

DESIGN AND APPLICATION OF RECYCLED ASPHALT ROADS FOR A
VINEYARD IN SAN LUIS OBISPO COUNTY

By

Carl Gates Molitor

Agricultural Systems Management

Bio-Resource and Agricultural Engineering Department

California Polytechnic State University San Luis Obispo

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AUTHOR : Carl Gates Molitor

DATE SUBMITTED : June 10th, 2013

Keith Crowe

Senior Project Advisor

Signature

Date

Dr. Ken Solomon Ph.D., P.E.

Department Head

Signature

Date

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ABSTRACT

This project encompasses the design, schedule and budget of a recycled asphalt driveway located on a vineyard in San Luis Obispo County. The design parameters that served as the basis of this project were provided by Mr. Jean-Pierre Wolff of Wolff vineyards. He owns and operates a local winery on the outskirts of San Luis Obispo. He implemented a similar upgrade on his own winery. The purpose of these road improvements was to improve the conditions for the grapes as well the air quality for visitors to the winery. The new road needed to be wider and more suitable for all weather conditions than the existing road. A wider road made the vineyard more accessible for large delivery trucks and large equipment. A width requirement and all-weather surface road is also enforced by the California Dept. of Forestry (CALFIRE) and county fire requirements. As mentioned in Article 2 *Summary of Fire Safe Regulations Title 14 Code of California Regulations: Division 1.5, Chapter 7, Subchapter 2, Articles 1-5*, CALFIRE of the mandates that any access road must be at least 18ft wide and be an all-weather surface for access in the event of an emergency.

The design of this road was completed in AutoCAD. This program provided a 2-D cross sectional model of the road. Cross sections are the most efficient way to convey a design scheme for this application. The dimensions used in this design fit all the parameters that were set by Mr. Wolff and CALFIRE. A 3 to 6 inch base layer would cover the existing roadway and have a width of at least 18 feet. The 3" top layer of recycled asphalt is placed on top of the base material. Swales and drainage systems will be installed where necessary.

If this design were to be implemented it would increase the quality of the environment of the vineyard for both the plants and the stakeholders that use the road on a regular basis.

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INTRODUCTION

The state of California is covered by over one hundred and seventy thousand miles of roadway. A large portion of these roads are constructed using a mixture of hot oil mixed asphalt. There are many different types of hot mix asphalt, varying in the size of aggregate and the oil mixture content. With a typical road needing to be resurfaced every 10-12 years, there is a problem. What happens to the old asphalt when it is replaced?

Nationwide and throughout the state of California there are massive stockpiles of asphalt spoils forming. There are few, if any, long-term solutions for using the spoiled asphalt except for private operations like vineyards and farms that use the asphalt spoil to maintain their transport roads that interconnect their fields and/or vineyards.

Using spoiled or recycled asphalt, farmers are using a material that otherwise is deemed useless. Not only is it a cost effective way to maintain farmer's transport roads or driveways, it solves the problem of having large stockpiles of used asphalt.

This project is applicable to agriculture because it affects the efficiency of the vehicles on the access and perimeter roads of the fields. The recycled asphalt creates more traction for the tires and improves growing conditions for the plants, which raises the quality of the product. This leads to higher grape yields for the vines and creates a better environment for the operation as a whole.

The purpose of this project is to understand the design and the construction of recycled asphalt on driveways and transport roads for agricultural applications.

LITERATURE REVIEW

Overview. A search was initiated to identify any data on the application of recycled asphalt or “grindings” and their application on access roads in an agricultural application. The recycled asphalt grindings are only used in small scale operations. Most grindings are broken down into sand size particles and are re-used class 2 base material. There is little published material on the applications of asphalt grindings because it is done on such a small scale.

Broadening the search and looking outside agricultural focused databases found a good source found in “Haul Road Design Considerations.” This article’s main focus is on mine haul roads, but is applicable to the scope of this Senior Project (Thompson, 2009).

There are two main phases for implementing haul roads for any application, whether it is in the agriculture, mining, or construction. These two phases are a design phase and an operational phase (Thompson, 2009).

- Basic haul road design data
 - Where will the road be?
 - When is construction to take place?
 - What area is affected by the new access road?
 - Type of vehicles to be used on these new roads?
- Geometric Design
 - Necessary dimensions, grade and alignment
- Structural Design
 - Considerations of native soils
- Functional Design
 - Traffic Index-Low-density traffic

Environmental Impact. An article titled: Impact of Total Petroleum Hydrocarbon Concentration and its effects on Soil Around Asphalt Producing Facility in Obinze Owerri helps explain what kind of damage happens to the soil when asphalt mixtures are exposed to the natural soil. Oil pollution is a major public health hazard, especially with inhabitants close to the industrial environment, as there could be possible seepage and subsequent ground water contamination. This contaminate water calls for serious public health intervention. Further, contaminated soils are usually deficient in macro and micronutrients necessary for plant growth and optimum yield.

Interviews. Large portions of this project came from interviews and personal experiences with people from industry. Wolff Vineyards is a local winery who has used recycled asphalt on their own operation to improve the accessibility on the vineyard. Detailed specifications issued by Caltrans and other government organizations are somewhat helpful, but since the scope of this project is for private and custom applications, these standards are too strong. Further information regarding the unit rates and pricing for fine grading are from my current employer, Granite Construction Company.

Jean-Pierre Wolff, Ph. D Owner / Vintner. Mr. Wolff was very knowledgeable and gave me a large basis of information on his personal application of a recycled asphalt road on his winery located at 6238 Orcutt Road in San Luis Obispo, CA. We discussed general engineering practices of drainage control, soil types, dust control, equipment, intended and unintended environment impacts, and schedule. Paragraphs below; Drainage Control and Road Design, Types of Soil, Dust Control, Equipment and Environmental Impacts were all developed through personal communications with Mr. Jean-Pierre Wolff (Wolff, 2013).

Drainage Control and Road Design. The road was originally narrow and in his application, and he expanded the road to 20ft wide. Installing culverts that directed the runoff water into his vineyards allows him to retain water that is normally lost and is also environmentally friendly. Cal Fire mandates that fire access roads must be a minimum of 20 feet wide and be made of an all-weather material. Furthermore, the roads needed to be wide enough to allow large trucks on the roads for import and export from the vineyard.

Types of Soil. Asphalt itself is susceptible to cracking erosion. To combat this effect, extra sand was added to the mixture. They acted as sealants for potholes and a binder of the fine materials in the asphalt. Other options were the use of red rock and class 2 base materials. These were local and viable options for this road design but were lesser alternatives due to their price and material resiliency.

Dust Control. Fugitive dust occurs from simple traffic on roads that surround vineyards. These dust particles carry dust mites which then land on the leaves of the grape vines and destroy them. Also, with a high volume of traffic, the overall air quality for people is reduced.

Equipment. Three different pieces of heavy equipment were used by Jean-Pierre Wolff to complete his asphalt roads. 1. An asphalt paver 2. Vibrating roller 3. Fog Sealer. Along with this equipment, he hired a contractor to grind the material a second time after receiving it from the contractor. The contractor extracted it from a local street rehabilitation.

Environmental Impacts. Unintended environmental impacts include the use of recycled asphalt. The recycled asphalt does contain oils and tar that are detrimental to the natural environment. Another fact is that a road in general effects the natural habitat of the land. Intended Environmental Impacts include unpaved roads that create a lot of dust, decreasing the quality of breathable air and harming the plants.

In conclusion, the impacts of installing the recycled asphalt road far outweigh the effects that an unpaved surface would have on the surround environment.

Schedule. The Wolff Vineyard application performed by Mr. Jean- Pierre Wolff took roughly 1 month from start to finish. Timing was an essential part of the success of this project. Since the asphalt was coming from a local street rehabilitation in San Luis Obispo, the grindings were fresh and the oils that had bound the street together were exposed and seeping out. It was crucial to use the wet oil when reapplying the material to the roads. That oil would help the road bound together again just as it was used the first time in the road.

PROCEDURES AND METHODS

Preliminary Stages. The first step is to determine the feasibility of completing a project of this nature. Installing any type of roadway can be very costly. Many questions have to be answered before ground is broken on a project. Important items like project scope and funding are two of the most important questions that need to be answered by the stakeholders.

There needs to be a carefully defined area in which a new road will be installed. This task can include the use of a land surveyor and grade checker in the preliminary stages. A land survey can be performed by a licensed surveyor in the state of California. The surveyor determines where the high and low elevations are in the area where the proposed road is to be built. This information can be vital when determining how much material is required to complete the project.

Second is to determine the performance of the road. There are many options for installing a driveway on a winery application. Some items that need to be considered when defining the scope of the project include traffic volume, native soils, and supply of asphalt materials in the area, how much material is needed, and how long the life of this road is before it needs to be replaced.

The next crucial decision that needs to be made is whether this project will be performed in-house or will it be hired out to a contractor to deliver a completed project. In either scenario, it is vital to establish a budget for the project and to implement a contingency plan for unforeseen events and conditions that might influence the success of your project. For the scope of this project, it is assumed that the project is being self-performed with a sub-contractor brought on to perform small portions of the work such as the regrinding of the spoiled asphalt. Often, the spoils that are ripped off of a roadway come in a large variety of sizes that need to ground down to a much more uniform size (1/2" to 3/4" mixes). This type of equipment is hard to come by and is almost always used by a hired specialty contractor. This contractor is usually hired on an availability basis, but the contractor can also be selected on the basis of "low-bid." This is where there might be multiple contractors in the area who compete for the work by submitting a bid of how much the work will cost to complete. The contract is then awarded based on who can perform the work for the least amount of money and on the appropriate schedule. In this case, the price might be based on a unit price of \$/ton of grinded asphalt or possibly be a lump sum or flat fee for performing the work. These values can differ depending on the contractor.

Schedule. The schedule below is based on a 1 month or 20 working day allotment of time. It is based on a completed project on the Wolff Vineyards land in San Luis Obispo. The schedule was built using a program called *Microsoft Project*, a program that shows a visual representation of project duration and provides a guideline to make sure the project is on schedule with specific milestones and deadlines. This is a fairly simple schedule for a project that is not very sophisticated. The parameters of the project include the delivery of nearly 1,000 tons of asphalt, 1,750 tons of class 2 base material, leveling and fine grading of a 1½ mile driveway using that 1,750 tons of class 2 base regrinding, placing and paving of the recycled asphalt along the 1½ mile driveway. Major milestones for this project are the mobilization or beginning of the project. A project like this relies on good weather. When scheduling this project, pick a time and duration that will least be affected by weather. This schedule has work beginning on June 10th and completed one month later on July 10th. The project parameters are set for the Central Coast of California, where little weather impacts the area. This allows weather to have a minimal impact on the schedule.

The second major milestone for this project is the paving stage. The leveling and fine grading portion of the project may be completed after all the base material has been delivered to the site. The leveling and grading work is not held up by the regrinding and stockpiling of the asphalt. Since is its not affected by this, they may occur at the same time, as long as there is enough staging area for both operations to be occurring at the same time. Once all the leveling and regrinding has taken place, the paving milestone can be achieved. The paving is the actual placing of the recycled asphalt on the road but it is not the final stage of the project. Immediately following the paving stage, the material must be compacted. Finally, a layer of fog-seal coat is placed on top as a binder to hold the road together and give it a longer life span. Figure 2 below is a visual representation of the schedule

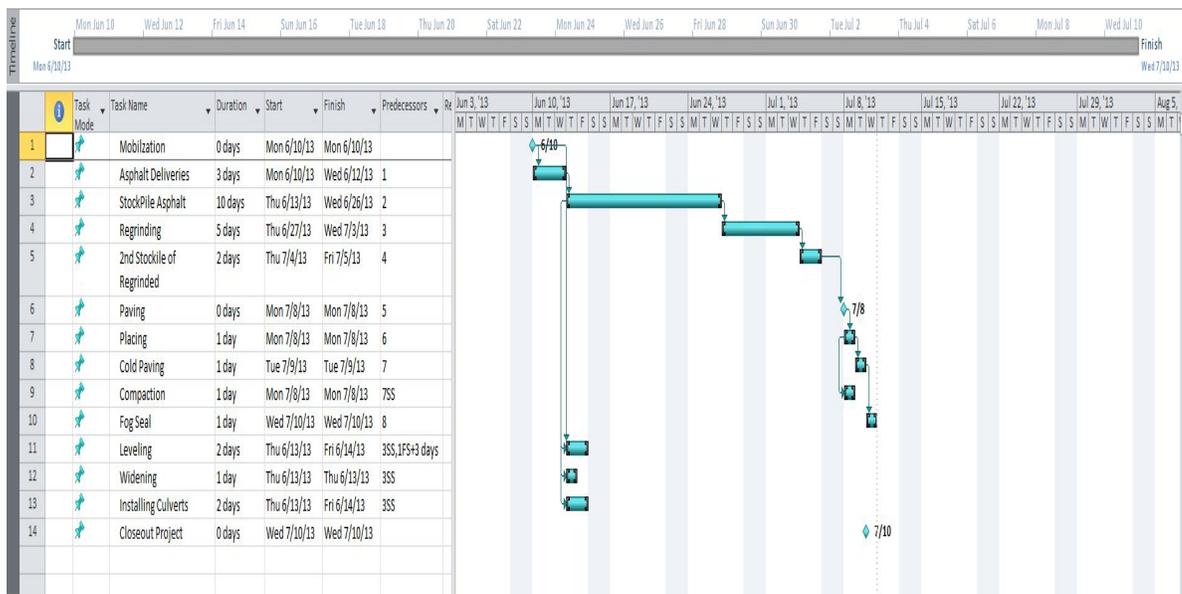


Figure 1: Microsoft Project 1 Month Project Schedule

Design

Initial Design. The initial design of the recycled asphalt road is modeled after a “typical” roadway common in the United States. This particular design is modeled after Figure 307.2 the *Highway Design Manual* (CALTRANS, 2012). This crown shape design has a high point in the middle of the road. This allows for water to drain off the road keeping it dry safe for drivers even at high speeds. It is a simple design that easily defines each side of the road. The design is also the industry standard for resurfacing. As a road ages and needs to be rehabilitated the slope of the road acts as a guide for taking away the correct amount of material. Since the asphalt grinders cut at an angle this design makes the most sense.

As mentioned earlier, there are standards that an access road must meet per the regulations set by the local fire dept. and state agencies such as CAL FIRE. The road must have a width no less than 20 feet to accommodate emergency vehicles, large transportation vehicles such as delivery trucks and 18-wheelers. (CA Code of Regulations, Chapter 7) The road has been designed with a 1-2% cross sectional slope integrated into it for easy run-off. There is no need for a drastic fall from the center of the road for this application. This project is based off a moderate climate on the central coast, so little precautions are needed in the event of violent weather. If the application is being performed in a more turbulent climate, further precautions may need to be taken or the life of the road may drastically decrease. A 1-2% cross-fall is very achievable using a bulldozer or blade.

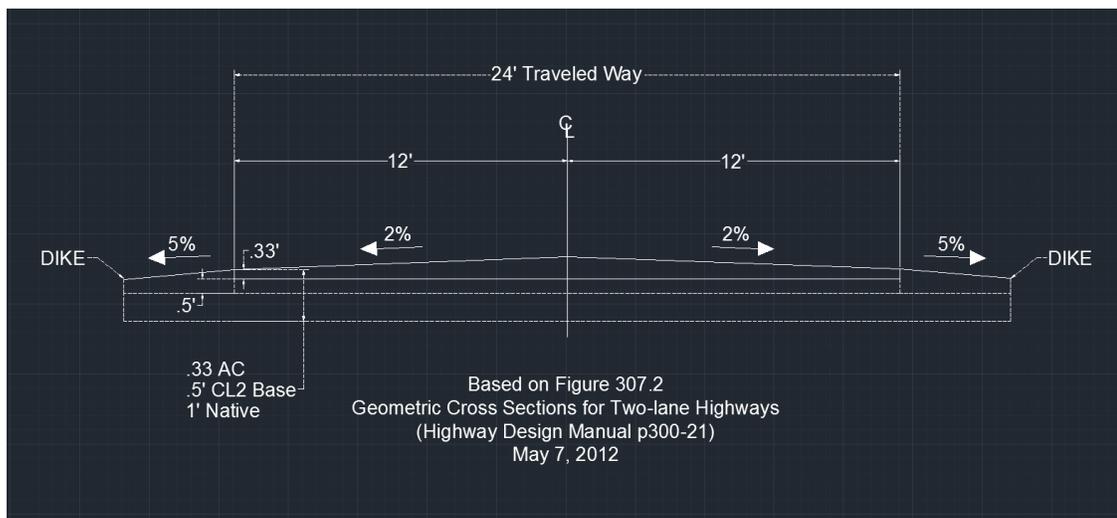


Figure 2: Initial Design Crown Shaped with 2% fall

This design calls for a road that has a 24 wide traveled way with a 2 percent slope leading away from the centerline. Further there are dikes placed on each side of the road for thorough drainage away from the road. These dikes have been set at a standard of a 5 percent slope leading away from the crown of the road.

Final Design. A single slope design is another option for a design of a recycled asphalt road. This is the final design chosen for this particular project based on its ability to help retain water on site. With a single sloped road that it is oriented to slope towards the vineyard, it allows all the runoff water to be controlled and possibly recycled for the vines. Implementing a “Bio-swale” system can also decrease the impact pollutants in the run-off have on the environment. Further, it is much easier for an operator to only have to worry about one slope instead on two slopes like the previous design had stated. Many of the same principles explained in the first design apply to this design, but the benefits for this design outweigh those from the first one based on the feasibility of the owner of the project.

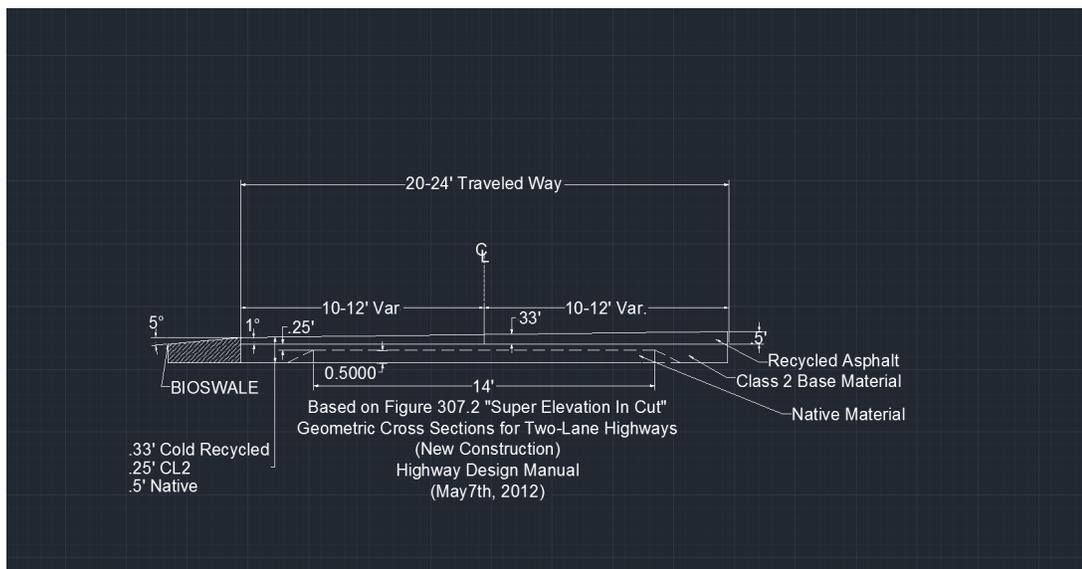


Figure 3: Final Design Super Elevation in Cut 1% Fall

RESULTS

This project is meant to serve as a simple reference for anyone that might be looking to implement a recycled asphalt system on his or her own property even though many of the quantities may be different, and much of the itemized cost can vary depending on the specific area. All construction operations are projects not processes. Each is an individual and unique. No two projects will be completed alike. Therefore, certain precautions need to be taken for each individual project. Simply trying to recreate the same project on a different site may result in a delays and an overrun on the budget.

The goal was to aid in being able to perform a system like this with the least expense possible. It is understood that this one-month schedule is based on a small crew of only 3-4 labors/operators performing all the work. The estimated cost for this project is \$55,425.00 for materials and equipment. Cost of labor is not included in the price. The feasibility of completing a project similar to this size and budget without hiring a contractor is very likely. It is a relatively simple project for anyone with an engineering or construction background.

Mr. Wolff, who was a huge asset to this project, was able to complete a project with similar parameters to this senior project with a budget of \$20,000.00. This is a large cut in budget compared to the projected \$55,500 budget for this project. Some major areas where there were differences in price would be trucking and buying the base material needed to make the road structurally sound. Mr. Wolff was able to mine all red rock base material he needed off of his own property which saved a large quantity of money and time on his project.

DISCUSSION

Design. The project emphasized all the design concepts used in road design today. Furthermore, they have been used for decades. Many parameters had to be taken into account to make this project a success. Design changes should be made to insure that owners are getting what they want out of a project. Without the use of programs like AutoCAD or background experience in engineering or construction management, performing a project like this could present a lot of issues.

Base Material. For this project, the best option was to use class 2 base materials, which can be bought by the ton at any local stockpile yard. Another option, such as the one Jean-Pierre Wolff used, was to obtain a small mining license. Since he had the resources to do it he was able to mine all the native red rock base material he needed for the project. Unfortunately, this is rare when trying to acquire base material for a project of this magnitude. The largest issue with acquiring base material is the expense. There are a wide range of costs which are all area dependent. The biggest expense is trucking the material, which can cost an owner anywhere from \$65-\$100 dollars per hour per truck. The best method for trucking this much volume of base material is a double bottom dump truck. Bottom dumps have a very easy delivery method. They simply drive past the area where the material needs to be deposited and open the gates. The material is simply dispersed on the ground as the truck drives along. This also makes it much easier during the leveling and earth moving stage because the material can be place strategically to minimize the amount of earth moving required for a given project.

Pricing on the central coast is currently \$90 dollars per hour for these types of trucks. The heaped capacity is roughly 22 CY or 12 TNS of material. Important variables to consider when purchasing base material is:

1. How far away is the base material coming from?
2. How many trucks to hire depending on schedule flexibility?
3. How many roundtrips can be made in a single day?
4. How much material does can be delivered in a single day?

Recycled Asphalt. In this scenario, the recycled asphalt was being trucked in from a local contractor that was performing a street rehabilitation nearby. This is an inexpensive way to get very good material to make recycled asphalt roads. Most general contractors will offer the spoils free of charge or at a low cost because they are saving a large amount of money on trucking and storage fees. It is common that the contractor will charge you simply the cost of trucking for the asphalt grindings.

Recycled asphalt is not the only option for a driveway. In some cases, it might be the least expensive depending on the site conditions. Concrete and Hot Mixed Asphalt (HMA) are prime options but both come at a higher cost. Higher costs translate into longer life spans for the road.

In most cases for projects like this one, the road is typically designed to be able to handle a much larger traffic demand than it will actually experience over the life of the road. Aesthetics and personal choice can become a deciding what materials to be used.

Project Cost Analysis. To be able to put together an accurate price for this particular project assumptions and parameters had to be made.

Assumptions:

1. Estimate of quantities based on Wolff Vineyard Property, which entailed roughly 1.5 miles long. Mr. Wolff determined the estimate on 1,000 tons of recycle asphalt.
2. 158,000 SF is roughly how much ground will be covered with recycled asphalt upon project completions
 - a. Does not include dikes or culverts
3. Equipment unit prices are based a rental fee from Granite Construction Company INC.
 - a. Paver, Screed Op, Back Hoe trucking was based on a \$/HR basis.
 - b. Vibrate Plate and Fog Sealing Equipment was based on a \$/Day rental basis.
4. Cost estimates for both material and equipment based on regional prices on the Central Coast varying between San Luis Obispo county and Santa Barbara county.
5. The table below shows material and the equipment required to perform all of the operations to complete this project.

Budget:

Budget						
Recycled Asphalt Driveway						
Project						
1000 TN's of Asphalt						
158,000 SF						
17500 SY						
MATERIAL RATES	Description	Unit of Measure	Estimated Quantity	Unit Rate		Cost
1	Recycled Asphalt	TON	1000		/TON	N/A
2	Class 2 Base Material	TON	1750	\$10	/TON	\$17,500
3	SS-1H Oil (TACK COAT)	GAL	1750	\$3	/GAL	\$4,725.00
						\$22,225.00
UNIT RENTAL RATES		Rate (\$/HR)	Operation Time (HR)	Quantity		Cost
1	Operated Cat asphalt Paver	\$321	24	1		\$7,704
2	Screed OP	\$105	24	1		\$2,520
3	Vibrate Plate	\$25/DAY	8	1		\$25.00
4	Fog Sealer	\$55/DAY	16	1		\$55.00
5	BackHoe-JD710	\$168	16	2		\$5,376
6	Trucking (Super 10's)	\$90	32	4		\$11,520
7	Regrinding Material	LUMPSUM	40	1		\$6,000.00
			160	11		\$33,200.00
					Total	\$55,425.00

Figure 4: Theoretical Budget for Designed Project

Cost Analysis Parameters. The majority of the assumptions made for this project were to make a comparison to the work done on the Wolff property. This was a project that had already been completed by Mr. Wolff and was done in a matter of one month and completed by him and 3-4 laborers at a time. No costs were allocated in the budget for labor with the exception of the Asphalt paver, which needs to be operated by a professional. The lump sum amount of \$6,000 dollars was the quoted amount given to Mr. Wolff by a contractor who performed the grinding of the asphalt spoils. The material needed to be ground down to a tolerance of $\frac{1}{2}$ " to $\frac{3}{4}$ " material.

Grade Checking. A grade checker may come later during the leveling and site work stages. A grade checker's job is to stake out the final elevations of where the road is supposed to be. Generally, a grade checker places a stake on each side of the road in increments of 50' along the length of the road. This is vital during the leveling process; this gives the tractor operator a guide of where there needs to be cut or fill.

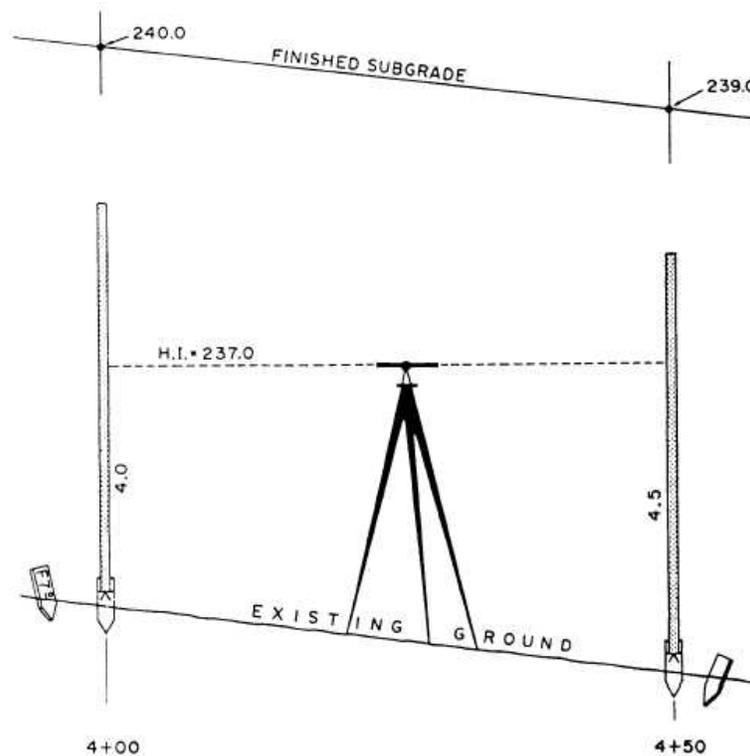


Figure 5: Example of Grade Checking

RECOMMENDATIONS

It should be noted that no one should attempt a project of this size without having proper means to cover the high cost of installing a driveway. Hiring a contractor to complete the work can result in a higher cost to the owner as well. Without the proper knowledge and experience of engineering or construction it may serve as the best option for the projects delivery. By hiring a contractor, many more regulations and contracting would be necessary to stay within the realms of the law.

Some methods not used in the project would be the added cost of putting a chip-seal coat on top of the recycled asphalt. This is a process that is commonly used to resurface parking lots and driveways. They can increase the longevity of a driveway or parking lot by 5-10 years depending on how much weather the area is susceptible to. Another large factor not tied into the total cost for this project is cost of labor and fuel and lube on equipment. Whether a project is being done in-house with rented equipment or being performed by a contractor, fuel and lube are important costs that need to be mentioned in the final proposed budget.

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Appendix A: How Project meets Requirements for the ASM Major

HOW PROJECT MEETS REQUIREMENTS FOR THE ASM MAJOR

ASM Project Requirements

The ASM senior project must include a problem solving experience that incorporates the application of technology and the organizational skills of business and management, and quantitative, analytical problem solving. This project addresses these issues as follows.

Application of Agriculture Technology. The project involves the application of working with equipment on an agricultural application. This is a real world process that can be potentially used in industry

Application of Business and Management Skills. This project focuses on the economic feasibility of a construction project entailing the installation of 1.5 miles of roadway on an agricultural application

Quantitative, Analytical Problem Solving Skills. Analytical problem solving skills include deciding what the most efficient road design that will work for this application.

Capstone Project Experience

The ASM senior project must incorporate knowledge and skills acquired in earlier coursework (Major, support and/or GE courses). This project incorporates knowledge skills from these key courses.

- BRAE 129 Lab Skills/ Safety
- BRAE 133 Engineering Graphics
- BRAR 151 AutoCAD
- BRAE 142 Machinery Management
- BRAE 203 Ag. Systems Analysis
- BRAE 239 Engineering Surveying
- BRAE 321 Ag. Safety
- BRAE 418/419 Ag. Systems Management
- CM 213 Heavy Civil Construction Management
- CM 212 Fundamentals of Construction Management

ASM Approach

Agricultural Systems Management involves the development of solutions to technological, business or management problems associated with agricultural or related industries. A systems approach, interdisciplinary experience, and agricultural training in specialized area are common features of this type of problem solving. The project addresses these issues as follows:

Systems Approach. The project involves the integration of a schedule, cost estimate and design of a recycled asphalt road on a vineyard. This provides a service to all stakeholders involved in the Winery.

Interdisciplinary Features. The project touches on several aspects of the ASM curriculum while also includes principles of construction management.

Appendix B: Map of Wolff Vineyards. 6238 Orcutt Road. San Luis Obispo, CA

Appendix C: 1 Month Microsoft Project Schedule

Appendix D: Initial Design: Crown with 2% fall

Appendix E: Final Design: Super Elevation in Cut 1% fall

Appendix F: Estimated Budget for project.