Value Engineering of Construction Quantities: "The Golden Report"

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The common materials that are seen everyday on a construction project are concrete, slab dowel baskets and base. Each of these materials can be most seen on highway and road construction. This is often taken for granted since it is in our everyday life. Each of these materials were gathered from a heavy civil project in the greater San Diego area. When collecting my information in the field we gathered existing quantities of concrete, slab dowel baskets, and aggregate. After all of this information is compiled and sent to the project manager hopefully this will result in a decrease in lost profits later on in the project. Although, working for a heavy civil contractor in the Southern California region that has more than proven themselves to be a reliable contractor there is always room for improvement. Even if this result in a small gains in profits for the summer this will be an overall success for the jobsite because the project manager will hopefully have a better understanding of the total profit lose and save money over the length of the project.

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Introduction

One area of construction that isn't greatly focused on in the construction management department at Cal Poly is heavy civil. This is one part of my life thrived since my first internship at fifteen years old. My expertise has been based on water treatment plants and wastewater for the local municipalities in the greater San Diego area. Flatiron seemed like a good change from the usual since they are a heavy civil contractor but with an emphasis on road and highway work. This is where my senior project had the most potential for new knowledge not only for myself but also for the university.

This senior project is an inclusive look into a specific heavy civil roadway project in the greater San Diego area. The total project budget is fourteen million dollars with change orders that increased the overall project budget to eighteen million. When looking at the main focus for my senior project we choice to report on the quantities being used in order to construct the road and how to value engineer the materials to save the project money. The five major aspects of a road are: the subgrade, base, slab dowel baskets and stripping. Out of these aspects we choice to focus on the base, slab dowel baskets, and concrete. These materials can be taken for granted when it is a common occurrence on a daily basis but just like any thing else on a construction project there is room for improvement. This project in particular was on an accelerated schedule because it was placed on UCSD's campus and needed to be completed a couple months sooner than the original contract date. When this deadline was pointed out, it allowed us more freedom to value engineer the three materials listed above under the condition that it would help the schedule instead of hurt it.

Out of the three materials of: concrete, slab dowel baskets and base. Each poised their own challenges that will be addressed later on in this report along with their solutions that were found to be the most helpful.

Process

The process of this project consists of collect data on the total materials being used (concrete, slab dowel baskets and aggregate). Once Flatiron was done doing a takeoff on these three materials, we presented this information to my project manager. After this was completed we asked for his advice on the alternatives that could be used in order to save time and profit. After each of these options were vetted for the jobsite, we went through the process of ordering all the materials along with assembling spreadsheets. The highest amount of discrepancies was found in the base used on the project. Each of these materials will be broken down into greater depths on the next couple paragraphs.

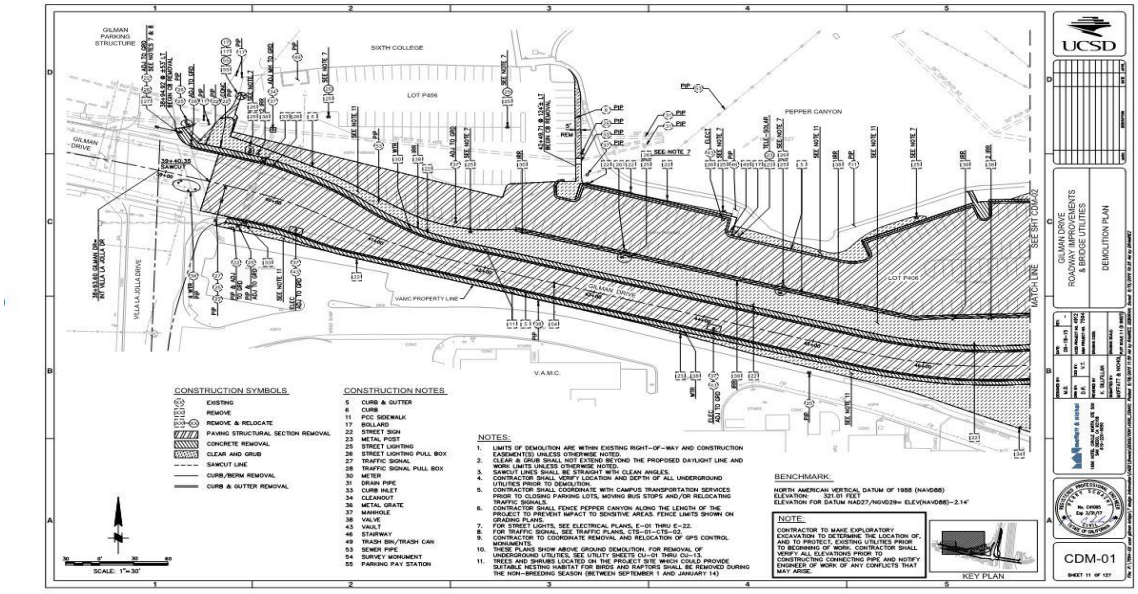

Exhibit A: Gilman drive demolition plan

The primary material to take into account for any roadway project is the existing road. If there already is an existing road in place a plan needs to be created for the removal of the so called material. For our project in particular we needed to remove the existing asphalt roadway and widen the road to take into account for the future bridge tie in. After interviewing the superintendent the best overall plan would be to saw cut both ends the road to create limits of excavation and then use a pulverizer to remove the primary 6inches of asphalt. A pulverizer is a piece of equipment that is mainly used as brute force that hits the asphalt to break up the asphalt into smaller pieces than it also acts like a scraper by dropping the back end to pick up the broken up asphalt. The one down side of this equipment is the time it takes to break up the asphalt, along with the total depth it can penetrate with each break. A good indicator that is used out in the field is a pulverizer can go to a depth of six inches before a decrease in production occurs. On the existing project both ends are built up to a depth of nine inches for the primary fifteen feet and then balanced for the roadway section's six inches. Before the pulverizer was used to demolition the roadway all existing manholes and stub ups had to be removed by an excavator to prevent any damage to the pulverizer. To overcome the fifteen feet at both limits of construction Flatiron used a 380 excavator to remove and load the asphalt into trucks that would be brought to a crusher up the road. We would use this material later on as our structural backfill. Another great thing about this project is the fact that we are demoing existing

asphalt instead of concrete. If Flatiron were to be demoing existing concrete a pulverizer couldn't be used because it would destroy the back end of the equipment that looks similarly to a scraper. Once this is completed Flatiron had one of their subcontractors come on to the project to do the header grinds at both limits of excavation. The header grind is used to take three inches off each limit of excavation to allow for a smooth transition between the current asphalt and the new asphalt being placed later on in the project.

Once the pulviser finishes demo all the existing roadway in place all material must be bought for the production of the roadway. In an existing roadway some of the major concerns are establishing subgrade, finished grade and limits to tie into new curb and gutter. Another major requirement is marking out all existing waterlines that would require major thrust blocks. On this project a majority of these items were value engineered but still meet the requirements of UCSD and Caltrans.

When it comes to establishing base grade, Flatiron had a pulverizer dig down eight inches, which is two inches lower than the Caltrans standard plans. This allowed for a quicker production rate instead of digging down the standard six inches with a pulverizer. If Flatiron were to dig down to the base grade of six inches an excavator would need to come down another inch for the scrapers to begin their cut on base grade. This would decrease efficiency costing the project more money during the shutdown. For all subgrade and base material, Flatiron used the standard class two base which is being supplied from an existing parking area. This was brought up to not only save money but time as well. The procedure for using existing asphalt for class two base is as follows: Flatiron used a grinder in order to demolish all existing asphalt in place. The grinder would then dump all of the finer aggregate asphalt on a conveyor belt into a belly dump truck, which would then take all usable material to the sister project to be filtered. After it was filtered properly and tested using a nuclear testing device by Group Delta, it would then be loaded by a 321 excavator to be brought back to our project. The total road trip from the time in which the asphalt had been loaded up in the belly dump and brought back to the jobsite to be used as base was two hours. At the beginning of the project, the process was actually longer than bringing in class two base by our aggregate supplier Vulcan but once this routine was established, it proved favorable for Flatiron. The total cost for shipping the materials to the sister project and back cost the project one hundred and fifty dollars for the road trip. The main cost that became very imperative from the start was standby time for the trucks. Once again, after this routine was perfected the total amount of standby time diminished from thirty minutes down to fifteen. The total cost of material was all in the cost of trucking and the operator on the excavator to move the asphalt through the filter and back on the truck was one hundred and eighty dollars burden cost.

Exhibit B: Nuclear testing for soil compaction

After this material has filtered through the process, the fine grading would begin. Since the soil is considered to be virgin it would need to be compacted more to release some of the extra oxygen left over after the filtering process. This could be solved by either putting a sheep foot compactor over grade once it has been placed or by running a loaded powder wheel over the base to create maximum compaction. Flatiron decided to use a loaded powder wheel because it was onsite already moving subgrade at one of the limits of excavation. One of the main drawbacks that was seen by running a loaded powder wheel was the total amount of force exerted on the grade. This would later on rupture an existing utility that would later be fixed. If any hindsight would be put into this base process it would be to not to use any powder wheels. It was more of a headache than it was worth in the initial cost savings.

Once our base was in placed and established to the correct grade the placement of stirrups was needed to allow for slab dowel baskets in the concrete. This consisted of three rows of stirrups at six feet on center. The purpose of stirrups in concrete roadways is to reduce the amount of steel in the concrete. Exhibit C shows the plan view layout of a concrete roadway without stirrups and it consists of a lot more rebar. To help value engineer the roadway even more. Flatiron decided to decrease the amount of rows in the concrete but increase the on center layout. The stirrups went from three rows down to two rows with an on centering of four feet. When Flatiron changed the layout of the stirrups it didn't decrease the amount of stirrups but it changed the amount of time it takes to layout the reinforcement in the road. This in turn saved Flatiron more money in the labor side of the roadway cost codes. The total amount of time it took to lay out all the reinforcement changed from 8 hours to 6 hours with the stirrups laid out the it allowed for more prep work when it came to the night time pour.

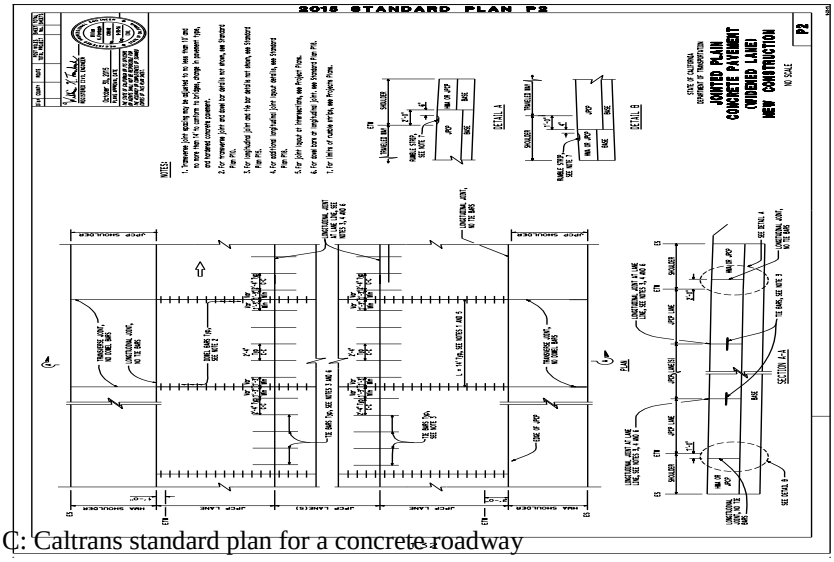

Exhibit C: Caltrans standard plan for a concrete roadway

The main event of paving the roadway caused a lot of interest when it came to value engineering. There were a couple ideas being brought up to help save either time or money. One of the ideas was to use a polar setting admixture that would cause the concrete to set quicker allowing for the roadway to be ready sooner for stripping. Another possibility was using powder alternatives in the concrete to make the concrete cheaper. Some of the alternatives that were brought up were: fly ash, volcano ash and coal ash. All of these options have proven to be beneficial in cost and a very similar product to normally produced concrete. The mix design that was approved by the owner was a four thousand pounds per square inch fly ash concrete with a polar set to allow for the concrete to harder quicker. When Flatiron choice to use concrete with Fly ash it decreased the overall cost of the concrete per cubic yard from one hundred and eighty-eight dollars to one hundred and fifty nine dollars by Hanson one of the main concrete suppliers in the greater San Diego area. The roadway was then sectioned into manageable sections for a night pour. Flatiron decided to make

each night pour around two hundred and fifty feet because this made it easier for the paving subcontractor to touch up all sides of the roadway while still being able to maintain the amount of trucks arriving on campus.

New Knowledge

Many of project engineers will conduct a quantity take off and end up going with the specified materials, since there aren't any true databases of alternatives that have been approved. When I conducted this senior project I gained new knowledge on alternatives used on key materials of a highway construction project. The materials that were seen to be the best to value engineer were: base, steel supports in the concrete, and concrete. Each of these materials were then inspected to make sure that they still meet the owner's requirements along with being a cheaper alternative for Flatiron. The hope will be to come up with a better representation of value engineering that will give an increase in profit up to ten percent.

Deliverables

The final deliverables for this Senior Project is a full analysis of quantities collected in the field to give realistic values for alternatives materials occurring on a highway project. This will in turn allow future projects engineers more effectively calculations of replacement materials saving the general contractor money in the long run. Flatiron's project is a boiler plate for most roadway projects. This consisted of a contract that was put out to public hard bid with the ability to value engineer materials in order to save the most money without giving a deficient product.

Lesson's learned

The reason why I think this would be beneficial to the construction industry because it will give the project engineers the real life alternatives of materials, which will in turn allow them to increase profits. As a project engineer starting out of college the most important thing that helps with progress is existing knowledge. The ability to use this senior project as a future project engineer to better understand how a highway project is conducted would be greatly beneficial. There were a couple lessons learned on this project. One of these lessons was the use of recycled asphalt that could be filtered in order to save money on the cost of class two base. Another lesson learned was the rearrangement of steel supports in the concrete can decrease the total amount of time to prepare for a concrete pours. Finally, the last thing that was learned was the need to put alternative powders in the concrete along with liquid admixtures to increase the setting time. When the concrete was cheaper and set faster it allowed for Flatiron to fast track the amount of concrete poured allowing the paving subcontractor Payco to arrive onto the project sooner.

Future Research

Future Cal Poly students could take this senior project even further by value engineering different materials related to roadway constructions. Some of these could consist of: stripping, curb and gutter, and grinding overlays. These are parts of the industry that require subcontractors to arrive onto the project in order to complete certain tasks. Another aspect that has really been touched on in this paper is the reporting of these alternatives to other projects and see if these alternatives are just as successful. Flatiron was fortunate for their track record. This allowed for trial and error that has perfected the process.

Bibliography

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