Case Study Analysis of Improving Productivity Rates for Self-Perform Concrete

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Productivity is one of the most important aspects of a successful construction project, especially if the work is self-performed and not sub-contracted out to another contractor. Usually the success of a project is directly correlated to how well the production has been throughout the course of the job. Often when a project manager notices their job is not doing well and not making their target profits or man-hours, productivity is usually the answer to that problem. This paper will examine the different ways and methods of tracking production that was used by Overaa construction. The focus of this study is on the production rates of self-performed concrete that was done by Overaa construction on three different jobs: Jamieson Canyon Water treatment plant improvements, Sacramento Water treatment facilities, and Napa's new pump station. This paper describes the different methods used for each job and compares each method with the success of the job. After comparing the three different tracking methods used by Overaa and after analyzing each of their success, there should be a definitive answer on which method to use when starting out in the construction industry.

Key Words: Productivity rates, Production, Self-performed, Concrete, Maximizing productivity

Introduction

According to Leo Sveikauskas, there are four main potential reasons why productivity trends in United States construction have been negative for a good period of time. First, United States statistical agencies may use inappropriate methods to measure productivity trends in construction. Second, productivity growth in construction may be weak or negative because of a variety of problems in the industry (Teicholz, 2004). Third, as Allen (1985) suggested in an influential article, resources may have systematically shifted towards lower productivity portions of the construction industry. Fourth, productivity growth in construction may be negative at least partially because increases in environmental regulation have held back productivity growth in this industry (Productivity Growth in Construction 2014). In order to see gain and maximize all profit, every Contractor in the construction industry should be aware of the potential risks of poor productivity as well as the tools and knowledge to improve poor productivity.

It is crucial to treat productivity with more scrutiny in the construction industry rather than the manufacturing industry because of the limitations in the construction industry. Everything we do in the construction industry is man built rather than machine built. The construction industry relies on man power while the manufacturing industry relies on machine power. Figure 1 shows how productivity in manufacturing has nearly doubled while remaining flat in the construction industry. This spike in productivity is from innovations and technologies used to produce products, unfortunately there is no machine that can build an 800 ft. skyscraper in downtown San Francisco. In order to keep up with the manufacturing industry and increase our productivity rates, we need to keep developing methods and techniques to track and improve production rates (The construction productivity imperative 2015).

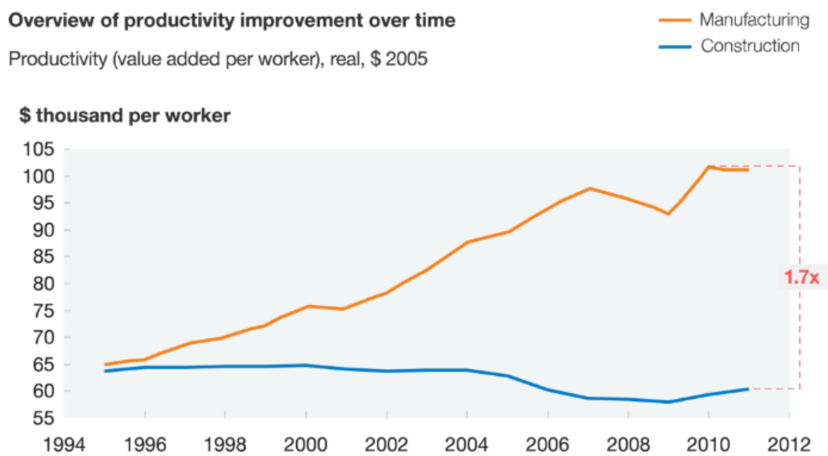

Figure 1: Overview of productivity improvements (The construction productivity imperative 2015)

Lauri Koskela developed a study defining the new production philosophy and compared it to the old production philosophy. Her point was that in manufacturing, the new production philosophy improves competiveness by identifying and eliminating waste activates while construction is viewed and modeled only as a series of conservation activities. Construction has traditionally tried to improve competiveness by making conversations more efficient. However, judging from the manufacturing experience, construction could realize dramatic improvements by eliminating non-conversation activities. The importance of this claim is that the process of construction must be developed in conjunction with the design itself. Figure 2 below shows the old traditional production philosophy compared to the new production philosophy

The traditional production philosophy

Production activities are:
- conceived as sets of **operations or functions**, which are
- controlled, operation-by-operation, for **least costs**, and
- improved **periodically** with respect to **productivity** by implementing **new technology**.

The new production philosophy

Production activities are:
- conceived as material and information **flow processes**, which are
- controlled for minimal **variability and cycle time**, and
- improved **continuously** with respect to **waste and value**, and periodically with respect to efficiency by implementing new technology.

Figure 2: The Traditional and new Production Philosophies (APPC 1992)

Productivity

Productivity can be defined in many ways. In construction, productivity is usually taken to mean labor productivity, which is, units of work placed or produced per man-hour. The inverse of labor productivity, man-hours per unit (unit rate), is also commonly used Horner and Talhouni stated, “A popular concept in the USA, and increasingly in the UK, is the concept of earned hours. It relies on the establishment of a set of standard outputs or “norms” for each unit operation. Thus, a number of “earned” hours are associated with each unit of work completed. “Productivity” may then be defined as the ratio of earned to actual hours. The problem with this concept is in establishing reliable “norms”, for setting standards. It also depends on the method used to measure productivity, and on the extent to which account is taken of all the factors which affect it.”

Productivity can make or break a job depending on the circumstances. If a job had good production rates then nine times out of ten that job was successful and made money. If a job had poor production rates, then that job usually will lose money and there is a possibility of not finishing the project on schedule. Some factors that lead to good production rates are good management, which falls on the shoulders of the project manager and superintendent, methods to track weekly or even daily production through man-hour reports, and proper communication between the Sub-contractors and general contractors to avoid any issues or problems that can arise. Poor production can stem from many different issues. Some of the main ones include inadequate management skills, not tracking man-hours, not meeting with the sub-contractors, and not having a good relationship with the laborers, which would fall into the same category as being an inadequate manger.

Good Production rates start and finish with the project manager and the superintendent. They have the most control of how a job is ran and have the most control over communicating with everyone involved on the job. One of the most over-looked aspect of production is the relationship between the crewmembers and the mangers. Besides counting man-hours and comparing them to the original budget the next best practice to have a good job is establish a relationship with the crewmembers. The crewmembers have the most important part of the job of building to code with no deficiencies. If there is a good relationship established in the beginning of the job the crewmembers would know whom their working for on a more personal level and have more motivation to make the job successful. There are many cases where a job went sour because the crew was under-appreciated and not communicated to properly. Keeping track of man-hours, comparing them to the budget and having good relationships with colleagues and work partners are good ways to start improving poor production rates, the question though is which method will bring the most success.

Productivity improvement in construction is best understood when the construction process is visualized as a complete system as shown in Figure 3. The system is made up of the construction project to which material; personnel, equipment, management, and money are inputs. They are consumed by the system in the process of producing the construction unit. Control of the system is achieved by collecting and processing information about the rates at which production is attained (Productivity in Construction 1993).

Category	Factors
Project Conditions	Weather Variabilitiy
Market conditions	Material shortages
	Lack of ecperienced design and project management personnel
Design and Procurement	Large number of changes
Construction Management	Ineffective communications
	Inadequate planning and scheduling
	Lack of sufficient supervisory training
Labor	Restrictive union rules
Government Policy	Slow approvals and issue of permits
Education and Training	Lack of management training for super-vision project management

Figure 3: Factors Related to Production (Productivity in Construction 1993)

Overaa Construction

Overaa Construction is a general contracting company located in Richmond California and has been around for over a hundred years. In 1907, Carl Overaa decided to help rebuild the Bay area after a devastating 8.2 magnitude earthquake and started Overaa construction. Overaa specializes in collaborative delivery systems, from design build to Integrated Project delivery. Overaa's main source of revenue comes from self-performing all concrete per job; the largest pour ever done by the company was 7,920 cubic feet of concrete for the foundation of the Elihu Harris Office State Building in downtown Oakland. Since Overaa self-performs all concrete per job, they are extremely cautious with their man-hours and production rates. Any kind of slip-up with the crew or in-proper management can really impact a job negatively. More than 50% of the company's profit comes from concrete so it is crucial everyone affiliated with the job knows how important the productivity is. Lasting over a hundred years, as a family owned business is a very big milestone for any kind of company but especially a company in the construction industry. Competition with neighboring general contractors, the market crashing like it did in 2007, and personnel problems are just a few of the many obstacles a company like Overaa has to deal with through the course of their existence. One of the key reasons why Overaa has managed to stay open all this time are by the techniques developed on projects throughout the years to track all man hours, and mesh everyone on the job together. All of the techniques developed were established after the devastating economic crash in 2008. Some methods are better than others and work more efficiently than others. In this paper, the three main ways to track productivity by Overaa will be compared to each other as well as new techniques other contactors use.

Methodology

The methodology I primarily have chosen in this case study is an analysis of quantitative data taken from multiple projects previously completed by Overaa construction. As well, I included qualitative data I received through interviewing the superintendents as well as the project managers for the three selected jobs regarding how they record and collect data for tracking man-hours as well as techniques used by them to get on the same page as the crewmembers. Together I have analyzed the results from both the quantitative and qualitative data to determine which technique is most useful and efficient in improving production rates. This information will be relevant for any project manager, superintendent, or general contractor who are having difficulties keeping up with their production rates and looking for a solution on how to keep better track of all transactions and man-hours.

The objectives of this Case Study are as follows:

- Expand the overall knowledge of the importance of production rates in the construction industry.
- Analyze the different techniques of tracking production rates.
- With my analysis of different techniques used in evaluating productivity, I hope other companies or new project engineers can review my work to help them make informed decisions on how they can improve their own probability and productivity.
- To provide recommendations in improving production rates.
- Lastly show the importance of a good relationship between the managers, superintendents with the crewmembers. It is a highly overlooked aspect in improving productivity.

Case Study

As mentioned above in the introduction section, Overaa construction is a general contractor that specializes in self-performed concrete work. Most of all their revenues come from large concrete jobs making it very crucial to be precise and efficient as possible to maximize profit. Any kind of slip up, miss-communication, or problem on the job can lead to a huge loss whether it is losing money or preventing you to bid and start the next job. Since the economic crash in 2008 Overaa has recognized how important productivity is too a large general contractor in the bay area and developed techniques to help track and improve production rates. Some techniques are stronger than others are while some are easier to manage. This case study analyzes different production rate tracking methods and compares them to each other in the time frame from 2007-2014. The first job Jamieson Canyon water treatment, began construction right before the crash in 2007, Sacramento water treatment plant started in 2011 right after Overaa hired a full-time productivity engineer, and the Napa waste water treatment plant started after the productivity engineer developed tricks and techniques to keep the schedule and flow of work on track. The tracking methods used At the Jamieson Canyon water treatment plant were very minimal; all they did to track hours was compare the original budget hours to the actual man hour reports. A couple years later Overaa established Production goals that was first used during the construction of the Sacramento Water treatment plant. Finally, in 2013 Overaa tracked Napa's production rates through man-hour reports, production goals, meetings with the subs, and charting any problems noticed or observed by the superintendent in the final project analysis report. The success of each productivity technique is compared to each other using the overall success of the job and the information gathered from the people working on each job. As the results come in, Overaa construction and any other project managers will know which method is most efficient in improving production rates through raw data, and a superintendent's perspectives.

Project Specifics and techniques Jamieson Canyon Water Treatment Plant

Jamieson Canyon Water treatment plant was a $35 Million dollar project located in American Canyon Ca that took approximately 30 months to complete. The work consisted of a concrete pre-zonation contractor, including plant inlet flow metering and control. The project included two concrete pretreatment basins, with a common rapid mix system, flocculation equipment and clarification equipment. This job was started and completed before we had a productivity engineer and before we established techniques to track productivity. I interviewed Nick Kebbas the Project manager for this job to ask about what kind of techniques and methods were used for this job and the results were very limited. According to Nick there was not a set way they tried to improve productivity because it wasn't that much of an issue for them, they were doing fine without using tools as production goals. The only kind of tracking used for this job was a comparison of the total estimated production rates with the actual current production rates and offer incentives to the crew establishing a better relationship. If the man-hour rates were good on a consistent level, Nick would reward the crew with a BBQ, catered lunch, or some kind of gift card incentive. The incentives aren't much but when you are building the same thing day after day, the addition of a potential prize or reward adds more joy and pride in the work being done for that day. Figure four below shows the weekly estimated rate next to the actual rate and displayed on a graph to display any kind of trend. For the week of 06/21/2008, there was an estimated production rate of 16.14 hours/100 SF, and the actual was only 4.55 hours/100 SF. This is a very exciting trend to see because this means we are pouring 100 SF in 12 less hours than the original budget called for. Even though this job was a success, there were still things that needed improvement. These rates gives the project manager and superintendent an idea of how hard the crew is working and what needs to be done for improvement as well as giving the estimator a template for future bids. Without these numbers it is easy to fall behind and not catch a mistake; making the margin for error much larger. Communication and efficiency were two things that could have been improved throughout this job to make it an even bigger success.

WEEK ENDING DATE	ESTIMATED PRODUCTION RATE	ACTUAL CURRENT PRODUCTION RATE	OVER (UNDER) ESTIMATE
06/21/08	16.14 HR/100SF	4.55 HR/100SF	-11.59
06/28/08	16.14 HR/100SF	4.69 HR/100SF	-11.45
07/05/08	16.14 HR/100SF	4.54 HR/100SF	-11.6
07/12/08	16.14 HR/100SF	4.72 HR/100SF	-11.42
07/19/08	16.14 HR/100SF	4.25 HR/100SF	-11.89
07/26/08	16.14 HR/100SF	4.59 HR/100SF	-11.55
08/02/08	16.14 HR/100SF	4.43 HR/100SF	-11.71
08/09/08	16.14 HR/100SF	4.78 HR/100SF	-11.36
08/16/08	16.14 HR/100SF	4.62 HR/100SF	-11.52
08/23/08	16.14 HR/100SF	4.63 HR/100SF	-11.51
08/30/08	16.14 HR/100SF	4.7 HR/100SF	-11.44
09/06/08	16.14 HR/100SF	4.7 HR/100SF	-11.44
09/13/08	16.14 HR/100SF	4.7 HR/100SF	-11.44

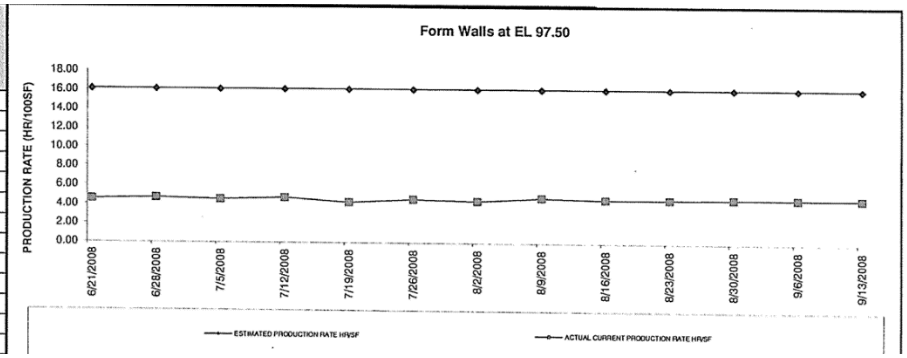

Figure 4: Jamieson Canyon water treatment plant estimated vs actual production rate graph. (Overaa Construction)

Project Specifics and techniques: Sacramento Waste Water Treatment plant

Sacramento's water treatment plant project consisted of work at two water teatment plants, the Sacrmento River water treatment plant and the E.A fairbairn water treatment plant. This project was a $114 million dollar project and there was a total of 120,000 manhours of concrete work. This was the first time since 1923 major construction had been done to this treatment plant. The construction of this job includes construction of mechanical dewatering facilities, FWW sludge collection system, yard piping, site improvements, and other work to create a more cost effective dewatering process and increase plant reliability. I interviewed Johnny Bryant, the superintendent on site to ask what kind of techniques and methods were used for tracking production. After interviewing him, I was informed they used more than one technique to track production because the size of this project was massive, the things they learned from the Jamieson Canyon plant implemented a better analytic approach, and they learned valuable lessons after the economic crash in 2008. Since this project was much larger than Jamieson canyon, there needed to be a different approach on tracking production. The superintendent, crew, manager, and subcontractors had to be on the same page one hundred percent of the time from start to finish, because any form of miss communication would lead to a delay of months, which could be very costly. Johnny Bryant tracked production, and tried improving productivity by comparing the weekly man-hour reports to the original estimate hours, and then from that he and the productivity engineer made weekly production goals that helped keep the project on track as well as keeping everyone more engaged and focused on the immediate task at hand especially the crew.

The goal of establishing a weekly Production goal sheet is to ensure everyone on the job including the superintendent, the project manager, the subs, and the crew are on the same page. Production goals help the crew stay more focused on the current tasks at hand rather than thinking about future tasks that can cause distractions, it ensures that the sub-contractors are on the same page making coordination a lot easier to deal with. Lastly, it gives the team weekly milestones to try and get through which adds more motivation and drive during the long work week. A production goal worksheet is based off the original estimated man-hour reports and the schedule. Before each job begins, the productivity engineer looks at the schedule made by the Superintendent and project manager, and the original estimate made by the estimating department to develop a production goal plan. By using the dates, durations, and estimates he is then able to construct a production goal worksheet that flows directly with the schedule. The content of a production goal worksheet contains a cost code, description of work, crew size, duration, man-hours, and notes. The process of how it is put together is simple; after the production engineer looks at both the schedule and man-hour estimates, he is ready to construct the plan by meeting with personnel associated to that specific task. The plan starts by separating all the big milestone events, which usually include breaking down events like large pours, or installations. Each milestone is then broken up by task associated with that milestone. For example, if the milestone was pour SOG, then the production goal sheet for that week would be broken down into different descriptions pertaining to the description of work. For the milestone of pouring the SOG, some of the broken-down descriptions could include placing rebar, laying down the AB, or forming the walls. The production goal worksheet works like a schedule within a schedule making everything as organized as can be. Figure 5 below shows an example of what a typical production goal log sheet looks like. The second line item states' SOG Form include sumps" which means form the slab on grade at the dewatering building, this line item stems from the milestone event of "SOG pour #1". Once a milestone of pouring the SOG is established, it can be broken down into many different descriptions that will eventually lead up to that pour. All the mini tasks are then grouped into the same cost code to ensure the right man hours go to the right task; this will avoid any problem of accumulating wrong man-hours to the wrong code. After the cost codes are established the production engineer meets with the superintendent to find out how big of a crew he will need for that task as well as how long he thinks the duration will be. The duration and crew size is then multiplied by each other times 8 hrs. in a day to get the overall man hours for that task. For the line item of "DW SOG form include slumps", the crew size was 7 with a duration of 10 days' times 8 hrs. in a day making 560 man-hours. Once the man-hour number is found its compared to the original budgeted man hours and the team now has new knowledge on how much time it should take for each task to be completed within the large milestone and they have a better understanding of what exactly needs to be done for that week. Production goals are done weekly as well which has a lasting effect on the job. Since a new set of goals are made per week they are comparable to each other which helps find areas of weakness and improve them for the following week. Lastly, the last column on the right shares any kind of side notes that will be helpful and informative when working on that certain task. Production goals helped made this job a success by adding organization between all parties involved, as well as giving Overaa a tool they can use to improve on each week.

Job Number: 3275
Job Name: Sac River WWTP
Structure: Dewatering Building

OVERAA Construction **Production Goal Setting Worksheet**

Date: 1/16/2014
By (Supt.): Johnny Bryant
By (Foreman.): Joe Renosa

CODE Cost Code Example: 123456	DESCRIPTION Not to exceed 60 characters (including spaces and punctuation)/use abbreviations / be descriptive. **Include meaningful quantities.** Example: Fnd.A-D line,excv,form,embedsPourStripB/F - 60cy	Characters	CREW Example: 4	DURATION in days Example: 8	MANHOURS Example 192	NOTES Notes; use this area to further describe the goal. These notes **will not** show up on the man hour report Example: assumes neat cut, and template forms, flagman, and cleanup
013102-002-019	**Foreman - Dewatering Bldg**		1	75	600	.
033010-000-019	**DW SOG Form incl sumps**	23	7	10	560	Lowest level Layout, Coordinate underground MEPs. Include hanging forms for pit walls to pour monolythic with slab pour
033010-001-019	**TankEquipPads-** LO,FormPourAStrip-11pads8yds	42	4	3	96	**INCLUDED IN FILLETS**
033030-006-019	**LWRWall#6-** FabFormW/SPourStripCureForms-2,728sf151yds	53	7	10	560	2d fab, 2d one side, 2d double, 2d ties, line & pour
033030-007-019	**LWRWall7&columns-** Strp#6FabFormLinerW/SPlceCJCur-3000sf166yds	60	7	12	672	2d strip, 4d set one side WITH FORMLINER, 2d double, 2d ties, line & pour.
033030-008-019	**LWRWall#8-** Strp#7FabFormPlaceCJsCur- 4,092sf227tds	49	7	13	728	2d strip and clean, 3d set one side, 3d close, 3 line ties and pour.
033030-009-019	**LWRWall#9-** Strp#8&9FabFormPlaceCure-5,084sf282yds	48	7	13	728	3d strip and set one side,3d close , 3d ties line and pour.2d strip.
033010-010-019	**SOG10Elev18.50-** EdgesTmpltsPourCur-462sf35yds	44	4	8	256	After Walls are poured from 16.5 level to Elevation 32.00'.2d edges,2d templates 2d pour and strip.
033010-011-019	**SOG11Elev.18.50-** EdgesTmpltsPourCurStrip10&11-462sf35yds	55	4	8	256	After Walls are poured from 16.5 level to Elevation 32.00'.2d edges,2d templates 2d pour and strip.
033060-012-019	**Deck#12-EL33-** CjsEdgesQCformingembdsScredsCleanUp-2,400sf	56	4	16	512	Deck shoring by Harsco-6d edges with handrails,3d CJs, 2d templates & embeds, 2d pour & strip CJs, 1d wtr blst, 1day strip edges and handrails.
033060-013-019	**Deck#13-EL33-** CjsEdgesQCformingembdsScredsCleanUp-2,400sf	56	4	6	192	Deck shoring by Harsco- 2d templates & embeds 2d

Figure 5: Sacramento Water facility production goals (Overaa Construction)

Project Specifics and techniques: Napa's Waste Water Treatment plant

Napa's Easterly Waste Water Treatment plant was the last job I analyzed. This job was constructed as Overaa established quite a few techniques to improve production thanks to our production engineer. Napa's wastewater treatment plant was an expansion job to the existing WWTP, and the influent pump structure was a cast in place concrete structure. This was a strange job for Overaa because the construction involved depths at around 45 feet, which was the largest depth for any project Overaa has encountered. This was a very complicated job that had many problems arise during construction. Some of the problems included an inadequate project manager that eventually was fired from the job and the company, and site limitations that were very hard to work around. The crew had to deal with that 45-foot depth, a very small jobsite about 5 feet away from the Napa River, and a project manager that contributed almost nothing to the job. After the manger eventually was fired, they brought in a new manager that had to resurrect this job from the dead; his name is Rich Papas. One very crucial way that Rich helped complete this project was establish production goals with the production engineer and superintendent. Even though production goals existed in the company at the start of the project, the first project manager still did not establish them with the crew, which affected this project in a negative way from the start. Since the job, conditions were so unique and the jobsite was so tiny there needed to be organization and goals set from the very beginning of the job to coordinate everyone's schedules and to avoid any issues arising before they happen. Since none of that was done Rich was forced into a project almost a whole year behind schedule, that already lost a ton of money. The only way to finish this job was to get more organized through weekly production goals and meeting with everyone on a weekly basis. The techniques Rich brought when he came to the job to track production, were track the weekly man hour reports, same as Jamieson Canyon, make weekly production goals, same as Sacramento, and bringing in new useful techniques such as the final project analysis. After talking to Rich, he made it clear that if the project started out with proper productivity tracking from the original project manager the job would have most made some kind of profit and finished on time.

Figure 6 below shows an example of a finished superintendent case study that is constructed as soon as the duration of the project ends with the project manager, superintendent and production engineer. The purpose of this analysis is to have on paper why certain problems occurred, and what lessons were learned to avoid these problems on future jobs. It breaks down the actual man-hours vs. the estimated man-hours, and has a section dedicated to lessons learned. Many superintendents, estimators, and project managers reference these ends of the job case studies to future jobs they have been assigned. These reports are extremely helpful to colleagues if a new assigned job has similar qualities and attributes to an old job. The estimating department uses these reports as a reference when putting together bids. From the project analysis, an estimator can verify a future cost on a bid if the job attributes are similar, as well as being able to notice if they missed anything in the original bid that came up during construction. The managers and superintendents can learn new methods and avoid any similar problems they might run into when constructing their job as well as the estimator being able to reference these rates for future bids.

IPS CASE STUDY #3 Napa Easterly WWTP Job #3290

Report information by Superintendent: Chris West – Project Manager: Rich Pappas- Subcontractor : Covello

Description: The Napa job is a expansion job to the existing WWTP, and the Influent Pump Station structure is a cast-in place concrete structure. The S.O.G ranges from 2-4' feet depending on what side of the pump station you are at, and how deep it is. We had to use a specific kind of concrete that was expensive at 134$/yd^3. The walls are either 1', 2', or 3' thick. The depth of the station is the biggest depth we encountered in any of our projects at around 45' feet.

Self Perform Scope: We did most of all the required concrete work on the job, but we subed out the scaffolding and shoring. We should look into doing our own scaffolding and shoring because it would save us time and money.

Forming system: For our forming system we made all the forms ourselves and had them prefabricated in our shop, and we set each wall individually. We doubled up our crew size for installing bulk heads, and singled up our crew for setting wall forms. Because the vertical walls were so large and because our rebar and waterstops got busted from the shoring we hadto use form savers which wasnt in our budget at all. Unfortunately our forming hours skyrocketed because of this issue.

Item	Quantity	Unit	Prod Goal MHS	Actual MHS	Variance	Actual Prod Rate	Unit	Project Specific Additional Comments
Concrete Walls	21,274	sf	5,647	8,097	(2,450)	(0.12)	mhs/sf	
S.O.G	14,530	sf	1,656	2,166	(510)	0.15	mhs/sf	

Lessons learned: Throughout the project there was big learning curve due to the lack of experience from the crew that slowed down the project, if we can even it out so we have more people to help the superintendant to teach the newer workers we will save a lot of time. It was a good thing we fabbed all the forms in the yard because it saved money. Obviuosly if our beginning project manager performed his duties like he should of, there wouldnt be problems like we had, but thankfully our new PM did a great job and helped resurect the project, communication was a huge leason learned from seeing the difference between a active and non-active PM. We should look into doing our own scaffolding and shoring for future projects like this to minimize cost. We also absorbed a huge cost from the sheet piles driven into the ground, and we could look into that as well for future jobs. Overall it was tough job based on certain circumstances but it also turned out to be a job many were proud to be part of because they were able to overcome the obstacles and work though them. The site is fairly small with little room to work, which made the accessibilty some what limited throughout the job. The job started out a mess due to reasons affiliated with the management role of the job. Once we addressed the problem things started to come together but unfortunately we were unable to get out of the hole. There was many problems with this job and it began with the estimate. Our estimate was too low which made us extremly over budget. The hole was very deep which made it hard to get somnething down it whether it was tools, food, water, or laborers, and some of the formwork was very complicated to make up. Because of this issue we had to use a crane for most of the job which wasnt in the budget and we were very far behind on our wall pours.

Attachments: Pictures, pour logs, drawings, estimate, budget, production report and goals.

Figure 6: Napa Water Treatment Final Project Analysis (Overaa Construction)

Successful techniques

The successful techniques to improve production rates and keep a job running smooth are: using man hour reports to compare to the original man hours, develop weekly production goals, do an end of the job analysis, and lastly have proper communication between the crew and upper management. Tension between different team members on a jobsite can cause stress for everyone, which eventually will limit the productivity.

Unsuccessful techniques

Out of the three techniques studied there really isn't any unsuccessful ways to improve productivity. All three methods were proven to be effective for all three jobs. There wasn't a technique used where the project manager or superintendent though to themselves that was completely useless and a waste of time. All techniques were successful but some were more efficient than others were.

Results and Discussion

After analyzing all three case studies, we can come up with a list of methods to improve production rates as well as rank them in order from most efficient to least efficient. The Jamieson canyon water treatment plant case study tracked production solely through man-hour reports and the original estimated hours. While this is efficient and easy, it is probably the least effective because there is not planning involved. The only thing being done is comparing the original man-hours to the actual man-hours. This information is important to know and gives you an idea of how close to the budget your hours are. It does not pre-plan or help avoid future problems like establishing production goals do. The second most effective technique in improving production rates comes from the final case study analysis done by the superintendent and project manager at the end of the job. The final case study analysis is a great reference for other managers and superintendents in the company to look at while trying to plan for a future job especially if the job shares similar qualities as the job being referenced. While having a good relationship with the laborers is highly important it isn't the most effective way to increase productivity. From the three case studies, it is evident that creating production goal worksheets for the duration of a job is the most effective way to track productivity. Through this technique, you get every parties perspective involved on the job as well as getting a forecast of potential problems or delays by pre-planning. After seeing the success of using production goals, Overaa has each superintendent and project manager use them during every project being constructed.

Conclusion and Future Research

Since the economic crash in 2008, Overaa construction has established more techniques to track production in the field to help save money and increase revenues. From experience and history, Overaa developed production goals and final project analysis reports in addition to man-hour reports to ensure quality, and time on a project. This case study shows that there can be advantages of tracking productivity if done properly. According to the majority of interviews conducted for this case study, all future project engineers, and mangers should construct all job plans using production goals. Production goals are proven the more efficient technique out of the three methods especially for large complicated jobs where everyone needs to be coordinated on schedule. While the man-hour reports and final project analysis are useful tools, production goals are proven the most efficient because of the little amount of time it takes to construct one as well as the time and money saved at the end of the job. Many jobs similar to the Sacramento water treatment plant would benefit using production goals especially if the size and complexity of the job are alike. In addition, this case study has shown the importance of early preparation for a job, learning from a job, and the relationships developed within a project team.

As more techniques to track production are developed, it may be beneficial for future researchers to complete additional case studies similar to this one. This will provide a much more accurate and well-rounded understanding of the advantages of tracking production. These subsequent case study results can then be combined into a single study that analyzes and presents the key information from all of them. The results can then be used to determine the future of tracking productivity results and the best way of doing it.

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