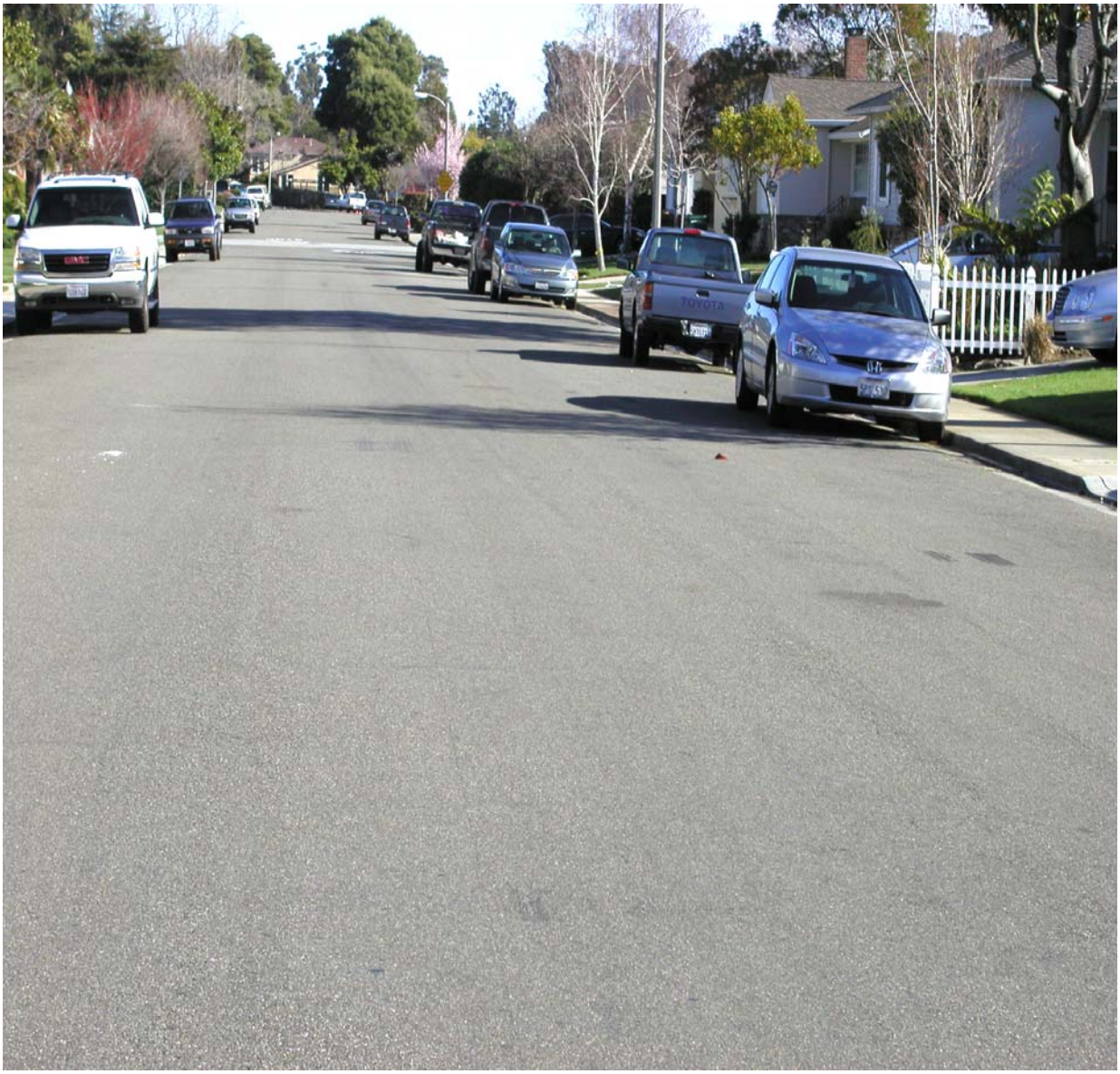
Pavement Rehabilitation Analysis



Half of this street was rehabilitated with rubberized asphalt chip seal and the other half with rejuvenating scrub seal; can you tell which is which?

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Introduction

The City of Novato has approximately 293 lane miles of asphalt concrete (AC) roadways. This represents a large portion of the City's infrastructure and is the key to transportation for residents and others. Over time AC roads degrade and as is true of every city, Novato rehabilitates the streets that can be restored to a good condition and replaces those that are damaged beyond that level. In order to better understand the issues with paving, one needs to understand AC and also the ways in which roads fail.

AC is comprised of asphalt (the binder or glue that holds it all together) with a combination of small and large aggregate (rock). The asphalt is one of the products produced from refining crude oil and comes in varying viscosities (ability to flow) and quality (like the quality of gasoline). The aggregate has different gradations (sizes of the rocks) depending on the paving requirements. The small aggregate reduces the distance the asphalt has to span in order to bind the large aggregate together, and it extends the time the asphalt will retain its elasticity (ability to stretch). The aggregate and asphalt are heated and mixed together into a homogenous fluid AC. The AC is then evenly placed on the street with a paving machine and compacted to provide the driving surface. The thickness of the AC depends on the anticipated traffic loading and the existing underlying soil conditions.

All road surfaces fail to varying degrees over time. The failures involve not only the asphalt concrete, but the underlying material as well. If the under-pavement material, which can be compacted rock or just compacted soil, is in good condition it will support the AC paving and the road will remain functional. If the material under the paving becomes soft, settles, breaks up, or in some other way fails to support the AC, the road will fail to the point of needing complete replacement of both the paving and the supporting material. This type of failure does not occur in most cases. Typically, AC paving will have surface failures (cracks) that are due to pavement deterioration. This kind of failure can be taken care of by rehabilitation or maintenance.

Roadway deterioration over time results from a number of different factors, the main ones being weather and traffic. AC paving is negatively affected by four weather elements: 1) sunlight, 2) rainfall, 3) wind, and 4) temperature. Sunlight breaks down the asphalt causing it to lose its elasticity and binding capacity, which in turn allows the smaller aggregates to break loose. Rainfall will hasten the process of the small aggregate breaking loose from the binder through erosion, and will wash away the smaller aggregates. Rainfall also changes the level of groundwater, and that causes the underlying soils to expand, resulting in reduced asphalt elasticity. Wind will also hasten the loosening of the small aggregate from the binder and blow the small aggregate from the roadway. Although fairly uncommon for this area, freezing temperatures will expand any water that is entrained in the AC, causing cracking and loss of fine aggregate. Seasonal temperature changes result in thermal expansion and contraction of the pavements and these cycles eventually will also cause cracking and deterioration.

Traffic affects the roadway by deflecting (bending) the AC and by the wearing action of the tires (turning, stopping, starting, etc.). Most of the damage caused by deflection is due to heavy vehicle (usually truck) traffic. Most roads are designed to take minimal truck traffic and can handle the

lighter vehicle loading with little effect. Just like rainfall, the deflection from heavy vehicle traffic will cause the asphalt to lose elasticity and its ability to keep the aggregates bound together. Tire action hastens aggregate loss.

AC is porous (allows water to pass through) and the less water that passes through it, the longer the roadway will hold up. As the elasticity of the asphalt deteriorates and the small aggregates break loose, cracks begin to form. As cracks form, more water is allowed to pass through to the supporting material below, and over time will cause sub-surface failures and ultimately total roadway failure. Studies have shown that cracks will start appearing in recently resurfaced streets, on the average, within three to five years. Pavement interlays can be used to delay the cracking for a short period of time and will provide a moisture barrier but these do not prevent the development of cracks. Interlays can also used for lateral (sideways) and structural (depth) strengthening.

Rehabilitation Strategies

In the past, the conventional method for rehabilitating the AC was to grind the road (either its edges or the entire roadway), place pavement reinforcing fabric, and place a new layer of AC over the entire surface. Normally an edge grind can only be done once on a street because it increases the crown (hump in the center of the road) and the cross-slope of the street. If a street is edge ground more than once, the resulting surface can lead to potential driving and driveway entry problems. Grinding the entire width of a street is done when the existing crown has reached is maximum allowable height, when the cross-slope has become too steep or the existing paving surface has become higher than the concrete gutters, creating a potential tripping hazard. The cost of this type of rehabilitation has risen sharply over the past five years, and with limited funding, the City sought an alternative paving strategy to reduce costs and more efficiently minimize the damage caused by weather and traffic, and thereby extend the life of the City's roadways. Staff determined that the new strategy needed to address certain criteria: cost efficiency, waste reduction, environmental friendliness and resistance to the effect of expansive soils.

After staff reviewed literature about various pavements, two strategies appeared to meet the criteria; 1) Rubberized Asphalt Chip Seal and 2) Rejuvenating Scrub Seal (Also referred to as "Polymer Modified Asphalt Surface Sealant", or Pass). As a result, staff conducted more intensive research to determine the advantages and disadvantages of each product and the process by which it is installed.

Rubberized Asphalt Chip Seal

In this process, the asphalt binder is enhanced through the addition of both asphalt and crumb rubber modifiers. These two additives increase the elasticity of the asphalt and its ability to adhere to the existing AC and newly installed chip (fine aggregate). The chip that is to be placed on the street is coated with the asphalt binder prior to installation. The modified asphalt binder is heated to 385 – 450 degrees Fahrenheit, blended, and then spread across the roadway by a tanker truck equipped with a spray bar. Immediately after that the coated chips are placed on the roadway. Then heavy equipment rolls over the coated chip to ensure that the chips are embedded into the modified asphalt binder. After the chips have been allowed to set, the final step is to cover the rubberized asphalt chip seal with a slurry seal or microsurfacing. Both of these sealing methods use mixtures of asphalt, sand

and rock, and they differ only in the type of asphalt and the sizes of the rock.

This product and process requires precautions in order to have a safe installation and an end product that is acceptable. Heating a modified asphalt binder mixture that contains rubber produces fumes that are hazardous and damaging to the environment. Consequently, special vacuum and treatment equipment is required to ensure that the byproduct fumes are not released into the atmosphere. In addition, precautions must be taken to ensure that there are not overlaps in the application. Where overlaps occur, the double application of the asphalt binder, the chip coating and spraying of the street, has resulted in what is termed "bleeding" on newly installed streets. Bleeding occurs when the asphalt is brought to the surface by vehicle traffic and a lowered skid resistance area is created. This in turn can create problems with a vehicle's traction and stopping ability.

Quality control is extremely important during this application process to ensure that the proper amount of modified asphalt binder is spread across the roadway at the required rate and that no overlapping occurs. The spray truck needs to be properly calibrated to ensure that the modified asphalt binder is spread evenly across the street at an optimum application rate. If too much of the modified asphalt binder is applied to the street or if overlapping/double application were to occur as mentioned above, bleeding would occur and result in lower skid resistance pavement surfaces. Due to this concern, there are limitations to the application of rubberized asphalt chip seals. For instance, since the application of binder on sharp curves can result in overlaps, the material is not applied at the ends of cul-de-sacs or at corners. Additionally, from the experience of others using this product, it has been noted that the stopping and starting of vehicles also results in material bleeding. As a result, the material is typically not applied within 50 feet of any intersection. That means that at the ends of cul-de-sacs and at intersections, some other pavement treatment must be employed to make the roads homogeneous in condition and appearance.

Rejuvenating Scrub Seal

In this process, the asphalt binder is enhanced through polymer modification (addition of elastic material). The asphalt modifier increases the elasticity of the binder and its ability to adhere to the existing AC and new chip. The modified asphalt is combined with water to create an emulsion for easier application to the roadway surface. The chips are not coated before placement on the street. After the existing paving surface and cracks are cleaned, the emulsion is spread across the roadway by a tanker truck equipped with a spray bar and a broom array (scrub broom). The broom is used to push the emulsion into the cracks and help to spread it evenly. Next rock chips are placed and rubber-tired vehicles roll over the chips to ensure that they are embedded into the modified asphalt binder and forced down into the cracks. The final step is to cover the Polymer Modified Asphalt Surface Sealant with a slurry seal or microsurfacing. This is the same final surfacing used in the rubberized asphalt chip seal process.

Unlike other hot applications, the emulsion is only heated to a maximum of 150 degrees Fahrenheit and does not require any special equipment other than the scrub broom. Since the scrub broom evenly distributes the emulsion across the roadway surface, this eliminates the concern about overlapping. For that reason, the material used in this process can be applied to all parts of a street including the ends of cul-de-sacs and intersections. In addition, experience has shown that due to the properties of the emulsion, bleeding is not a problem in stop and start areas at intersections.

Quality control is less of a concern with this process as the preparation and application of the material does not result in any by-products that are harmful to the public or the environment. However, particular attention needs to be paid to be sure that the scrub broom(s) are in good condition and have the proper array to spread the emulsion evenly.

Cost Comparison

At the time the comparison was being performed (FY 04/05) the costs for the different strategies were as follows:

- AC overlays 2-inch thickness including edge grinding and pavement reinforcing fabric ranged from $6.00 to $9.00 per square yard.
- Rubberized chip seals, including modified asphalt binder and chips and slurry seal, ranged from $5.00 to $7.00 per square yard.
- Rejuvenating scrub seal, including modified asphalt binder and chips and slurry seal, ranged from $2.00 to $4.00 per square yard.

Comparison

- Since both processes use a modified asphalt binder, they both seal the existing roadway better than a conventional AC overlay.
- With the use of modified asphalt binder, both processes will withstand the weathering, traffic and expansion of the underlying soils better than a conventional AC overlay.
- Both processes will resist cracking better than conventional AC overlay.
- Both processes rehabilitate the roadway through the application of a thin layer of modified asphalt binder to the existing roadway, and little or no removal of the existing AC.
- Both processes place the modified asphalt binder directly onto the street rather than having it mixed at a plant and delivered to the site by truck.
- Both processes are applied in thin layers approximately 3/8” thick.
- Both processes require minimal compaction effort because the layers are thin.
- Both processes place the modified asphalt binder onto the roadway followed by placement of a layer of small aggregate (chips) that provides a primary seal.
- Both processes can be installed without a wearing surface, although a slurry seal or microsurface is applied in most cases. If there is no curb and gutter, a thin AC overlay is sometimes applied.
- The rubberized chip seal is slightly better for use in filling low spots in the road.
- The rubberized chip seal process requires thorough quality control to ensure that by-products do not contaminate the environment.
- The rubberized chip seal process cannot be used at the ends of cul-de-sacs or in intersections.
- The rubberized chip seal requires crack filling prior to the process, normally without chip.
- The rejuvenating scrub seal fills cracks as part of the process with chips being pressed into the cracks.
- The rejuvenating scrub seal process can be applied to all parts of the streets.
- The cost of the rejuvenating scrub seal was substantially lower than the cost for overlays and

the rubberized chip seal process.

- The rejuvenating scrub seal is more environmental friendly and safer due to the lower temperature at which the binder is placed.
- The final or wearing surface options are the same for both strategies that provide a secondary seal to the AC over the primary seal.

As part of the investigation, other agencies that have utilized one or both processes were contacted to learn from their experiences. Staff contacted the cities of Burlingame, Modesto, Stockton, and Watsonville, and the County of Marin, and discussed in detail the preparation, installation, problems and costs associated with both processes. All of the agencies confirmed the information that was presented by vendors and information presented in this document. The agencies were satisfied with the processes, but confirmed the limitations that have been noted. They all indicated that the installations improved with time as their staff learned from their experience and made adjustments to improve their programs. Most of the agencies chose the rejuvenating scrub seal due to the environmental concerns associated with the rubberized asphalt chip seal. The other reason for choosing it was that it provided basically the same benefits as the rubberized chip seal at a significantly lower cost.

Additionally, staff visited the cities of Burlingame, Greenfield, and Vacaville to see the products in their final form. The installations that were observed were from three to ten years in age and all looked to be in fine condition. Although small cracks were noted in some of the streets, staff was told that they healed each summer and had not resulted in road failures. The City of Burlingame had one street in which half was rehabilitated with the rubberized chip seal process and the other with the rejuvenating scrub seal process. It was very difficult to visually tell the difference between the two halves of the street.

Conclusion

The rubberized chip seal cannot be used to seal the entire street and has a greater risk of bleeding. The rejuvenating scrub seal is more environmentally friendly and requires less stringent quality control. The rubberized chip seal did not cost that much less then that of an AC overlay. The rejuvenating scrub seal resulted in a substantial cost saving when compared to an AC overlay.

Recommendation

The rejuvenating scrub seals should be utilized on residential streets, collectors and some arterials. The rubberized chip seal should be considered for isolated cases where improving the surface for a smoother ride is necessary.

Answer to Question on Front Cover

The left side of the photo is rejuvenating scrub seal and the right side is rubberized asphalt chip seal.