build a project. The project will typically have 4 Cal Poly students on each project team. The team is tasked with estimating, budgeting, planning, acquiring material and purchasing equipment for the project. The particular project this paper will examine is an asphalt replace project that took place in Templeton, California.

Background

The project team was tasked with replacing a section of damaged asphalt on the tenants drive way. Earlier in the year the tenant need emergency assistance to come to their home. A fire engine and an ambulance took the call and responded. Due to heavy rain and a poorly maintained driveway the fire engine ended up halfway off the driveway on the down slope in the soil below. Through many hour of trying to drive the fire engine out the situation and with no luck a large tow truck was called. After the fire engine was removed from the drive way the tenant notices significant damage to their drive way. The damage is depicted in Figure.6.

Figure 6. the damaged section of the drive for the asphalt replace project

Planning

After deciding to accept the project the four team members started the planning process. It was evident early on most of the student had never been subjected to this type of project. The equipment that need to be rented for the project was unfamiliar to most of the team. Fortunately the team had two members that could drive stick shift and operate some light equipment. However, they team came to realize that they were in a bit over their heads. The project was initially underestimated by approximately 30%.

Working Days

The work schedule consisted of 3 days. First day saw cutting out the project perimeter, next day was assigned for demolition of the project area, and the final day was meant for the asphalt pave. Saw cutting went according to plan. The proper area was cut out, but the depth of the cuts varied evident of the inexperienced operator. The project captain and co-captain decided that since the drive was substantially damaged the use of a mini-excavator was unnecessary. They felt that the demolition of the asphalt could be handled by shovels and picks. At first it worked and the asphalt was removed fairly easily. As the team worked their way towards the middle they ran into material that was much harder to remove. The project captain and co-captain decided that the best idea at the moment was to rent a skid-steer to remove the harder material. Work was then halted until the skid steer was delivered. However, upon arrival the skid steer did not come with teeth on its bucket which rendered it useless for demolition. The project team did find out that the skid steer worked great for loading the dumb truck. Demolition was completed on time and was prepared for paving.

Pave Day

ThThe final day was pave day. The asphalt truck was scheduled to arrive at 11:30. The plan was to have the captain dump the demoed material at the local dump with the dump truck, and have the rest of the crew grade the site. The projected team acquired a compactor plate to aid with the grading and also for the compaction of the asphalt. When the project captain arrived at the dump he struggled to understand how to properly use the PTO system (Power Take-Off). Engaging the system allows the trailer to engage the hydraulics and dump the bed. It was evident that the project captain was not well educated in dump trucks. During that time the rest of the team finished grading early and ended up taking an extended lunch. The asphalt truck did not arrive until 12:45 p.m. This only extended the work day. Fortunately the team employed 3 friend to assist them, which allowed for a 45 minute pave time. The aspect that saved the most time was the projects captains' brother who had 4 moths of experience with asphalt repaves.

Project Closeout

After the completion of the project, the team realized that if they should educate themselves more on heavy equipment management. Cost and time were large factors in this project and if it was a larger projects the team probability would not have completed it. Running over budget was not an issue, because other project teams were substantial under budget. However, if the project was strictly funded by the project team they would be deemed unsuccessful. It was a great learning experience for all the team member that highlighted the need for more education in heavy equipment management.

Conclusion

Heavy equipment management is an area of the Cal Poly construction management curriculum that should be emphasized more. With the amount of time the construction management courses require, it would benefit the student to offer it as a topics course. By doing so the class will be able to focus on not just the broad management components required in all construction, but will allow the students to explore heavy equipment and heavy equipment management more thoroughly. It was show by the survey conducted that most Cal Poly construction management students chose to work in commercial construction and see heavy equipment on their jobsites regularly. However, approximately 38% of construction management students that took the survey felt less then confident when it came to properly estimating for heavy equipment. The majority of those student were third years and above. It was expressed by the students that they though having a topics course on heavy equipment management would improve their education. The service learning project that was examined confirmed the surveys finding that most students in the construction management program have limited knowledge when it comes to proper heavy equipment management. The project was completed within the time frame that was set by the student and the client was extremely pleased with the final result. However, the students ran over budget due to not renting the proper equipment. The equipment then had to be rented, but at a much later timed which delayed certain milestone completion times. It is important to note that two of the student had some previous knowledge when operating the rental equipment, however it took both students a few hours to become comfortable enough in their abilities to drive the equipment. If a topics course on heavy equipment management it would advance further the Cal Poly construction management curriculum and would make the students even more desirable by industry.

References

Blake T. Dulin, MSCFM and John C. Hildreth, Ph.D .(2013) *Effect of Data Collection Period Length on Marginal Cost Models for Heavy Equipment* [WWW document].URL http://ascpro.ascweb.org/main.php

HOWARD C. OLSON, SIDNEY A. FINE, DAVID C. MYERS, AND MARGARETTE C. JENNINGS. (1981) *THE USE OF FUNCTIONAL JOB ANALYSIS IN ESTABLISHING PERFORMANCE STANDARDS FOR HEAVY EOUIPMENT OPERATORS* [WWW document].URL http://eds.b.ebscohost.com.ezproxy.lib.calpoly.edu/ehost/pdfviewer/pdfviewer?vid=1&sid=36b570e6-2a68-4efb-aa71-992fb3b81163%40sessionmgr104&hid=121

Thanapun Prasertrungruangand B. H. W. Hadikusumo (2009). *Modeling the Dynamics of Heavy Equipment Management Practices and Downtime in Large Highway Contractors* [WWW document].URLhttp://ascelibrary.org.ezproxy.lib.calpoly.edu/doi/pdf/10.1061/%28ASCE%29CO.1943-7862.0000076

Murali Sambasivan ,Yau Wen Soon (2006) *Causes and effects of delays in Malaysian construction industry* [WWW document]. URL www.sciemcedirect.com

Ahmad JRADEand Nizar MARKIZ (2012) *A Decision-Support Model Utilizing a Linear Cost Optimization Approach for Heavy Equipment Selection* [WWW document]. URL http://ascelibrary.org/doi/pdf/10.1061/9780784412329.011

Michael McCann (2006) *Heavy equipment and truck-related deaths on excavation work sites*. Journey of Saftey, 37, 511-51