December
Tires and Tire Rubber

This packet provides information about how and why to use tire and tire rubber in roadway construction and maintenance projects.

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Material Brief

Scrap tire management is a challenge worldwide. Texas generates approximately 20 million tires annually, roughly one per person. An additional 70 million shredded tires are stockpiled at registered storage sites throughout the state, plus an estimated 2.3 million whole tires remain at illegal tire dumps. In 1998, there were end uses, or demand, for approximately two-thirds of the tires generated that year, leaving an excess of approximately eight million scrap tires. In other words, the supply exceeded the demand that year. (See material availability map and table, page 18.)

Road construction end uses can, and should, be part of the scrap tire solution. Applications for scrap tires—whether in the form of crumb rubber or tire shreds—can yield engineering benefits and a positive life-cycle cost-benefit ratio in certain highway construction projects.

TxDOT has conducted eight research projects to identify beneficial uses for scrap tires in highway construction and maintenance applications. During the past four years, TxDOT has consumed the equivalent of more than 2.3 million tires in asphalt rubber hot mix, crack seals, shred seals and embankment fill.

As part of a joint Texas Natural Resource Conservation Committee (TNRCC)–TxDOT initiative, TxDOT will develop an action plan to increase the use of scrap tires in state and local road construction operations. One important action item will be to provide training work sessions for Texas scrap tire processors and highway industry representatives on the methods to incorporate scrap tires into various roadway features.

Progress on the development of highway end uses must be reported to the Texas Legislature on January 1, 2001.

Overview

Scrap tires are troublesome to manage. There are expenses associated with all phases of handling tires. In addition to the normal collection and transportation costs connected with all scrap materials, there is extra expense in landfilling tires. Texas law requires that tires be split, quartered or shredded before they are disposed in a landfill. Dealing with insect, vermin and fire problems linked to stockpiling and processing scrap tires addes even more to disposal cost.

From 1992 to 1997, the State of Texas managed all scrap tires under the Waste Tire Recycling Fund (WTRF) program financed by a $2 recycling fee charged to consumers for every tire bought. During the program, tire generators were guaranteed free collection of scrap tires in exchange for collecting the recycling fee. The fund paid tire processors to collect and process the tires. When the WTRF program expired on December 31, 1997, tire generators and processors, including local governments, resumed scrap tire management responsibilities under a market-driven system.

End use demand for scrap tires falls into four primary categories:

- tire-derived fuel (TDF),
- civil engineering,
- crumb rubber and
- other miscellaneous uses.

As Figure 1 shows, the largest end use in Texas is TDF (62 percent), consuming more than double the next largest end use, civil engineering (30 percent). Crumb rubber and other miscellaneous uses each consume approximately four percent. There is minimal recycling of scrap tires into the production of new tires in the tire manufacturing industry.

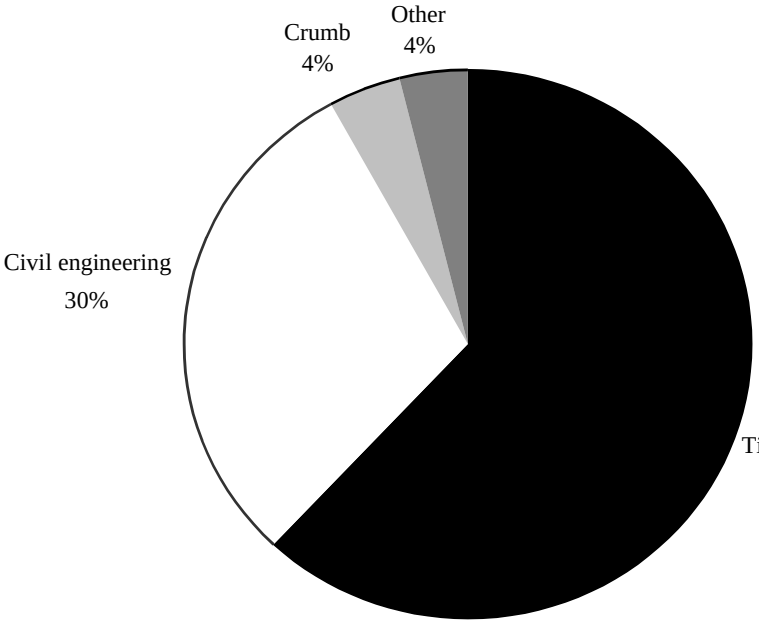

Figure 1. 1998 Scrap Tire End Uses in Texas

Within these four broad scrap tire end use categories, there are a number of specific uses. These uses are summarized in the following table and then explained in more detail.

Table 1. End Uses for Scrap Tires

Scrap Tire End Use Category	Specific Use
Tire-derived fuel (TDF)	Burn whole tires
	Burn tire shreds
Civil engineering	Landfills
	On-site sewage facilities
	Land reclamation
	Erosion control projects
	Highway embankment fill
Crumb rubber	Highway asphalt materials
	Products
Other	Whole tire projects including bales
	Die-cut products

Tire-derived fuel (TDF)

The major use for scrap tires in Texas is tire-derived fuel. This use has steadily increased since 1995, accounting for more than half the tire recycling rate in 1998.

Using whole or shredded tires as a fuel supplement to boilers and cement kilns reduces the demand for fossil fuels. Tires are a desirable alternative to coal because they are compact, have consistent composition, contain a low moisture content, produce high levels of heat, and have been shown to burn cleaner than many types of coal burned in Texas.

Some public concern has been expressed about the use of TDF at power facilities, but the TNRCC believes scientific evidence has demonstrated that tires can be safely burned as a fuel, provided that proper emission control devices are used. The United States Environmental Protection Agency (EPA) reached the same conclusion. In fact, there may be evidence that burning tires results in a nitrogen oxide (NO_x) reduction when TDF is used to supplement other fuels.

Cement kilns can safely burn tires because of their unusually high operating temperature and oxygen-starved environment that allow for complete combustion

of tires and oxidation of the steel beads or belts without adversely affecting kiln operation. Ten facilities, most of them cement kilns, are presently equipped and permitted to use whole or shredded tires as a partial fuel source. Only six of these facilities, however, burned tires in 1998.

Table 2. Texas Facilities Burning TDF

Facility name	Location	Size of tire burned
Capital Aggregates	San Antonio	Whole
North Texas Cement	Midlothian	Whole
Texas-Lehigh Cement Company	Buda	Whole
Holnam	Midlothian	1" to 2" shred
Donohue Industries	Houston	1" to 2" shred
Texas Industries-Cement	Hunter	1" to 2" shred

TxDOT has a specification that allows for a $2 per cubic yard premium to be paid for cement produced at cement kilns using scrap tires for at least 15 percent of their fuel stock (see Special Provision to Item 524 at the end of this packet).

Civil engineering

A number of different end uses fall within the civil engineering category, including: landfill applications, alternative porous media in the drainfields of on-site sewage facilities, land reclamation, erosion control projects, and highway embankment fill. The majority of scrap tires used in civil engineering applications in Texas are shredded to size specifications and permitted at landfills as either daily cover or leachate collection media.

Tire shreds, scrap tires cut into 3- to 12-inch pieces, can be used as a lightweight fill material in embankments. This shred application has been used more than 70 times in the U.S. Tire shreds as a fill material have the potential to improve construction results if the embankment project has a problem with weak foundation soils or a potential for slope slide failures. If the properties of tire shreds—lightweight, free-draining, low-pressure, and durable—are needed, then tire shreds may be less expensive than alternatives that address the same problems.

TxDOT has experimented with the use of tire shred embankments in El Paso. This project was among the first constructed in the nation after the adoption of the ASTM standards. Engineers at the University of Texas at El Paso and Texas Tech University are collecting research data on the performance of tire shreds in this project. (See Case Study #1.)

Crumb rubber

Crumb rubber is defined as rubber that has been reduced to a particle size of 3/8 inch or less. It can be produced by mechanical or cryogenic size reduction. Buffings, which are generated during tire retreading, can be used as a feedstock for the tire crumbing process. Asphalt rubber products and production of other products, including traffic control devices, use crumb rubber.

Crumb rubber can be blended into asphalt and used in several different highway applications. Crumb rubber asphalt, according to ASTM, is defined as “a blend of asphalt cement, reclaimed tire rubber, and certain additives in which the rubber component is at least 15 percent by weight of the total blend and has reacted in the hot asphalt cement sufficiently to cause swelling of the rubber particles.” Crumb rubber modifies and improves the performance of the asphalt binder. The modified binder is commonly referred to as asphalt rubber. (See Case Study #2.)

Crack seal and shred seals are the most commonly used applications of rubber modified asphalt by TxDOT. Rubberized crack and shred seals offer performance benefits.

Crumb rubber, however, cannot be used to modify all asphalts successfully. It does not work well in "Type D," for example. The best use for asphalt rubber binders is in particular types of mixes typically used in areas of the state with heavy traffic, extreme temperatures, and low rainfall. These conditions fully utilize the properties of the modified asphalt. Another constraint on the use of asphalt rubber is job size. The life cycle cost benefits of asphalt rubber hot mixes cannot typically be fully realized on projects less than 25,000 tons.

Several research studies on the use of crumb rubber as a substitute for aggregate in concrete, sponsored by TxDOT, indicate that adding rubber to concrete weakens it, which could be problematic in some applications.

Other miscellaneous uses

This category includes rubber or die-cut products, playground applications, mulch, silage cover, bales, metal recovery, resale and whole tire uses. Traffic control devices made from rubber die-cut products would also be included in this category.

Rubber or die-cut products can be used for weighting bases on traffic cones, delineator posts, barrels and other traffic control devices to prevent them from being blown over in the wind. Road construction contractors and TxDOT frequently purchase these types of products. While traffic control devices offer an excellent use for scrap tire pieces, they do not consume large volumes of scrap tires.

Research Summary

Tire Shreds in Road and Bridge Construction: Civil Engineering Applications of Shredded Tires

Desirable properties

Tire shreds have a number of qualities that make them well suited for use in road and bridge construction. Tire shreds are:

- lightweight
- good thermal insulators
- low-pressure
- durable
- free-draining
- low-price

Tire shreds can help reduce fill weight and address slope stability, landslide and embankment settlement problems. Tire shred unit weights (compacted in place) range from 40 pcf for a thin fill with no soil cover to 60 pcf for a thick fill covered with a thick soil cover. Gravel compares at 125 pcf. For retaining wall and bridge abutments, tire shreds reduce wall pressure, which can save money. For example, using tire shreds as backfill can lower pressure at the base of a 5-foot wall by 50 percent.

Tire shreds are more permeable than most granular aggregates and can be used in roadside French drains or drainage layers. Tire shred permeability is greater than 10cm/s. Tire shreds have also been shown to be a great thermal insulator, eight times better than gravel. Moreover, tire shreds are durable and cheap.

Tires shreds are generally uniformly graded with specific gravities ranging from 1.02 to 1.27 depending on whether steel belted, glass belted or a mixture. Specific gravities for soils are typically 2.60 to 2.80, more than double that of tire shreds. Water absorption capacities generally range from 2 to 4.3 percent. Unlike with most soils, water content does not affect tire shred compaction. Compacted dry unit weights of tires range from 38–43 pcf, approximately 1/3 the unit weight of soils. However, the unit weight of tire shreds does increase under the weight of overlying soils and tire shreds.

Large volumes of tires can be used in civil engineering construction applications. As a guideline, 75 tires yield about 1 cubic yard of compacted tire shred fill, and 1,000 tires will fill a 14-cubic-yard dump truck.

Tire Shred Compressibility

Tire shreds used in road and bridge applications settle during construction and within a month or two after construction due to the weight of the overburden. Settlement varies, but a 14-foot thick tire shred layer (3-inch pieces) covered with about 6 feet of soil settled more than 3 inches after the soil was in place. Temporary post-construction deflection also occurs each time a vehicle drives over the pavement. Deflections decrease as the thickness of the overlying soil increases and tend to be less for 3-inch shreds than for 12-inch shreds.

Initial tests show that soil cover for maximum pavement life using 3-inch tire shreds should be 2.5 to 5 feet to minimize deflection. It is important not to underestimate the compressibility of tire shreds.

Design Considerations—Paved Roads

Tire shreds should be wrapped in an appropriate geotextile, with 18-inch overlaps at the seams, to prevent surrounding soil from being washed between the tire shreds. The 3-inch nominal shreds are easier to shape to the desired grade than 12-inch shreds. To compensate for post construction compression, it

is necessary to overbuild the tire shred layer so that the compressed elevation of the tire shreds is at the desired level. Moist soils compact much more easily over tire shreds. Final grading and paving should be delayed to allow for tire shred settlement.

Mixing soil with tire shreds to minimize compression is not recommended. The difficulty of mixing the soil and shreds increases construction costs. Improper mixing may lead to long-term settlement problems. Also, soil decreases the benefits tire shreds offer.

Design Considerations—Unpaved Roads

Soil cover on unpaved roads should be thick enough to prevent rutting and will depend on the thickness of the tire shred layer and on traffic loads. Use of geotextile may be unnecessary with 3-inch shreds.

Design Considerations—Retaining Walls and Bridge Abutment Backfills

Because tire shreds exert less than half the pressure of gravel, retaining walls built with shreds can be thinner and, therefore, cheaper. When using 3-inch shreds, a reasonable coefficient of lateral earth pressure at rest is 0.40 for design.

Geotextiles should be used to separate the tire shreds from the surrounding soil using a "belt and suspenders" design at the contact between the geotextile and the back of the wall.

Design Considerations—Frost Penetration Limits

Tire shreds provide thermal insulation to reduce frost penetration depths. The shreds have been shown to reduce penetration by up to 25 percent. The thermal conductivity of tire shreds (0.1 to 0.2 Btu/hr-ft-E F) is eight times lower than that of typical soil.

Design Considerations—Drainage Layers

Tire shreds have very high permeability and are an attractive substitute for granular soils in highway edge drains, French drains and drainage layers at the bottom of subgrades. Tire shreds need to be completely enclosed in geotextile to prevent fines from reducing permeability.

Environmental Considerations

Experiments indicate that tire shred leaching levels are below the limits for metals in primary drinking water standards and for metals with secondary standards, except for manganese and iron. Tests for volatile and semi-volatile organics showed non-detect levels for all compounds measured above groundwater. Tire shreds are not recommended for use below groundwater tables at this time.

Construction Specifications

Pay quantity: Be specific as to how quantity is measured, i.e. loose-in-truck, compacted in-place or compacted with overlying soil cover. The general contractor assumes liability for the quantity of tire shreds loose-in-truck. Tire shred suppliers or general contractors assume liability for shreds compacted in-place. Buying tire shreds by the ton may reduce the contractor's bid price but requires the project manager to track weight tickets.

Stockpiling: Tire shreds may need to be stockpiled on-site to keep construction projects on track.

Spreading: Tire shreds can be spread most easily with a track-mounted dozer or track-mounted loader. A smaller dozer is easier to use than a large one.

Compacting: Twelve-inch compacted lift thickness works best for 3-inch shreds, using a heavy vibratory smooth drum or vibratory sheep's-foot roller or heavy, standard-width track dozer in 6 to 8 passes. Granular soils for cover are easier to compact over tire shreds if they are slightly wetter than optimum.

Exothermic Reactions in Tire Shred Fills

Of 70 installations of tire shred fill applications in the U.S., three experienced exothermic, or heat-producing, reactions. These three were very large installations with a number of common features that should be avoided in the future, including: free access to oxygen, thin soil cover, topsoil placed directly on tire shreds, tire shreds contaminated with liquid petroleum, lots of exposed steel, contact of tire shreds with fertilizer and concentrations of crumb rubber.

In general, recommended preliminary construction procedures are to:

- provide at least four feet of soil cover to reduce oxygen and water infiltration (soil should contain a minimum of 25 percent fines);
- prevent topsoil or fertilizer from coming in direct contact with tire shreds;
- use large tire shreds (8-inch nominal for fills of 10 feet or more);
- limit exposed steel belts; and
- limit the amount of crumb rubber included with the shreds (no more than 1–2 percent passing #4 sieve).

ASTM Approval

TxDOT has adopted ASTM's "Standard Practice for Use of Scrap Tires in Civil Engineering Applications." This standard practice includes information on material characterization, construction practices and leachate. The ASTM Subcommittee D-34.15, Construction and Other Secondary Applications of Recovered Materials, has approved the standard practice, as has the ASTM Committee D-34 Waste Management.

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Case Study #1

El Paso Tire Schred Embankment Case Study

In 1996, TNRCC approached TxDOT about helping to find an end use for scrap tires accumulating in El Paso. TxDOT agreed to construct an experimental embankment using tire shreds as a fill material, and TNRCC agreed to pay to have the scrap tires shredded to TxDOT specifications. The El Paso project was the first tire shred embankment built in Texas and the first in the nation to compare two different methods of construction utilizing tire shred fill.

Project overview:

In July 1998 TxDOT used approximately 4,500 tons of tire shreds as embankment fill material on the Loop 375 overpass in El Paso. Loop 375 crosses over Alcan, Dyer, McCombs and Bomarc streets. The bridges have been built by incorporating tire shreds behind the earth retaining structures.

One embankment consists of 100 percent shredded tires, maximum size of 12-inch shreds, enclosed in a geotextile wrap—much like a burrito—and covered with compacted soil. This embankment is located on the east of Dyer street. The unit weight of this size uncompacted tire shreds is 22 lbs/cubic ft. A total of 4,895 cubic meter tire shreds have been used with 6,192 cubic meter of embankment material in constructing geotextile fabric wrapped tire embankment section.

The total width of the "burrito" embankment is 80.7 ft (24.6 m) and the height of the embankment is 26.6 ft (8 m). Shredded tires fill material placed in the center of the embankment is 48 ft (14.6 m) wide; suggested height of the soil/shredded tire fill is 5.4 ft (1.8 m).

Construction began during the last week of June 1998. The shredded tires were spread with track-mounted bulldozers and compacted with a sheep's-foot roller over the full width of the shredded tire section during the first week of July 1998. The complete shredded tire section was constructed in six 12-in (300 mm) thick lifts. An additional 14-in (36 cm) thick layer of shredded tires was placed on the top of the embankment to compensate for the settlement due to the placement of the overlying soil.

The compacted shredded tire section was then covered with the geotextile. A minimum overlap of 18 in (450 mm) was allowed between the sheets of the geotextile wrap. The "burrito" is confined by 16 ft (5 m) of compacted soil on each side of the section and by a 13.2 ft (4 m) soil cap on top.

A second embankment type consists of a mix of 50 percent soil and 50 percent shredded tires and is also covered by compacted soil, located on the west side of Dyer street and the west side of Bomarc street. This embankment contains a maximum tire shred size of four inches, sections while the unit weight for the uncompacted tire chip was 25 lbs/cubic ft.. A total of 5.802 cubic meter tire shreds have been blended with 13,120 cubic meter of embankment material for the 50:50 soil-tire mix sections.

The 50 percent soil and 50 percent shredded tire embankment's total is 80.7 ft (24.6 m), and the proposed height of the embankment is 26.2 ft (8 m). The width of the fill is 48 ft (14.6 m) and suggested height 6.6 ft (2 m). Shredded tires and soil mixtures were spread in seven 12-in lifts, and each one was subjected to a non-vibratory compaction.

After compaction of the seventh lift, an additional 16-in (40 cm) layer of soil tire chip mixture was placed and compacted on the top. A trench was excavated around the embankment to construct retaining wall footing.

All the tires shreds used on this project were processed to TxDOT specifications by a TNRCC-paid contractor.

The third embankment type consists of conventional soil fill with the total width of the embankment measuring 88.3 ft (26.9 m) and the proposed height 19.7 ft (6 m). Fill material was placed in approximately 12-in (300 mm) thick lifts.

Researchers from the University of Texas at El Paso (UTEP) are currently evaluating constructability, short- and long-term performance. Instrumentation has been installed to obtain settlement, leachate and temperature data for short- and long-term evaluation. Researchers at Texas Tech University are evaluating costs.

Specifications

TxDOT Special Specification Item 5160 for Tires For Use In Embankment has been included at the end of this packet.

Test data

Monitoring devices were installed at each embankment. Measurements were taken on: vertical settlement using horizontal inclinometers and magnetic extensometers, temperature variation using a system of thermocouples, leachate using a sump pump, and air quality using air ducts.

The settlements observed for the 100 percent shredded tire embankment and the tire shred/soil mix were less than expected. The 100 percent shredded tire embankment had a maximum settlement of 1 inch, and the mixed embankment had a maximum settlement of 0.8 inch, both of which are minimal. This settlement has occurred during eight months of construction.

There have been no significant temperature elevations within the 100 percent shredded tire or the mixed embankments. Test results also indicate that the soil tire chip mix is less impacted by the ambient temperature than the 100 percent shredded tire chip embankment.

No water has percolated down to the sump, so no comparison of leachate has been made yet.

Table 1. Burrito Tire Shred Gradation**

Sieve Size	Percent Passing
300 mm (12")	100% min
200 mm (8")	75% min
37.5 mm (1.5")	100% min
4.75 mm (No. 4)	1% max

**Exposed steel and crumb rubber should not exceed 1 percent by weight. Shreds must be free of any contaminant, such as oil or gasoline.

Table 2. 50/50 Soil-Tire Mix Tire Shred Gradation*

Sieve Size	Percent Passing
100 mm (4")	100% min.
75 mm (3")	95% min.
50 mm (2")	50% min.
4.75 mm (No. 4)	15% max.

*Exposed steel should not exceed 1 percent by mass of the shredded tires.

Results

The tire shred embankment in El Paso appears to be functioning without problems.

TxDOT's costs for using the tire shreds in the embankment were considered high, coming in at more than double the costs of using traditional fill materials. These costs were due to a 30-mile haul distance

to bring the shreds to the project site, at a cost of $3.16/cubic meter, and the contractor's lack of familiarity regarding the compaction effort of tire shreds. Better understanding of this material and planning may reduce these costs in future projects.

Table 3. Cost Comparison of Embankment Fill Used in TxDOT's El Paso District

Type of embankment material	Construction cost per cubic meter
100% tire shreds	$11.62
50:50 tire-soil mix	$9.60
Conventional soil	$5.00

It is important to note that these cost figures do not include expenditures by the TNRCC, which totaled more than $600,000 to transport, shred and provide security for the 4,500 tons of tire shreds used on the project. It is also important to note that tire as a fill material have the potential to improve construction results if the embankment project has a problem with weak foundation soils or a potential for slope slide failures. If the properties of tire shreds—lightweight, free-draining, low-pressure, and durable—are needed, then tire shreds may be less expensive than alternatives that address the same problems.

To maintain the construction schedule, the conventional soil fill was placed and compacted on top of the shredded tire section before side constrains in the form of the conventional soil fill were placed. As soon as the first line of retaining wall panels was placed, the conventional fill material was placed between the shredded tire section and the retaining walls. By then, the wrapped shredded tires section was covered by about a foot of conventional fill.

Due to the lack of side constraint, the shredded tire wrap became flatter and wider than intended. This significantly reduced the settlement but, also, somewhat diminished the advantages of a lightweight fill and increased the quantity of shredded tires used in the project.

A more effective process may be as follows. The retaining wall should be constructed to a level slightly higher than the proposed height of the shredded tire wrap. The geotextile should then be placed to separate the shredded tire section and the compacted soil. The tire wrap constrained by the two side sections should be constructed next. The compacted shredded tire section should then be wrapped with the geotextile. The rest of the construction can proceed with the covering of the shredded tire section with the conventional fill material until the final grade elevation is reached.

The proposed construction guidelines ensure side confinement so that the compaction level will be achieved by rearrangement of the shredded tires. To achieve consistent levels of compaction, the number of roller passes will be less. In addition, the shredded tire section will be stronger due to a reduction in void spaces by the rearrangement of tire shreds.

Stringent construction quality control and a better enforcing mechanism for the proposed specifications are also desirable. The specifications proposed by TxDOT suggest that the shredded tires should not be longer than 12 inches. However, whole tires were observed during the compaction of the shredded tires. These tires were typically shredded but they were held together by the steel wires.

The construction specifications suggest that no exposed steel wire should be in the

tire shreds, and no soil should be present in the 100 percent shredded tire section. The geotextile wrap should fully separate the tire shred section from the conventional fill. In reality, these specifications were not always followed.

The University of Texas at El Paso (UTEP) researchers are evaluating constructability, quality control/quality assurance procedures, instrumentation data, short- and long-term performance and cost. They will develop a report with their evaluations, conclusions and recommendations. The UTEP researchers have also developed an excellent web page with weekly pictorial updates on the construction activities and embankment monitoring results. Their web address is http://www.utep.edu/civil/tirechip/tirechip.htm.

Contacts

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Case Study #2

Asphalt Rubber Hot Mix Asphalt Concrete in the Odessa District

Project Overview

The Odessa District installed an 18-mile section of asphalt rubber hot mix asphalt concrete. This project starts at the Crane County line and goes into Crane City. According to a 1996 estimation, the annual daily traffic on this highway was 6,600 and 7,200 for northbound and southbound Highway 385, respectively. The major distress with the existing pavement was reflective cracking.

As part of rehabilitation, a hot rubber underseal has been used in conjunction with crumb rubber modified hot mix asphalt concrete (HMAC) overlay. The rehabilitation started with the introduction of hot rubber seal in fall 1997 and spring 1998 when HMAC was put on top of it. The construction project was completed in summer 1998.

The equivalent of 200,000 tires was used to produce 80,000 tons of crumb rubber modified asphalt pavement overlaid on US 385. The asphalt rubber hot mix used reduces reflective cracking, rutting, surface oxidation and road noise, and it lengthens the time between required maintenance. The project won a 1998 National Asphalt Pavement Association Quality in Construction Award.

Specifications

TxDOT Special Specification Item 3020 for Crumb Rubber Modified (CRM) Hot Mix Asphaltic Concrete Pavement has been included at the end of this packet.

Test data

Laboratory results show the specific gravity of asphalt used in the mix was 1.043 and the combined bulk specific gravity for the mix was 2.638. Tables 1–4 show additional laboratory test results related to crumb rubber, asphalt rubber binder, aggregates and hot mix design.

Field test results: Visual distress survey conducted in summer 1998 and summer 1999 did not reveal any noticeable distress.

Table 1. Combined Gradation of Aggregates

Sieve Size	Cumulative Passing (%)	Min. Specification (%)	Max. Specification (%)
1 1/4"	100	100	100
1"	100	100	100
7/8"	100	100	100
5/8"	100	100	100
1/2"	100	100	100
3/8"	97.4	98	100
1/4"	97.4	85	100
#4	46.7	40	60
#10	16.9	15	25
#40	8.3	6	20
#80	6.5	6	18
#200	5.4	4	8

Table 2. Gradation for Crumb Rubber

Sieve size	Result	Specified limits
No. 16 1.18mm	100	100
No. 30 0.600 mm	98	90-100
No. 40 0.425 mm	62	45-100

Table 3. Physical Properties of Asphalt Rubber Binder (16% crumb rubber, 84% asphalt cement)

Test Performed	Minutes of Reaction					Specified Limits
	60	90	240	360	1440	
Viscosity, Haake at 175°C, Pa-S (centipoise)	3.2 (3,200)	2.5 (2,500)	2.0 (2,000)	1.8 (1,800)	1.5 (1,500)	1.5-4.5 Pa-S
Resilience at 25°C, % rebound (ASTM D3407)	27	-	21	-	20	15 minutes
Ring & ball softening point, °C (Tex-505-C)	63	62	61.5	61	60.5	57 minutes
Cone penetration at 25°C, 150 g., 5 sec., 1/10 mm (ASTM D 3407)	48	-	57	63	63	20 minutes

Note: The asphalt rubber mixture was held overnight at 135°C and heated back to 175°C for the final 24-hour reaction period.

Table 4. Mix Design Information for HMAC

Optimum Asphalt Content (OAC) (%)	Air Void at OAC (%)	Void in Mineral Aggregate at OAC (%)	Static Creep Test		
			Creep Stiffness (Psi)	Perm. Strain * 1,000 (in./in.)	Slope of SS Curve * 100,000,000 (in./in./sec.)
8.3	3.0	20.8	7,409	0.24	4.0

Results

Using asphalt rubber did not affect the construction schedule. This crumb rubber pavement section has not required any major maintenance since it was opened to traffic. Use of crumb rubber in HMAC reduced life cycle cost of pavement in Odessa because of less maintenance requirement.

The expected additional life on this project is three to four years with little to no maintenance required. TxDOT paid a premium of approximately $363,000 (approximately 9 percent of the total cost of the job) to use crumb rubber modified hot mix compared to a non-rubber modified mix. Costs in general for using crumb rubber modified asphalts have dropped within the last several years because a patent expired. This additional initial expense is expected to balance out by providing improved performance.

The proven advantages of using asphalt rubber as the binder in hot mix include:

- increased pavement life,
- resistance to rutting, aging and reflective cracking,
- reduced pavement thickness,
- increased skid resistance and
- reduction in traffic noise by an estimated 65 to 85 percent.

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Kathryn C. Evans	TxDOT Odessa District	Phone: (915) 498-4684 Fax: (915) 498-4689
Sidney Cox	Cox Paving Company	Phone: (830) 833-4547 Fax: (830) 833-4136
Randy Battenfield	Gibson Recycling	Phone: (903) 796-8640 Fax: (903) 796-0115
Phillip T. Nash, P.E.	Texas Tech University	Phone: (806) 742-2783, ext. 231 Fax: (806) 742-3488

TxDOT Experience

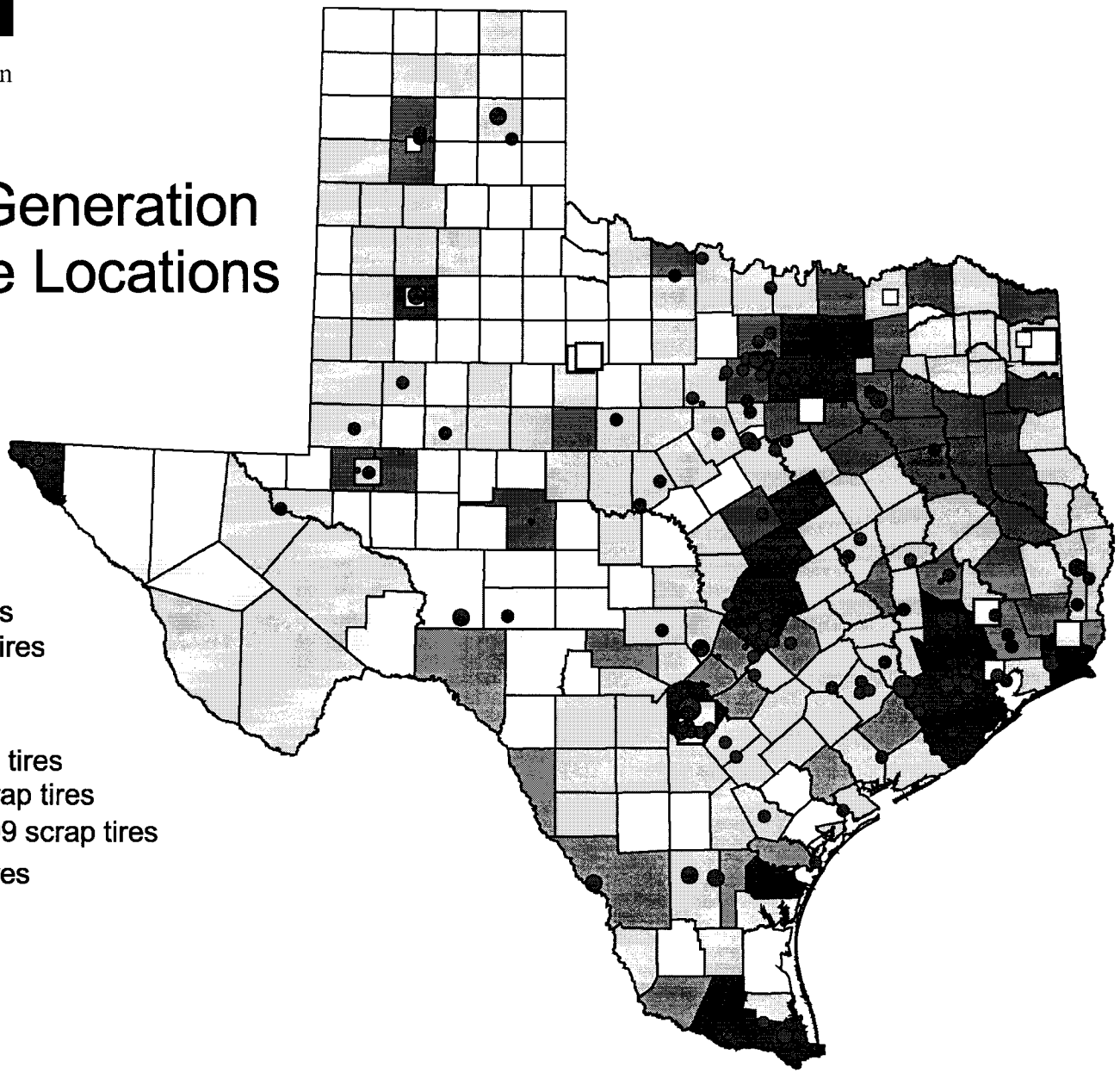
District Name	Construction Application	Material	Results	Years of Experience	Specification	Location
Abilene	Paving Materials-Asphaltic Concrete	Tire Rubber (including crumb)	Excellent	1993	340	Taylor Co.
Amarillo	Paving Materials-Asphaltic Concrete	Tire Rubber (including crumb)	Good	1991	340	IH 40
Amarillo	Paving Materials-Asphaltic Concrete	Tire Rubber (including crumb)	Good	1991	340	Sherman-US 54
Amarillo	Paving Materials-Asphaltic Concrete	Tire Rubber (including crumb)	Poor	1991	340	Potter-IH40
Atlanta	Paving Materials-Asphaltic Concrete	Tire Rubber (including crumb)	Unknown	1996	Standard	Harrison (US 59 [S. of Marshall] northbound)
Beaumont	Paving Materials-Asphaltic Concrete	Tire Rubber (including crumb)	Unknown		3022	US 96-Hardin
Beaumont	Paving Materials-Asphaltic Concrete	Tire Rubber (including crumb)	Good	1995		Chambers
Beaumont	Paving Materials-Asphaltic Concrete	Tire Rubber (including crumb)	Good	1992	Hardin	
Bryan	Paving Materials-Asphaltic Concrete	Tire Rubber (including crumb)	Good	1995		Angelina
Childress	Paving Materials-Asphaltic Concrete	Tire Rubber (including crumb)	Good	1977	316	Motley (US 62), Donley (US 287), & Wheeler (IH-40)
Corpus Christi	Paving Materials-Asphaltic Concrete	Tire Rubber (including crumb)	Good	1987	300	Various
El Paso	Paving Materials-Asphaltic Concrete	Tire Rubber (including crumb)		1996	3000	El Paso

District Name	Construction Application	Material	Results	Years of Experience	Specification	Location
Houston	Paving Materials-Asphaltic Concrete	Tire Rubber (including crumb)	Good	1994	Item 340	FM 1301, FM 360, FM 1458
Lubbock	Paving Materials-Asphaltic Concrete	Tire Rubber (including crumb)	Good	1996	Item 300-027	SH 83-Yoakum Co.
Lubbock	Paving Materials-Asphaltic Concrete	Tire Rubber (including crumb)	Good	1992	Item 340-278	US 84-Parmer Co.
Lufkin	Paving Materials-Asphaltic Concrete	Tire Rubber (including crumb)	Good	1993	3868	SH 63, US 259
Odessa	Paving Materials-Asphaltic Concrete	Tire Rubber (including crumb)	Excellent	1994	3006 & 3007	Ector & Martin
San Angelo	Paving Materials-Asphaltic Concrete	Tire Rubber (including crumb)	Excellent	1994	AC-15-5TR	District-wide
San Antonio	Paving Materials-Asphaltic Concrete	Tire Rubber (including crumb)	Excellent	1992	Standard Item 300	Bexar
Tyler	Paving Materials-Asphaltic Concrete	Tire Rubber (including crumb)	Excellent	1989	Special Spec.	LP 323-Smith Co.
Tyler	Paving Materials-Asphaltic Concrete	Tire Rubber (including crumb)	Poor	1991	Special Spec.	IH 20-Gregg Co.
Waco	Paving Materials-Asphaltic Concrete	Tire Rubber (including crumb)	Excellent	1996	3063	Various in Waco
Wichita Falls	Paving Materials-Asphaltic Concrete	Tire Rubber (including crumb)		1989	TxDOT Standard Spec.	Wichita, Cooke, Clay, Montague
Yoakum	Paving Materials-Asphaltic Concrete	Tire Rubber (including crumb)	Excellent	1988	Item 318 (latest)	District-wide
Yoakum	Paving Materials-Asphaltic Concrete	Tire Rubber (including crumb)	Unknown	1996	Special Provision 300-022 (10-94)	District-wide

Material Availability

The map and table provide information on scrap tire generation and stockpiles.

Scrap Tire Generation and Stockpile Locations



Whole Tires Stockpiles
- < 999 scrap tires
- 1,000 - 9,999 scrap tires
- 10,000 - 99,999 scrap tires
- > 100,000 scrap tires

Shredded Tires Stockpiles
- 10,000 - 99,999 scrap tires
- 100,000 - 999,999 scrap tires
- 1,000,000 - 24,999,999 scrap tires
- > 25,000,000 scrap tires

Tire Generation - 1998*
- 0 - 9,999
- 10,000 - 49,999
- 50,000 - 249,999
- 250,000 +

* Annual generation rate based on 1.25 tires per person.

Shredded Tire Stockpile Locations

Facility Name	City	# of Tires Stockpiled	Reg. #
THOSHANOWASTI	Amarillo	22,682	79544
Acme Tyre Company	Atlanta	37,227	79539
Gibson Recycling, Inc.	Atlanta	27,116,847	79500
Waste Recovery, Inc.	Baytown	558,866	79503
Gibson Recycling, Inc.	Beaumont	2,048,100	79508
Safe Tire Disposal Corp.	Cleveland	6,060,909	79507
Anthony J. Johnston	Dodd City	21,509	79549
Granular Products & Services	Fort Worth	500,000	76204
Lubbock Waste Tire Recycling	Lubbock	104,200	79540
Safe Tire Disposal Corp.	Midlothian	4,436,634	79504
Safe Tire Disposal Corp.	Penwell	5,422,546	79505
American Tire	San Antonio	1,250,000	79019
Safe Tire Disposal Corp.	San Antonio	6,884,890	79506
Environmental Recovery & Rec.	Stamford	2,261,789	79502
Texas Crumb Industries, Inc.	Stamford	5,441,499	76203
TOTAL		62,167,698	

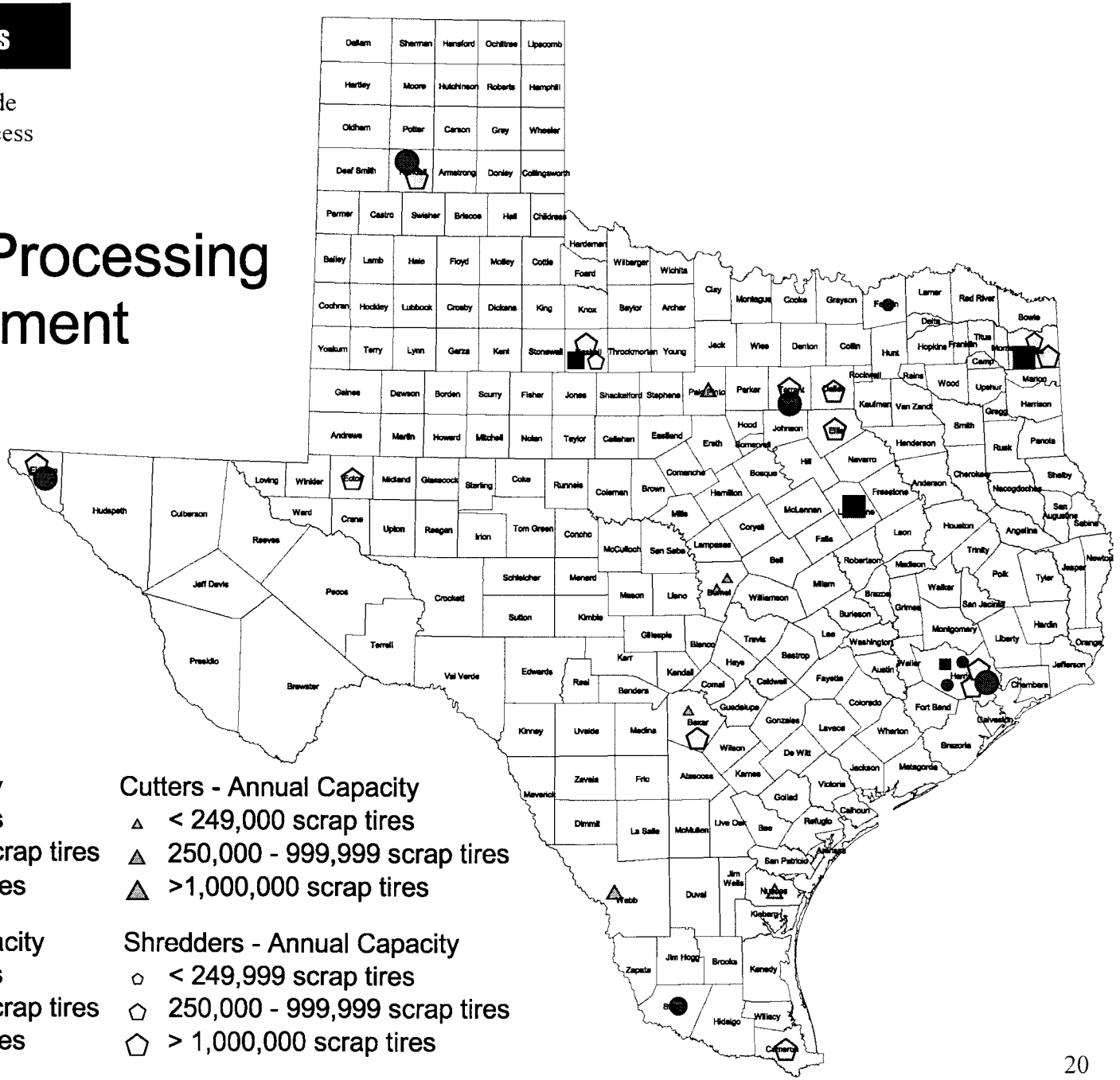
*Numbers are based on last report submitted through March 1999.

Source: TNRCC.

Material Processors

The following map and table provide information on companies that process scrap tires.

Scrap Tire Processing Equipment



Balers - Annual Capacity
- < 249,999 scrap tires
- 250,000 - 999,999 scrap tires
- > 1,000,000 scrap tires

Cutters - Annual Capacity
- < 249,000 scrap tires
- 250,000 - 999,999 scrap tires
- >1,000,000 scrap tires

Crumbers - Annual Capacity
- < 249,999 scrap tires
- 250,000 - 999,999 scrap tires
- > 1,000,000 scrap tires

Shredders - Annual Capacity
- < 249,999 scrap tires
- 250,000 - 999,999 scrap tires
- > 1,000,000 scrap tires

Scrap Tire Processors

Facility	County	City	Tires/hour	Lbs./hour	Tires/year	Equipment
Cameron Land & Cattle Co.	Bexar	San Antonio	400	8,000	844,800	Baler
J & M Truck Tire Shop, Inc.	Bexar	San Antonio	100	2,000	211,200	Cutter
Safe Tire Disposal Corp.	Bexar	San Antonio	3,000	60,000	6,336,000	Shredder
H&V Tire Disposal	Burnet	Betram	0	0	36,000	Cutter
DWI Hobby Shop	Burnet	Marble Falls	9	180	19,008	Cutter
World Tire Recycling, Inc.	Cameron	Brownsville	600	12,000	1,267,200	Shredder
Acme Tyre Company	Cass	Atlanta	126	2,520	266,112	Shredder
Gibson Recycling, Inc.	Cass	Atlanta	500	10,000	1,056,000	Crumber, Shredder
Metroplex Tire Disposal, In	Dallas	Fort Worth	1,500	30,000	3,168,000	Shredder
Safe Tire Disposal Corp.	Ector	Penwell	3,000	60,000	6,336,000	Shredder
Tres Pesetas, Inc.	El Paso	El Paso	500	10,000	1,056,000	Baler, Shredder
Safe Tire Disposal Corp.	Ellis	Midlothian	3,000	60,000	6,336,000	Shredder
Anthony J. Johnston	Fannin	Dodd City	0	0	0	Baler
Ecological Building Blocks	Harris	Alief	0	0	0	Baler
Waste Recovery, Inc.	Harris	Baytown	3,500	70,000	7,392,000	Shredder
Crubber Corporation	Harris	Houston	0	0	0	Crumber
Dearth Brothers, Inc.	Harris	Houston	0	0	1,056,000	Baler
Uni-Wide Auto Imports, Inc.	Harris	Houston	0	0	8,448	Baler
Scrap Tire Recycling	Harris	Pasadena	500	10,000	1,056,000	Shredder
Environmental Recovery & Re	Jones	Stamford	800	16,000	1,689,600	Shredder
Texas Crumb Industries, Inc	Jones	Stamford	150	3,000	316,800	Crumber, Shredder
Granular Products & Service	Limestone	Fort Worth	4,000	80,000	8,448,000	Crumber
Island Industries	Nueces	Corpus Christi	350	7,000	739,200	Cutter
Real Deal Recycling	Palo Pint	Mineral Well	125	2,500	264,000	Cutter
THOSHANOWASTI	Potter	Amarillo	500	10,000	1,056,000	Baler, Shredder
Touche International	Tarrant	Burleson	0	0	1,056,000	Baler
Silver Creek Materials, Inc	Tarrant	Fort Worth	2,000	40,000	4,224,000	Shredder
UTW Tire Disposal	Webb	Laredo	0	0	506,880	Cutter

Federal-Aid Projects
Special Provision to Item 318
Hot Asphalt-Rubber Surface Treatments

For this project, Item 318, "Hot Asphalt-Rubber Surface Treatments", of the Standard Specifications, is hereby amended with respect to the clauses cited below and no other clauses or requirements of this Item are waived or changed hereby.

Article 318.2. Materials, Subarticle (1) Asphaltic Materials, is voided and replaced by the following:

(1) Asphaltic Materials.

(a) Asphaltic Materials. The asphaltic materials used shall be one or more of the materials prescribed in Item 300, "Asphalts, Oils and Emulsions". A change in source or grade shall require verification that the binder and moisture susceptibility requirements of this specification are met.

(b) Crumb Rubber Modifier. The crumb rubber modifier shall be produced from processing automobile and/or truck tires by ambient-temperature grinding methods. The rubber shall be substantially free from contaminants including fabric, metal, mineral and other non-rubber substances. The rubber shall be sufficiently dry to be free-flowing and not produce a foaming problem when added to hot asphalt cement. Up to 2% (by mass of rubber) of talc or other appropriate blocking agent may be added to reduce agglomeration of the rubber particles. When tested in accordance with Test Method Tex-200-F, Part I, using a 50 gram sample, the resulting rubber gradation shall meet the following gradation limits for the type of rubber specified.

	Percent Passing		
Sieve Size	Type I	Type II	Type III
2.36 mm	100	-	-
2.00 mm	95-100	100	-
1.18 mm	40-60	70-100	100
0.60 mm	0-20	25-60	90-100
0.425 mm	-	-	45-100
0.30 mm	0-10	0-20	-
0.18 mm	-	-	-
0.15 mm	-	0-5	-
0.075 mm	-	0-5	-
Max. Particle Size	4.8 mm	4.8 mm	4.8 mm

A change in type or source of crumb rubber modifier shall require verification that the binder and mixture design requirements of this specification are met.

(i) Fiber Content. The ground rubber shall have less than 0.1% of fiber by mass. Fiber content shall be determined by weighing fiber agglomerations which are formed during the gradation test procedure.

(ii) Moisture Content. For each rubber type and grade, the moisture content shall be less than 0.75% by mass.

(iii) Metal Contamination. The rubber shall contain no visible metal particles as indicated by thorough stirring of a 50-gram sample with a magnet.

(c) Scrap High Natural Rubber. 100% of the scrap high natural rubber must pass the 1.18 mm Sieve.

(d) Diluent. The diluent shall be a hydrocarbon distillate complying with the following requirements when tested in accordance with ASTM D 86:

Initial Boiling Point, C, Minimum.....170
End Point, C, Maximum.....315

(e) Extender Oil. The extender oil shall be a high-flash, resinous aromatic type which, when blended with the asphalt cement, will result in a mixture with an absolute viscosity of 60-200 pascal.second at 60 C. Sampling and testing will be in accordance with Test Method Tex-528-C.

(f) Asphalt-Rubber Binder. The asphalt cement and crumb rubber modifier shall be blended for a period of at least one hour prior to mixing with the aggregate. The temperature of the asphalt cement shall be between 175 and 200 C at the addition of the crumb rubber modifier. Temperature of the asphalt-rubber binder shall be maintained between 160 and 190 C during the one hour reaction period. The mixture of asphalt cement and rubber shall not be held at temperatures over 175 C for a period over 8 hours. For Type III rubber, other blending/ reaction time, temperatures or binder properties may be allowed by the Engineer. When the blended asphalt-rubber is held for more than 8 hours, the viscosity of the asphalt-rubber blend shall be measured prior to use and shall meet the viscosity requirements stated in this section.

The design blend of asphalt cement and rubber shall be provided by the Contractor along with laboratory tests showing that the following requirements are met. These requirements may be adjusted as approved by the Engineer. The Engineer may verify any or all of these required proportions at any time.

The blended asphalt-rubber binder shall meet the following requirements:

Property	**Requirements**	**Test Methods**
Viscosity, Haake, 175 C	15-45 pascal.second	-
Cone Penetration, 4 C, 200g, 1 min.	10 minimum	ASTM D1191
Cone Penetration, 25 C, 150g, 5 sec.	75 maximum	ASTM D1191
Softening Point, C	57 C, minimum	Tex-505-C
Resilience, 25 C	20% minimum	ASTM D3407
Crumb Rubber Content	16%-20%	-
Scrap Natural Rubber Content	0%-3%	-

At the end of each shift, the Contractor shall provide the Engineer with documentation on the production of asphalt-rubber which includes the following:

1. The amount and temperature of the asphalt cement prior to the addition of rubber.
2. The amount of rubber added.
3. The viscosity of each batch of asphalt-rubber just prior to the mixing with the aggregates.
4. The time of the rubber additions and viscosity tests.

Just prior to application, diluent up to a maximum amount of 7.5% by volume of the hot asphalt-rubber mixture may be added as required to obtain optimum viscosity for spray application and better “wetting” of the cover aggregate.

(g) Tack Coat. Cut-back asphalt may not be diluted with gasoline and/or kerosene. Emulsions may be diluted with the addition of water, with the approval of the Engineer.

Article 318.2. Materials, Subarticle (2) Rubber is voided and not replaced.

Article 318.2. Materials, Subarticle (3) Diluent is voided and not replaced.

Article 318.2. Materials, Subarticle (4) Extender Oil is voided and not replaced.

Article 318.4. Construction Methods, Subarticle (2) Mixing is voided and not replaced.

Article 318.6. Payment, is voided and replaced by the following:

318.6. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit prices bid for “Hot Asphalt-Rubber” of the rubber gradation type specified, and “Aggregate” of the type and grade specified, which prices shall be full compensation for cleaning the existing surface; for furnishing all materials including tack coat and freight involved; for all heating, mixing, hauling and placing all materials, including tack coat; for rolling, removing excess aggregate and cleaning up stockpile areas; and for all manipulations, labor and tools, equipment and incidentals necessary to complete the work including royalties, permit costs, etc., and test sections.

Non-Federal-Aid Projects
Special Provision to Item 318
Hot Asphalt-Rubber Surface Treatments

For this project, Item 318, "Hot Asphalt-Rubber Surface Treatments", of the Standard Specifications, is hereby amended with respect to the clauses cited below and no other clauses or requirements of this Item are waived or changed hereby.

Article 318.2. Materials, Subarticle (1) Asphaltic Materials, is voided and replaced by the following:

(1) Asphaltic Materials.

(a) Asphaltic Materials. The asphaltic materials used shall be one or more of the materials prescribed in Item 300, "Asphalts, Oils and Emulsions". A change in source or grade shall require verification that the binder and moisture susceptibility requirements of this specification are met.

(b) Crumb Rubber Modifier. The crumb rubber modifier shall be produced from processing automobile and/or truck tires by ambient- temperature grinding methods. The rubber shall be substantially free from contaminants including fabric, metal, mineral and other non-rubber substances. The rubber shall be sufficiently dry to be free-flowing and not produce a foaming problem when added to hot asphalt cement. Up to 2% (by mass of rubber) of talc or other appropriate blocking agent may be added to reduce agglomeration of the rubber particles. When tested in accordance with Test Method Tex-200-F, Part I, using a 50 gram sample, the resulting rubber gradation shall meet the following gradation limits for the type of rubber specified.

		Percent Passing	
Sieve Size	**Type I**	**Type II**	**Type III**
2.36 mm	100	-	-
2.00 mm	95-100	100	-
1.18 mm	40-60	70-100	100
0.60 mm	0-20	25-60	90-100
0.425 mm	-	-	45-100
0.30 mm	0-10	0-20	-
0.18 mm	-	-	-
0.15 mm	-	-	-
0.075 mm	-	0-5	-
Max. Particle Size	4.8 mm	4.8 mm	4.8 mm

A change in type or source of crumb rubber modifier shall require verification that the binder and mixture design requirements of this specification are met.

(i) Fiber Content. The ground rubber shall have less than 0.1% of fiber by mass. Fiber content shall be determined by weighing fiber agglomerations which are formed during the gradation test procedure.

(ii) Moisture Content. For each rubber type and grade, the moisture content shall be less than 0.75% by mass.

(iii) Metal Contamination. The rubber shall contain no visible metal particles as indicated by thorough stirring of a 50-gram sample with a magnet.

(iv) Non-Federal Aid Projects. Ground tire rubber shall be produced from scrap tires ground in a facility in Texas, if such material is available in Texas.

(c) Scrap High Natural Rubber. 100% of the scrap high natural rubber must pass the 1.18 mm Sieve.

(d) Diluent. The diluent shall be a hydrocarbon distillate complying with the following requirements when tested in accordance with ASTM D 86:

Initial Boiling Point, C, Minimum 170
End Point, C, Maximum 315

(e) Extender Oil. The extender oil shall be a high-flash, resinous aromatic type which, when blended with the asphalt cement, will result in a mixture with an absolute viscosity of 60-200 pascal.second at 60 C. Sampling and testing will be in accordance with Test Method Tex-528-C.

(f) Asphalt-Rubber Binder. The asphalt cement and crumb rubber modifier shall be blended for a period of at least one hour prior to mixing with the aggregate. The temperature of the asphalt cement shall be between 175 and 200 C at the addition of the crumb rubber modifier. Temperature of the asphalt-rubber binder shall be maintained between 160 and 190 F during the one hour reaction period. The mixture of asphalt cement and rubber shall not be held at temperatures over 175 C for a period over 8 hours. For Type III rubber, other blending/ reaction time, temperatures or binder properties may be allowed by the Engineer. When the blended asphalt-rubber is held for more than 8 hours, the viscosity of the asphalt-rubber blend shall be measured prior to use and shall meet the viscosity requirements stated in this section.

The design blend of asphalt cement and rubber shall be provided by the Contractor along with laboratory tests showing that the following requirements are met. These requirements may be adjusted as approved by the Engineer. The Engineer may verify any or all of these required proportions at any time.

The blended asphalt-rubber binder shall meet the following requirements:

Property	**Requirements**	**Test Methods**
Viscosity, Haake, 175 C	15-45 pascal.second	-
Cone Penetration, 4 C, 200g, 1 min.	10 minimum	ASTM D1191
Cone Penetration, 25 C, 150g, 5 sec.	75 maximum	ASTM D1191
Softening Point, C	57 C minimum	Tex-505-C
Resilience, 25 C	20% minimum	ASTM D3407
Crumb Rubber Content	16%-20%	-
Scrap Natural Rubber Content	0%-3%	-

At the end of each shift, the Contractor shall provide the Engineer with documentation on the production of asphalt-rubber which includes the following:

1. The amount and temperature of the asphalt cement prior to the addition of rubber.
2. The amount of rubber added.
3. The viscosity of each batch of asphalt-rubber just prior to the mixing with the aggregates.
4. The time of the rubber additions and viscosity tests.

Just prior to application, diluent up to a maximum amount of 7.5% by volume of the hot asphalt-rubber mixture may be added as required to obtain optimum viscosity for spray application and better “wetting” of the cover aggregate.

(g) Tack Coat. Cut-back asphalt may not be diluted with gasoline and/or kerosene. Emulsions may be diluted with the addition of water, with the approval of the Engineer.

Article 318.2. Materials, Subarticle (2) Rubber is voided and not replaced.

Article 318.2. Materials, Subarticle (3) Diluent is voided and not replaced.

Article 318.2. Materials, Subarticle (4) Extender Oil is voided and not replaced.

Article 318.4. Construction Methods, Subarticle (2) Mixing is voided and not replaced.

Article 318.6. Payment, is voided and replaced by the following:

318.6. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit prices bid for “Hot Asphalt-Rubber” of the rubber gradation type specified, and “Aggregate” of the type and grade specified, which prices shall be full compensation for cleaning the existing surface; for furnishing all materials including tack coat and freight involved; for all heating, mixing, hauling and placing all materials, including tack coat; for rolling, removing excess aggregate and cleaning up stockpile areas; and for all manipulations, labor and tools, equipment and incidentals necessary to complete the work including royalties, permit costs, etc., and test sections.

Special Provision to Item 342
Plant Mix Seal

For this project, Item 342, "Plant Mix Seal", of the Standard Specifications is hereby amended with respect to the clauses cited below and no other clauses or requirements of this Item are waived or changed hereby.

Article 342.1. Description is supplemented by the following:

Environmental Permitting. The Contractor shall be required to obtain the necessary permits from the Texas Natural Resource Conservation Commission to insure compliance with standards for air quality. Additional stack emissions tests may be required to determine the levels of potentially hazardous compounds which may include, but are not limited to total Volatile Organic Compounds (VOC) and particulates emission. Permitting will be site specific and consideration will be given on a case by case basis to be determined by the levels of said compounds and site sensitivity.

Article 342.2. Materials, Subarticle (1) Aggregate, Section (a) Description. The second and third paragraphs are voided and replaced by the following:

Coarse aggregates used in surface courses shall have a minimum surface aggregate classification as shown on the plans. Unless otherwise shown on the plans, the surface aggregate classification requirement will apply only to aggregate used on travel lanes. The surface aggregate classification for sources on the Aggregate Quality Monitoring Program (AQMP) are listed in the Rated Source Quality Catalog (RSQC). When aggregates are supplied from a source which is not on the AQMP, the aggregate will be sampled and tested prior to use. The procedure will be in accordance with the AQMP.

Blending of aggregates to achieve classification requirements will not be permitted.

Article 342.2. Materials, Subarticle (2) Asphaltic Materials, Section (a) Asphaltic Materials and Section (b) Tack Coat are voided and replaced by the following:

(a) Asphaltic Materials. The asphaltic materials used shall be one or more of the materials prescribed in Item 300, "Asphalts, Oils and Emulsions". A change in source or grade shall require verification that the binder and moisture susceptibility requirements of this specification are met.

(b) Asphalt Extender Oil. An asphalt extender oil may be added, if necessary, to meet the requirements for asphalt-rubber binder. Extender oil shall be a resinous aromatic hydrocarbon with a minimum flash point of 205 C.

(c) Crumb Rubber Modifier. The crumb rubber modifier shall be produced from processing automobile and/or truck tires by ambient-temperature grinding methods. The rubber shall be substantially free from contaminants including fabric, metal, mineral and other non-rubber substances. The rubber shall be sufficiently dry to be free-flowing and not produce a foaming problem when added to hot asphalt cement. Up to 2% (by mass of rubber) of talc or other appropriate blocking agent may be added to reduce agglomeration of the rubber particles. When tested in accordance with Test Method Tex-200-F, Part I, using a 50 gram sample, the resulting rubber gradation shall meet the following gradation limits.

Sieve Size	Percent Passing
1.18 mm	100
0.60 mm	90-100
0.425 mm	45-100

A change in source of crumb rubber modifier shall require verification that the binder and mixture design requirements of this specification are met.

(i) Fiber Content. The ground rubber shall have less than 0.1% of fiber by mass. Fiber content shall be determined by weighing fiber agglomerations which are formed during the gradation test procedure.

(ii) Moisture Content. The moisture content shall be less than 0.75% by mass.

(iii) Metal Contamination. The rubber shall contain no visible metal particles as indicated by thorough stirring of a 50-gram sample with a magnet.

(iv) Non-Federal Aid Projects. Ground tire rubber shall be produced from scrap tires ground in a facility in Texas, if such material is available in Texas.

(d) Asphalt-Rubber Binder. The asphalt cement shall be modified by the addition of a maximum of 18 percent of crumb rubber modifier, by mass of the asphalt-rubber binder. Additionally a minimum of 9 kilograms of crumb rubber modifier shall be used per megagram of the mixture. The asphalt cement, extender oil (when required), and the crumb rubber modifier shall be blended for a period of at least one (1) hour prior to mixing with the aggregate. The temperature of the asphalt cement shall be between 175 and 200 C at the addition of the crumb rubber modifier.

Temperature of the asphalt-rubber binder shall be maintained between 163 and 190 C during the one (1) hour reaction period. The mixture of asphalt cement and rubber shall not be held at temperatures over 175 C for a period over eight (8) hours. When the blended asphalt-rubber is held for more than eight (8) hours, the viscosity of the asphalt-rubber blend shall be measured prior to use and shall meet the viscosity requirements stated in this section.

The design blend of asphalt cement, rubber and, if required, extender oil, shall be provided by the Contractor along with laboratory tests showing that the following requirements are met. These requirements may be adjusted as approved by the Engineer. The Engineer may verify any or all of these required proportions at any time.

The blended asphalt-rubber binder shall meet the following requirements:

Property	**Requirements**	**Test Method**
Viscosity, Haake, 175 C	15-45 pascal.second	-
Cone Penetration, 4 C, 200g, 1 min.	10 minimum	ASTM D1191
Cone Penetration, 25 C 150g, 5 sec.	75 maximum	ASTM D1191
Softening Point, C	57 C, minimum	Tex-505-C
Resilience, 25 C	15% minimum	ASTM D3407

At the end of each shift, the Contractor shall provide the Engineer with documentation on the production of asphalt-rubber which includes the following:

1. The amount of asphalt in liters and temperature in degrees in Celsius of the asphalt cement prior to the addition of rubber.
2. The amount of crumb rubber modifier added in percent by mass of the asphalt-rubber binder and in kilograms of crumb rubber modifier per megagram of mixture.
3. The viscosity of each batch of asphalt-rubber just prior to the mixing with the aggregates. Viscosity will be reported in pascal.second.
4. The time of the rubber additions and viscosity tests.

Article 342.3. Plant Mix Seal Surfacing Mixture, Subarticle (1) General is supplemented by the following:

The plant mix seal surfacing mixture shall not show more than 0.5 percent draindown when tested in accordance with Test Method Tex-235-F.

Article 342.6. Construction Methods, Subarticle (1) Tack Coat is voided and not replaced.

Article 342.7. Measurement. The first and second paragraphs are voided and replaced by the following:

The plant mix seal will be measured separately by the megagram of “Asphalt” and/or “Asphalt-Rubber Binder” and by the cubic meter or by the megagram, as shown on the plans, of dry, loose “Aggregate” used in the completed and accepted work in accordance with the plans and specifications for the project.

Asphalt. The mass of asphalt cement and/or asphalt-rubber binder (including asphalt cement, rubber and extender oil) will be calculated from the measured mass of plant mix seal surfacing mixture using the selected percentages of asphalt and/or asphalt-rubber binder.

Article 342.8. Payment. The first paragraph is voided and replaced by the following:

> **(1)** The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement”, will be paid for at the unit prices bid for “Asphalt” and/or “Asphalt-Rubber Binder” and for “Aggregate”, of the types and/or grades specified. These prices shall be full compensation for quarrying, furnishing all materials and freight involved; for all heating, mixing, hauling, cleaning the existing pavement, placing tack coat and plant mix seal surfacing mixture, rolling, finishing, and sprinkling the finished surface; and for all manipulations, labor, tools, equipment and incidentals necessary to complete the work.

SPECIAL PROVISION

TO

ITEM 524

HYDRAULIC CEMENT

For this project, Item 524, "Hydraulic Cement", of the Standard Specifications, is hereby amended with respect to the clauses cited below and no other clauses or requirements of this Item are waived or changed hereby.

Article 524.2. Materials, Subarticle (1) Portland Cement is voided and replaced by the following:

(1) Portland Cement. Type I and Type II portland cements shall conform to all the requirements of AASHTO M 85, "Portland Cement", with the following modifications:

(a) AASHTO M 85 Table 1, Note B, shall be amended to include the following additional requirements:

There are cases where optimum SO3 (using ASTM C 563) for a particular cement is close to or in excess of the limit in this specification. In such cases where properties of a cement can be improved by exceeding the SO3 limits stated in the table, it is permissible to exceed the values in the table provided it has been demonstrated by ASTM C 1038 that the cement with the increased SO3 will not develop expansion in water exceeding 0.020 percent at 14 days, and that total cement SO3 will not exceed optimum SO3 by more than 0.5 percent. When the cement being produced has a SO3 content equal to or greater than 3.0 percent, it must be demonstrated by ASTM C 265, that the calcium sulfate in the hydrated mortar at 24 +/- 1/4 h expressed as SO3 does not exceed 0.50 g/liter. When the manufacturer supplies cement under this provision, supporting documents shall be furnished.

ASTM C 1038 and ASTM C 265 shall be performed on an annual basis as indicated above and at any time the source of gypsum or any raw material is changed and at any time the total cement SO3 exceeds the highest value previously tested.

(b) The fineness of Type III cement shall be as follows:

The maximum average Blaine (air permeability test) fineness value shall be 560 m2/kg with a maximum single sample value of 580 m2/kg or the maximum average Wagner (turbidimiter test) fineness value shall be 310 m2/kg with a maximum single sample value of 320 m2/kg.

(c) The specific surface area requirement for Type I or Type II is waived on cements used in concrete piling or prestressed members and on white cement, when white cement is specified, except that it may not exceed the requirements specified for Type III cement.

(d) The 55 maximum percent of tricalcium silicate for Type II cement is waived.

Article 524.2. Materials, Subarticle (3) Blended Cement is voided and replaced with the following:

(3) Blended Cements. Type IP portland-pozzolan and Type IS portland blast furnace slag cement shall conform to all the requirements of ASTM C 595, "Blended Hydraulic Cement" with the following modifications:

(a) Type IP portland-pozzolan shall be a uniform blend of portland cement and pozzolan produced by intergrinding portland cement clinker, gypsum and pozzolan, in which the pozzolan constituent is between 20 and 35 percent of the portland-pozzolan cement. The pozzolan shall conform to the Departmental Material Specification D-9-8900, Class F. Copies of the Departmental Materials Specification are available from the Texas Department of Transportation, Construction Division, Materials and Tests, 125 East 11th Street, Austin, Texas 78701.

(b) Type IS portland blast furnace slag cement shall be the moderate sulfate resistance type, (MS).

Article 524.4. Measurement and Payment is voided and replaced by the following:

Except as noted below, the work performed, materials furnished and all labor, tools, equipment and incidentals necessary to complete the work under this item will not be measured or paid for directly, but will be considered subsidiary to the various bid items of the contract.

On those projects using cement produced by burning scrap tires as fuel, an additional payment of $2.00 per ton of cement will be made when scrap tires comprise 15 percent (by weight) or more of the fuel mixture. This payment will be in addition to the indirect payment made under the various bid items as noted on the above paragraph.

On projects with concrete structures, concrete paving, cement treated materials (delivered) or bulk cement delivered on the project for treatment of materials in place, and when the total amount of cement used equals or exceeds 75 tons, the Contractor may request and receive this additional payment. The Contractor will coordinate with the cement producer and submit a certification from the cement producer stating that the cement was produced by burning scrap tires as fuel. The cement producer must maintain a twelve-month moving percent average of the fuel mixture. Payment will be based on $2.00 per ton for cement produced using at least 15 percent of the fuel mixture composed of scrap tires. If the fuel mixture is composed of a smaller percent of scrap tires, the payment will be on a pro rata basis. No payment will be made if fuel

mixture average is less than 5 percent by mass of scrap tires. Payment will be based on the twelve-month moving average existing on the date payment is requested. The Certification must show the tons of cement used on the project (calculated and furnished by the Contractor), and the 12-month moving percentage average of scrap tires used as fuel, as well as other pertinent project information. The blank certification form with instructions will be provided by the Department.

Payment will be in accordance with Item 9.4. Force Account and will be based on invoices submitted by the Contractor. The invoices will be based on $2.00, or a proration as detailed above, per ton of cement used and no other charges, overhead, etc. will be allowed. Lump sum payment requests will be made for 75 tons or more of cement used. Each invoice will be limited to 2500 tons or less of cement and must be submitted when that limit is reached. The Contractor may submit the request for final payment at any time prior to the completion of the project. No payment request will be accepted if not received, complete with all documentation, by the date of project acceptance by the State.

Special Specification
Item 3020
Crumb Rubber Modified (CRM) Hot Mix Asphaltic Concrete Pavement

1. Description. This Item shall govern for the construction of a level-up course, a surface course or any combination of these courses as shown on the plans, each course being composed of a compacted mixture of aggregate and asphalt-rubber mixed hot in a mixing plant, in accordance with the details shown on the plans and the requirements herein.

2. Environmental Permitting. The Contractor shall be required to obtain the necessary permits from the Texas Natural Resource Conservation Commission to insure compliance with standards for air quality. Additional stack emissions tests may be required to determine the levels of potentially hazardous compounds which may include, but are not limited to total Volatile Organic Compounds.

(VOC) and particulates emission. Permitting will be site specific and consideration will be given on a case by case basis to be determined by the levels of said compounds and site sensitivity.

3. Materials. The Contractor shall furnish materials to the project meeting the following requirements prior to mixing. Additional test requirements affecting the quality of individual materials or the paving mixture shall be required when indicated on the plans.

(1) Aggregate. The aggregate shall be composed of a coarse aggregate, a fine aggregate, and if required or allowed, a mineral filler. Samples of each aggregate shall be submitted for approval in accordance with Item 6, “Control of Materials”.

Aggregate from each stockpile shall meet the quality requirements of Table 1 and other requirements as specified herein.

(a) Coarse Aggregate. Coarse aggregate is defined as that part of the aggregate retained on a 2.00 millimeter sieve. The aggregate shall be natural, and be of uniform quality throughout. When specified on the plans, certain coarse aggregate material may be allowed, required or prohibited.

Gravel from each source shall be so crushed as to have a minimum of 85 percent of the particles retained on the 4.75 millimeter sieve with two or more mechanically induced crushed faces, as determined by Test Method Tex-460-A (Part I). The material passing the 4.75 millimeter sieve and retained on the 2.00 millimeter sieve must be the product of crushing aggregate that was originally retained on the 4.75 millimeter sieve.

The polish value for coarse aggregate used in the surface or finish course shall not be less than the value shown on the plans, when tested in accordance with Test Method Tex-438-A. Unless otherwise shown on the plans, the polish value requirement will apply only to aggregate used on travel lanes. For rated sources, the Materials and Tests Division’s Rated Source Polish Value (RSPV) catalog will be used to determine polish value compliance. Unless otherwise shown on the plans, coarse aggregates may be blended in accordance with Test Method Tex-438-A, Part II, Method B, to meet the polish value requirement. When blending is allowed, the blended aggregates shall contain non-polishing aggregates of not less than 50 percent by volume of the aggregate.

Aggregates with a satisfactory skid history that do not meet the minimum polish value or RSPV requirement may be used on this project. A list of aggregate sources with an acceptable skid history is available from the Engineer.

(b) Fine Aggregate. The fine aggregate is defined as that part of the aggregate passing the 2.00 millimeter sieve and shall be of uniform quality throughout. When specified on the plans, certain fine aggregate material may be allowed, required or prohibited. However, a maximum of 15 percent of the total aggregate may be field sand or other uncrushed fine aggregate.

1. Unless otherwise shown on the plans, stone screenings are required and shall be the result of a rock crushing operation and meet the following gradation requirements, when tested in accordance with Test Method Tex-200-F, Part II.

	Percent by Mass
Passing the 9.5-millimeter sieve	100
Passing the 2.00 millimeter sieve	70 -100

2. Crushed gravel screenings may be used with, or in lieu of, stone screenings when shown on the plans. Crushed gravel screenings must be the product of crushing aggregate that was originally retained on the 4.75-millimeter sieve and meet the gradation for stone screenings shown above.

(c) Mineral Filler. Mineral filler shall consist of thoroughly dried stone dust. The mineral filler shall be free from foreign matter.

When a specific type of mineral filler is specified on the plans, fines collected by the baghouse or other air cleaning or dust collecting equipment shall not be used to meet this requirement. When mineral filler is not specifically required, the addition of baghouse or other collected fines will be permitted if the mixture quality is not adversely affected in the opinion of the Engineer. In no case shall the amount of material passing the 0.075 millimeter sieve exceed the tolerances of the job-mix formula or the master gradation limits.

When mineral filler is specified or allowed by the Engineer, or baghouse fines are permitted to be added to the mixture, it shall be proportioned into the mix by a vane meter or an equivalent measuring device acceptable to the Engineer. A hopper or other acceptable storage system shall be required to maintain a constant supply of mineral filler to the measuring device.

The measuring device for adding mineral filler shall be tied into the automatic plant controls so that the supply of mineral filler will be automatically adjusted to plant production and provide a consistent percentage to the mixture. When shown on the plans, the measuring device for adding baghouse fines shall have controls in the plant control room which will allow manual adjustment of feed rates to match plant production rate adjustments.

When tested in accordance with Test Method Tex-200-F, Part II, the mineral filler shall meet the following gradation requirements, unless otherwise shown on the plans. Baghouse fines are not required to meet the gradation requirements.

	Percent by Mass or Volume
Passing the 0.60 millimeter sieve	95 -100
Passing the 0.180 millimeter sieve	not less than 75
Passing the 0.075 millimeter sieve	not less than 55

TABLE 1
AGGREGATE
QUALITY REQUIREMENTS*

Requirement	Test Method	Natural Aggreg
COARSE AGGREGATE		
Deleterious Material, percent, maximum	Tex-217-F Part I	1.5
Decantation, percent, maximum	Tex-217-F Part II	1.5
Los Angeles Abrasion, percent, maximum	Tex-410-A	35
Magnesium Sulfate Soundness Loss, 5 cycle, percent, maximum	Tex-411-A	30**
Flakiness Index, maximum	Tex-224-F	17
FINE AGGREGATE		
Linear Shrinkage, maximum	Tex-107-E Part II	3
COMBINED AGGREGATE		
Sand Equivalent Value, minimum	Tex-203-F	45

* Sampled during delivery to the plant or from the stockpile, unless otherwise shown on the plans.
**Unless otherwise shown on the plans.
***Aggregates, without added mineral filler or additives, combined as used in the job-mix formula.

(2) Asphaltic Material.

(a) Asphaltic Materials. The asphaltic materials used shall be one or more of the materials prescribed in Item 300, “Asphalts, Oils and Emulsions”. A change in source or grade shall require verification that the binder and moisture susceptibility requirements of this specification are met.

(b) Asphalt Extender Oil. An asphalt extender oil may be added, if necessary, to meet the requirements for asphalt-rubber binder. Extender oil shall be a resinous aromatic hydrocarbon with a minimum flash point of 205 C.

(c) Crumb Rubber Modifier. The crumb rubber modifier shall be produced from processing automobile and/or truck tires by ambient-temperature grinding methods. The rubber shall be substantially free from contaminants including fabric, metal, mineral and other non-rubber substances. The rubber shall be sufficiently dry to be free-flowing and not produce a foaming problem when added to hot asphalt cement. Up to 2% (by mass of rubber) of talc or other appropriate blocking agent may be added to reduce agglomeration of the rubber particles. When tested in accordance with Test Method Tex-200-F, Part I, using a 50-gram sample, the resulting rubber gradation shall meet the following gradation limits.

Sieve Size	Percent Passing
1.18 millimeter	100
0.60 millimeter	90-100
0.425 millimeter	45-100

A change in source of crumb rubber modifier shall require verification that the binder and mixture design requirements of this specification are met.

(i) Fiber Content. The ground rubber shall have less than 0.1% by mass fiber. Fiber content shall be determined by weighing fiber agglomerations, which are formed during the gradation test procedure.

(ii) Moisture Content. The moisture content shall be less than 0.75% by mass.

(iii) Metal Contamination. The rubber shall contain no visible metal particles as indicated by thorough stirring of a 50-gram sample with a magnet.

(iv) Non-Federal Aid Projects. Ground tire rubber shall be produced from scrap tires ground in a facility in Texas, if such material is available in Texas.

(d) Asphalt-Rubber Binder. The asphalt cement shall be modified by the addition of a maximum of 18 percent of crumb rubber modifier, by mass of the asphalt-rubber binder. Additionally a minimum of 10 kilograms of crumb rubber modifier shall be used per megagram of the mixture. The asphalt cement, extender oil (when required), and the crumb rubber modifier shall be blended for a period of at least one (1) hour prior to mixing with the aggregate. The temperature of the asphalt cement shall be between 175 C and 205 C at the addition of the crumb rubber modifier. Temperature of the asphalt-rubber binder shall be maintained between 165 C and 190 C during the one (1) hour reaction period. The mixture of asphalt cement and rubber shall not be held at temperatures over 175 C for a period over eight (8) hours. When the blended asphalt-rubber is held for more than eight (8) hours, the viscosity of the asphalt-rubber blend shall be measured prior to use and shall meet the viscosity requirements stated in this section.

The design blend of asphalt cement, rubber and, if required, extender oil, shall be provided by the Contractor along with laboratory tests showing that the following requirements are met. These requirements may be adjusted as approved by the Engineer. The Contractor shall select a target viscosity for the blend at the time of use. The Engineer may verify any or all of these required proportions at any time. The blended asphalt-rubber binder shall meet the following requirements:

Property	**Requirements**	**Tes**
Viscosity, Haake, 175 C	1.5-4.5 Pa-S	
Cone Penetration, 25 C, 150 g, 5 s	20 minimum	AS
Softening Point, C	57 C, minimum	Tex
Resilience, 25 C	15% minimum	AS

At the end of each shift, the Contractor shall provide the Engineer with documentation on the production of asphalt-rubber which includes the following:

1. The amount and temperature of the asphalt cement prior to the addition of rubber.
2. The amount of rubber added.

3. The viscosity of each batch of asphalt-rubber just prior to the mixing with the aggregates.
4. The time of the rubber additions and viscosity tests.

(e) Tack Coat. Asphaltic materials for tack coat shall be an asphalt cement of a grade shown on the plans or approved by the Engineer, complying with the requirements of Item 300, "Asphalts, Oils and Emulsions".

(3) Additives. Additives to facilitate mixing and/or improve the quality of the asphaltic mixture shall be used when noted on the plans or may be used with the authorization of the Engineer. Unless otherwise shown on the plans, the Contractor may choose to use either lime or a liquid antistripping agent to reduce the moisture susceptibility of the aggregate. The evaluation and addition of antistripping agents will be in accordance with Item 301, "Asphalt Antistripping Agents".

4. Paving Mixtures. The paving mixtures shall consist of a uniform mixture of aggregate, hot asphalt-rubber, and additives if allowed or required.

An asphalt mixture design is a laboratory process which includes the determination of the quality of the asphalt-rubber and the individual aggregates, the development of the job-mix formula, and the testing of the combined mixture.

The job-mix formula lists the quantity of each component to be used in the mix and the combined gradation of the aggregates used.

(1) Mixture Design. The Contractor shall furnish the Engineer with representative samples of the materials to be used in production 20 working days prior to start of the production. Using these materials, the mix shall be designed in accordance with Test Method Tex-232-F to conform with the requirements herein. Unless otherwise shown on the plans, the Engineer will furnish the mix design for all mixtures. The Engineer may accept a design from the Contractor which was derived using these design procedures.

The second and subsequent mixture designs, or partial designs, for each type of paving fixture which are necessitated by changes in the material or at the request of the Contractor will be charged to the Contractor when a rate is shown on the plans.

When properly proportioned, for the type specified, the blend of aggregates shall produce an aggregate gradation which will conform to the limits of the master grading shown in Table 2. Unless otherwise shown on the plans, the gradation of the aggregate will be determined in accordance with Test Method Tex-200-F, Part II (Washed Sieve Analysis), to develop the job-mix formula.

The master grading limits for the appropriate type and the proposed job-mix formula will be plotted on a gradation chart with sieve sizes raised to the 0.45 power. This plot must show that the proposed job-mix formula is within the limits of the master grading.

The voids in the mineral aggregate (VMA) will be determined as a mixture design requirement only, in accordance with Test Method Tex-207-F, and shall not be less than the value indicated in Table 2.

Unless otherwise shown on the plans, the mixture of aggregate, asphalt and additives proposed for use will be evaluated in the design stage for moisture susceptibility, in accordance with Test Method Tex-530-C. The mixture will be acceptable when no visual stripping is evident after running Test Method Tex-530-C. When visual stripping is evident, suitable antistripping additives shall be used. The Engineer may waive this test if a similar design, using the same ingredients, has proven satisfactory.

To substantiate the design, trial mixtures shall be produced and tested using all of the proposed project materials and equipment prior to any placement. The Engineer may waive trial mixtures if similar designs have proven satisfactory.

(2) Density. The mixture shall be designed to produce an acceptable mixture at an optimum density of 97.0 percent, when tested in accordance with Test Method Tex-207-F and Test Method Tex-227-F. The operating range for control of laboratory density during production shall be optimum density plus or minus 1.0 percent.

Laboratory density is a mixture design and process control parameter. If the laboratory density of the mixture produced has a value outside the range specified above, the Contractor shall investigate the cause and take corrective action. If three (3) consecutive test results fall outside the specified range, production shall cease unless test results or other information indicate, to the satisfaction of the Engineer, that the next mixture to be produced will be within the specified range.

(3) Creep Properties. The materials used in the mixture design shall produce a mixture with the creep properties shown in Table 2, unless otherwise shown on the plans, when tested in accordance with Test Method Tex-231-F.

(4) Job-Mix Formula Field Adjustments. The Contractor shall produce a mixture of uniform composition closely conforming to the approved job-mix formula.

If, during initial days of production, it is determined that adjustments to the mixture design job-mix formula are necessary to achieve the specified requirements, or to more nearly match the aggregate production, the Engineer may allow adjustment of the mixture design job-mix formula within the following limits without a laboratory redesign of the mixture. The adjusted job-mix formula shall not exceed the limits of the master grading for the type of mixture specified nor shall the adjustments exceed 5 percent on any one sieve, 12.5 millimeter size and larger, or 3 percent on the sieve sizes below the 12.5 millimeter sieve.

When the considered adjustments exceed either the 5 or 3 percent limits, and the Engineer determines that the impact of these changes may adversely affect pavement performance, a new laboratory mixture design will be required.

The asphalt-rubber content and/or gradation will be adjusted as deemed necessary by the Engineer to maintain desirable laboratory density near the optimum value while achieving other mix requirements.

(5) Types. The aggregate gradation of the job-mix formula shall conform to the master grading limits shown in Table 2 for the type mix specified on the plans.

TABLE 2
Master Grading Limits and Required Mixture Design Properties

Percent Passing by Mass or Limits

Sieve Sizes	Type	
(mm)	Fine Surface	Coarse Surface
22.4		100
16.0	100	95-100
9.5	85-100	50-70
4.75	40-50	30-45
2	15-25	15-25
0.425	6-20	6-20
0.18	6-18	6-18
0.075	4-8	4-8
Air Voids, percent	3	3
VMA, % minimum		1209
Creep Slope*, maximum	0.00000004 mm/mm/sec	0.00000004 mm/mm/sec
Creep Stiffness*, minimum	41,400 kPa	41,400 kPa
Permanent Strain*, maximum	0.006 mm/mm	0.006 mm/mm

*Unless otherwise approved by the Director of Materials and Tests.

(6) Tolerances. The gradation of the aggregate and the asphalt-rubber content of the produced mixture shall not vary from the job-mix formula by more than the tolerances allowed herein. When within applied tolerances, the gradation of the produced mixture may fall outside the master grading limits for any of the sieve sizes from the largest sieve size on which aggregate may be retained down through the 0.180 millimeter sieve. Only the quantity of aggregate passing the 0.075 millimeter sieve is further restricted to conform to the master grading limitations shown in Table 2 or as modified in Test Method Tex-229-F. A tolerance of two (2) percent is allowed on the sieve size for each mixture type which shows 100 percent passing in Table 2.

	Tolerance, Percent by Mass or Volume as Applicable
Passing the 22.4 to 2.00 mm sieve	Plus or Minus 5
Passing the 0.425 to 0.075 mm sieve	Plus or Minus 3
Asphalt, mass	Plus or Minus 0.5
Asphalt, volume	Plus or Minus 1.2

The mixture will be tested in accordance with Test Method Tex-228-F used in conjunction with combined cold feed belt samples tested in accordance with Test Method Tex-229-F. Other methods of proven accuracy may be used. The methods of test will be determined by the Engineer. If three (3) consecutive tests indicate that the material produced exceeds the above tolerances on any individual sieve, or if two (2) consecutive tests indicate that the asphalt content tolerance is exceeded, production shall stop and not resume until test results or other information indicate, to the satisfaction of the Engineer, that the next mixture to be produced will be within the above tolerances. When disagreements concerning determination of specification compliance occur between allowed sampling and testing procedures, extracted aggregate testing shall take precedence over cold feed belt testing.

When cold feed belt samples are used for job control, the Engineer will select the sieve analysis method that corresponds with the one used to determine the mixture design gradation. The tolerances will be adjusted as outlined in Test Method Tex-229-F.

5. Equipment.

(1) General. All equipment for the handling of all materials, mixing, placing and compacting of the mixture shall be maintained in good repair and operating condition and subject to the approval of the Engineer. Any equipment found to be defective and potentially having a negative effect on the quality of the paving mixture or ride quality will not be allowed.

(2) Mixing Plants. Mixing plants may be the weigh-batch type, the modified weigh-batch type or the drum-mix type. All plants shall be equipped with satisfactory conveyors, power units, mixing equipment, aggregate handling equipment, bins and dust collectors.

Automatic proportioning devices are required for all plants and shall be in accordance with Item 520, "Weighing and Measuring Equipment".

It shall be the Contractor's responsibility to provide safe and accurate means to enable inspection forces to take all required samples, to provide permanent means for checking the output of any specified metering device, and to perform calibration and mass checks as required by the Engineer. When cold feed belt sampling is to be used for gradation testing, occasional stoppage of the belt may be necessary unless other means of sampling are approved by the Engineer.

When using fuel oil heavier than Grade No. 2, or waste oil, the Contractor shall insure that the fuel delivered to the burner is at a viscosity of 100 SSU or less, when tested in accordance with Test Method Tex-534-C, to insure complete burning of the fuel. Higher viscosities will be allowed if recommended by the burner manufacturer. If necessary, the Contractor shall preheat the oil to maintain the required viscosity.

The Contractor shall provide means for obtaining a sample of the fuel, just prior to entry into the burner, in order to perform the viscosity test. The Contractor shall perform this test or provide a laboratory test report that will establish the temperature of the fuel necessary to meet the viscosity requirements. There shall be an in-line thermometer to check the temperature of the fuel delivered to the burner. Regardless of the burner fuel used, the burner or combination of burners and types of fuel used shall provide a complete burn of the fuel and not leave any fuel residue that will adhere to the heated aggregate or become mixed with the asphalt.

The Contractor shall provide equipment to blend the asphalt cement and ground rubber at the specified temperature and for the specified time so that an asphalt rubber is provided with uniform properties which meet the requirements of Section 3.(2)(d). The equipment shall be of adequate capacity and the system shall have the necessary supporting storage equipment to keep the plant in constant supply so that continuous plant operation may occur. A continuously reading thermometer shall be provided to show the temperature of the asphalt-rubber during the reaction and storage periods.

(a) Weigh-Batch Type.

(i) Cold Aggregate Bin Unit and Proportioning Device. The cold aggregate bin unit shall have at least four bins of sufficient size to store the amount of aggregate required to keep the plant in continuous operation and of proper design to prevent overflow of material from one bin to another. There shall be vertical partitions between each bin and on each end of the bins of sufficient height so that any over-

flow will be to the front and back, and not allow overflow to the sides or between bins. Overflow that might occur shall not fall onto any feeder belt. The proportioning device shall provide a uniform and continuous flow of aggregate in the desired proportion to the dryer. Each aggregate shall be proportioned from a separate bin.

When mineral filler is used, as specified in Section 3.(1)(c), an additional bin shall be provided.

(ii) Dryer. The dryer shall continually agitate the aggregate during heating. The temperature shall be controlled so that the aggregate will not be damaged in the drying and heating operations. The dryer shall be of sufficient size to keep the plant in continuous operation.

(iii) Screening and Proportioning. The screening capacity and size of the hot aggregate bins shall be sufficient to screen and store the amount of aggregate required to poperly operate the plant and keep the plant in continuous operation at full capacity. The hot bins shall be constructed so that oversize and overloaded material will be discarded through overflow chutes. Provisions shall be made to enable inspection forces to have easy and safe access to the proper location on the mixing plant where representative samples may be taken from the hot bins for testing.

(iv) Aggregate Weigh Box and Batching Scale. The aggregate weigh box and batching scales shall be of sufficient capacity to hold and weigh a complete batch of aggregate. The weigh box and scales shall conform to the requirements of Item 520, “Weighing and Measuring Equipment”.

(v) Asphaltic Material Measuring System. If an asphaltic material bucket and scales are used, they shall be of sufficient capacity to hold and weigh the necessary asphaltic material for one batch. The bucket and scales shall conform to the requirements of Item 520, “Weighing and Measuring Equipment”.

If a pressure type flow meter is used to measure the asphaltic material, the requirements of Item 520, “Weighing and Measuring Equipment”, shall apply. This system shall include an automatic temperature compensation device to insure a constant percent by weight of asphaltic material in the mixture.

Provisions of a permanent nature shall be made for checking the accuracy of the asphaltic-rubber material measuring device. The asphalt line to the measuring device shall be protected with a jacket of hot oil or other approved means to maintain the temperature of the line near the temperature specified for the asphaltic material.

(vi) Mixer. The mixer shall be of the pugmill type and shall have a capacity of not less than 1360 kilograms (of natural-aggregate mixture) in a single batch, unless otherwise shown on the plans. Any mixer that has a tendency to segregate the aggregate or fails to secure a thorough and uniform mixture with the asphaltic material shall not be used. All mixers shall be provided with an automatic timer that will lock the discharge doors of the mixer for the required mixing period. The dump door or doors and the shaft seals of the mixer shall be tight enough to prevent spilling of aggregate or mixture from the pugmill.

(vii) Surge-Storage System and Scales. A surge-storage system may be used to minimize the production interruptions during the normal day’s operations. A device

such as a gob hopper or other device approved by the Engineer to prevent segregation in the surge-storage bin shall be used. The mixture shall be weighed upon discharge from the surge-storage system.

When a surge-storage system is used, scales shall be standard platform truck scales or other equipment such as weigh hopper (suspended) scales and shall conform to Item 520, “Weighing and Measuring Equipment”. If truck scales are used, they shall be placed at a location approved by the Engineer. If other weighing equipment is used, the Engineer may require mass checks by truck scales for the basis of approval of the equipment.

(viii) Recording Device and Record Printer. The mixture shall be weighed for payment. If a surge-storage system is used, an automatic recording device and a digital record printer shall be provided to indicate the date, project identification number, vehicle identification, total mass of the load, tare mass of the vehicle, the mass of asphaltic mixture in each load and the number of loads for the day, unless otherwise indicated on the plans. When surge-storage is not used, batch masses will be used as the basis for payment and automatic recording devices and automatic digital record printers in accordance with Item 520, “Weighing and Measuring Equipment”, shall be required.

(b) Modified Weigh-Batch Type.

(i) General. This plant is similar to the weigh-batch type plant. The hot bin screens shall be removed and the aggregate control is placed at the cold feeds. The cold feed bins will be the same as those required for the drum-mix type plant.

(ii) Cold-Aggregate Bin Unit and Feed System. The number of bins in the cold-aggregate bin unit shall be equal to or greater than the number of stockpiles of individual materials to be used.

The bins shall be of sufficient size to store the amount of aggregate required to keep the plant in continuous operation and of proper design to prevent overflow of material from one bin to another. There shall be vertical partitions between each bin and on each end of the bins of sufficient height so that any overflow will be to the front and back and not allow overflow to the sides or between bins. Overflow that might occur shall not fall onto any feeder belt. When required by the Engineer, an approved stationary scalping screen shall be placed on top of the field sand bin to eliminate roots and other objectionable material. The feed system shall provide a uniform and continuous flow of aggregate in the desired proportion to the dryer. The Contractor shall furnish a chart indicating the calibration of each cold bin in accordance with the plant manufacturer’s recommended calibration procedures, or other methods of cold bin calibration acceptable to the Engineer.

When mineral filler is used, as specified in Section 3.(1)(c), an additional bin shall be provided.

(iii) Scalping Screen. A scalping screen shall be required after the cold feeds and ahead of the hot aggregate surge bins.

(iv) Dryer. The dryer shall continually agitate the aggregate during heating. The temperature shall be controlled so that the aggregate will not be damaged in the

drying and heating operations. The dryer shall be of sufficient size to keep the plant in continuous operation.

(v) Screening and Proportioning. The hot aggregate shall not be separated into sizes after being dried. There shall be one or more surge bins provided between the dryer and the weigh hopper. Surge bins shall be of sufficient size to hold enough combined aggregate for one complete batch of mixture.

(vi) Aggregate Weigh Box and Batching Scale. The aggregate weigh box and batching scales shall be of sufficient capacity to hold and weigh a complete batch of aggregate. The weigh box and scales shall conform to the requirements of Item 520, "Weighing and Measuring Equipment".

(vii) Asphaltic Material Measuring System. If an asphaltic material bucket and scales are used, they shall be of sufficient capacity to hold and weigh the necessary asphaltic material for one batch. The bucket and scales shall conform to the requirements of Item 520, "Weighing and Measuring Equipment".

If a pressure type flow meter is used to measure the asphaltic material, the requirements of Item 520, "Weighing and Measuring Equipment", shall apply. This system shall include an automatic temperature compensation device to insure a constant percent by mass of asphaltic material in the mixture. Provisions of a permanent nature shall be made for checking the accuracy of the asphaltic-rubber material measuring device. The asphalt line to the measuring device shall be protected with a jacket of hot oil or other approved means to maintain the temperature of the line near the temperature specified for the asphaltic material.

(viii) Mixer. The mixer shall be of the pugmill type and shall have a capacity of not less than 1360 kilograms (of natural-aggregate mixture) in a single batch, unless otherwise shown on the plans. Any mixer that has a tendency to segregate the aggregate or fails to secure a thorough and uniform mixture with the asphaltic material shall not be used. All mixers shall be provided with an automatic timer that will lock the discharge doors of the mixer for the required mixing period. The dump door or doors and the shaft seals of the mixer shall be tight enough to prevent spilling of aggregate or mixture from the pugmill.

(ix) Surge-Storage System and Scales. A surge-storage system may be used to minimize the production interruptions during the normal day's operations. A device such as a gob hopper or other device approved by the Engineer to prevent segregation in the surge-storage bin shall be used. The mixture shall be weighed upon discharge from the surge-storage system.

When a surge-storage system is used, scales shall be standard platform truck scales or other equipment such as weigh hopper (suspended) scales and shall conform to Item 520, "Weighing and Measuring Equipment". If truck scales are used, they shall be placed at a location approved by the Engineer. If other weighing equipment is used, the Engineer may require weight checks by truck scales for the basis of approval of the equipment.

(x) Recording Device and Record Printer. The mixture shall be weighed for payment. If a surge-storage system is used, an automatic recording device and a

digital record printer shall be provided to indicate the date, project identification number, vehicle identification, total mass of the load, tare mass of the vehicle, the mass of asphaltic mixture in each load and the number of loads for the day, unless otherwise indicated on the plans. When surge-storage is not used, batch masses will be used as the basis for payment and automatic recording devices and automatic digital record printers in accordance with Item 520, “Weighing and Measuring Equipment”, shall be required.

(c) Drum-Mix Type.

(i) General. The plant shall be adequately designed and constructed for the process of mixing aggregates and asphalt. The plant shall be equipped with satisfactory conveyors, power units, aggregate-handling equipment and feed controls.

(ii) Cold-Aggregate Bin Unit and Feed System. The number of bins in the cold-aggregate bin unit shall be equal to or greater than the number of stockpiles of individual materials to be used.

The bins shall be of sufficient size to store the amount of aggregate required to keep the plant in continuous operation and of proper design to prevent overflow of material from one bin to another. There shall be vertical partitions between each bin and on each end of the bins of sufficient height so that any overflow will be to the front and back and not allow overflow to the sides or between bins. Overflow that might occur shall not fall onto any feeder belt. When required by the Engineer, an approved stationary scalping screen shall be placed on top of the field sand bin to eliminate roots and other objectionable material. The feed system shall provide a uniform and continuous flow of aggregate in the desired proportion to the mixer. The Contractor shall furnish a chart indicating the calibration of each cold bin in accordance with the plant manufacturer’s recommended calibration procedures, or other methods of cold bin calibration acceptable to the Engineer.

The system shall provide positive mass measurement of the combined cold-aggregate feed by use of belt scales or other approved devices. Provisions of a permanent nature shall be made for checking the accuracy of the measuring device as required by Item 520, “Weighing and Measuring Equipment”. When a belt scale is used, mixture production shall be maintained so that the scale normally operates between 50 percent and 100 percent of its rated capacity. Belt scale operation below 50 percent of the rated capacity may be allowed by the Engineer if accuracy checks show the scale to meet the requirements of Item 520, “Weighing and Measuring Equipment”, at the selected rate. It shall be satisfactorily demonstrated to the Engineer that mixture uniformity and quality have not been adversely affected.

(iii) Scalping Screen. A scalping screen shall be required after the cold feeds and ahead of the combined aggregate belt scales.

(iv) Asphaltic Material Measuring System. An asphaltic material measuring device meeting the requirements of Item 520, “Weighing and Measuring Equipment,” shall be placed in the asphalt line leading to the mixer so that the cumulative amount of asphalt used can be accurately determined. Provisions of a permanent nature shall be made for checking the accuracy of the measuring device output. The asphalt line to the measuring device shall be protected with a jacket of hot oil or other approved

means to maintain the temperature of the line near the temperature specified for the asphaltic material. The measuring system shall include an automatic temperature compensation device to maintain a constant percent by mass of asphaltic material in the mixture.

(v) Synchronization Equipment for Feed-Control System. The asphaltic material feed-control shall be coupled with the total aggregate mass measuring device to automatically vary the asphalt-feed rate in order to maintain the required proportion.

(vi) Mixing System. The mixing system shall control the temperature so that the aggregate and asphalt-rubber will not be damaged in the drying, heating and mixing operations. A continuously recording thermometer shall be provided which will indicate the temperature of the mixture as it leaves the mixer.

(vii) Surge-Storage System and Scales. A surge-storage system shall be used to minimize the production interruptions during the normal day's operations. A device such as a gob hopper or other device approved by the Engineer to prevent segregation in the surge-storage bin shall be used. The mixture shall be weighed upon discharge from the surge-storage system.

Scales shall be standard platform truck scales or other equipment such as weigh hopper (suspended) scales and shall conform to Item 520, "Weighing and Measuring Equipment". If truck scales are used, they shall be placed at a location approved by the Engineer. If other weighing equipment is used, the Engineer may require mass checks by truck scales for the basis of approval of the equipment.

(viii) Recording Device and Record Printer. Automatic recording devices and automatic digital record printers shall be provided to indicate the date, project identification number, vehicle identification, total mass of the load, tare mass of the vehicle, the mass of asphaltic mixture in each load and the number of loads for the day in accordance with Item 520, "Weighing and Measuring Equipment", unless otherwise shown on the plans.

(3) Asphalt-Rubber Blending Equipment. The Contractor shall provide equipment to blend the asphalt cement and ground rubber at the specified temperature and for the specified time so that an asphalt rubber is provided with uniform properties which meet the requirements of Section 3.(2)(d). The equipment shall be of adequate capacity and the system shall have the necessary supporting storage equipment to keep the plant in constant supply so that continuous plant operation may occur. A continuously reading thermometer shall be provided to show the temperature of the asphalt-rubber during the reaction and storage periods. Equipment to blend crumb rubber and asphalt shall be equipped with satisfactory power units, heaters, augers and other necessary equipment to positively control the rate of addition of crumb rubber to heated asphalt, blend the crumb rubber with asphalt at specified temperature and maintain the blended binder at the required reaction temperature for a minimum of one hour. Any portion of the pavement containing asphalt rubber which has not been reacted for a minimum of one hour will be removed and replaced at the Contractor's expense. Metering units shall be equipped with readout units to enable determination of the amount of asphalt and crumb rubber which are being blended. The crumb rubber and asphalt meters shall be calibrated prior to start of each project and thereafter as required by the Engineer. Portable field viscometers shall be provided by the Contractor and used to measure viscosity of the blend prior to introduction into the mixing plant.

(4) Spreading and Finishing Machine. The spreading and finishing machine shall be approved by the Engineer and shall meet the requirements indicated below.

(a) Screed Unit. The spreading and finishing machine shall be equipped with a heated compacting screed. It shall produce a finished surface meeting the requirements of the typical cross sections and the surface tests.

Extensions added to the screed shall be provided with the same compacting action and heating capability as the main screed unit, except for use on variable depth tapered areas and/ or as approved by the Engineer.

The spreading and finishing machine shall be equipped with an approved automatic dual longitudinal screed control system and automatic transverse screed control system. The longitudinal controls shall be capable of operating from any longitudinal grade reference including a stringline, ski, mobile stringline or matching shoe.

The Contractor shall furnish all equipment required for grade reference. It shall be maintained in good operating condition by personnel trained in the use of this type of equipment. The grade reference used by the Contractor may be of any type approved by the Engineer. Control points, if required by the plans, shall be established for the finished profile in accordance with Item 5, “Control of the Work”. These points shall be set at intervals not to exceed 15.5 meters. The Contractor shall set the grade reference from the control points. The grade reference shall have sufficient support so that the maximum deflection shall not exceed 1.5 millimeters between supports.

(b) Tractor Unit. The tractor unit shall be equipped with a hydraulic hitch sufficient in design and capacity to maintain contact between the rear wheels of the hauling equipment and the pusher rollers of the finishing machine while the mixture is being unloaded.

No portion of the mass of hauling equipment, other than the connection, shall be supported by the asphalt paver. No vibrations or other motions of the loading equipment, which could have a detrimental effect on the riding quality of the completed pavement, shall be transmitted to the paver.

The use of any vehicle which requires dumping directly into the finishing machine and which the finishing machine cannot push or propel to obtain the desired lines and grades without resorting to hand finishing will not be allowed.

(5) Material Transfer Equipment. Equipment to transfer mixture from the hauling units or the roadbed to the spreading and finishing machine will be allowed unless otherwise shown on the plans. A specific type of material transfer equipment shall be required when shown on the plans.

(a) Windrow Pick-Up Equipment. Windrow pick-up equipment shall be constructed in such a manner that substantially all the mixture deposited on the roadbed is picked up and loaded into the spreading and finishing machine. The mixture shall not be contaminated with foreign material. The loading equipment shall be designed so that it does not interfere with the spreading and finishing machine in obtaining the required line, grade and s0rface without resorting to hand finishing.

(b) Material Feeding System. Material feeding systems shall be designed to provide a continuous flow of uniform mixture to the spreading and finishing machine. When use of a material feeding system is required on the plans, it shall meet the storage capacity, remixing capability or other requirements shown on the plans.

(6) Rollers. A minimum of two static wheel compactors and two vibratory steel wheel compactors shall be provided. For courses of 25 millimeters or less in nominal thickness, four static steel wheel compactors shall be provided. The compactors shall weigh not less than 7.2 megagrams. When shown on the plans, a pneumatic compactor shall be provided. The compactors shall be self-propelled. All rollers shall be equipped with pads and a watering system to prevent sticking of the asphaltic concrete mix to the steel wheels. The steel wheels shall have adequate width such that two rollers operating in tandem can make a full coverage across the mat being compacted.

(7) Straightedges and Templates. When directed by the Engineer, the Contractor shall provide acceptable 3 meter straightedges for surface testing. Satisfactory templates shall be provided as required by the Engineer.

(8) Alternate Equipment. When permitted by the Engineer, equipment other than that specified herein which will consistently produce satisfactory results may be used.

6. Stockpiling, Storage and Mixing.

(1) Stockpiling of Aggregates.

(a) Weigh-Batch Plant. Prior to stockpiling of aggregates, the area shall be cleaned of trash, weeds, grass and shall be relatively smooth and well drained. The stockpiling shall be done in a manner that will minimize aggregate degradation, segregation, mixing of one stockpile with another, and will not allow contamination with foreign material.

The plant shall have at least a two-day supply of aggregates on hand before production can begin and at least a two-day supply shall be maintained through the course of the project, unless otherwise directed by the Engineer.

No stockpile shall contain aggregate from more than one source.

Coarse aggregates for Coarse Surface Type mixtures shall be separated into at least two stockpiles, such as coarse and intermediate aggregate stockpiles.

When shown on the plans, coarse aggregates for Fine Surface Type mixtures shall also be separated into at least two stockpiles of different gradation.

No coarse-aggregate stockpile shall contain more than 15 percent by mass of material that will pass a 2.00 millimeter sieve.

Fine-aggregate stockpiles may contain coarse aggregate in amounts up to 20 percent by mass. This requirement does not apply to stone screenings stockpiles, which must meet the gradation requirements shown in Section 3.(1)(b), unless otherwise shown on the plans.

When required by the Engineer, additional material shall not be added to stockpiles that have previously been sampled for approval.

Equipment of an acceptable size and type shall be furnished to work the stockpiles and prevent segregation and degradation of the aggregates.

(b) Modified Weigh-Batch Plant. The stockpiling requirements or aggregate shall be the same as required for a drum-mix type plant.

(c) Drum-Mix Plant. When a drum-mix plant is used, the following stockpiling requirements for coarse aggregates shall apply in addition to the aggregate stockpiling requirements listed under Section 6.(l)(a).

Once a job-mix formula has been established, the coarse aggregates delivered to the stockpiles shall not vary on any grading size fraction by more than plus or minus eight (8) percentage points from the percentage found in the samples submitted by the Contractor and upon which the job-mix formula was based. Should the gradation of coarse aggregates in the stockpiles vary by more than the allowed tolerance, the Engineer may stop production. If production is stopped, new aggregates shall be furnished that meet the gradations of the aggregates submitted for the job-mix formula, or a new mix design shall be formulated.

When the volume of production from a commercial plant makes sampling of all coarse aggregate delivered to the stockpiles impractical, cold feeds will be sampled to determine stockpile uniformity. Should this sampling prove the stockpiles non-uniform beyond the acceptable tolerance, separate stockpiles which meet these specifications may be required.

(2) Storage and Heating of Asphaltic Materials. The asphaltic material storage capacity shall be ample to meet the requirements of the plant. Asphalt shall not be heated to a temperature in excess of that specified in Item 300, “Asphalts, Oils and Emulsions”. The mixture of asphalt and rubber shall comply with the temperature requirements specified in Section 3.(2)(d). All equipment used in the storage and handling of asphaltic material shall be kept in a clean condition at all times and shall be operated in such a manner that there will be no contamination with foreign matter.

(3) Feeding and Drying of Aggregate. The feeding of various sizes of aggregate to the dryer shall be done through the cold aggregate bins and the proportioning device in such a manner that a uniform and constant flow of materials in the required proportions will be maintained. The aggregate shall be dried and heated to the temperature necessary to produce a mixture having the specified temperature.

(4) Mixing and Storage.

(a) Weigh-Batch Plant. In introducing the batch into the mixer, all aggregate shall be introduced first and shall be mixed thoroughly for a minimum period of 5 seconds to uniformly distribute the various sizes throughout the batch before the asphaltic material is added. The asphaltic material shall then be added and the mixing continued for a wet mixing period of not less than 15 seconds. The mixing period shall be increased if, in the opinion of the Engineer, the mixture is not uniform or the aggregates are not properly coated.

Temporary storing or holding of the asphaltic mixture by the surge-storage system will be permitted during the normal day’s operation. Overnight storage will not be permitted unless authorized on the plans or in writing by the Engineer. The mixture coming out of the surge-storage bin shall be of equal quality to that coming out of the mixer.

(b) Modified Weigh-Batch Plant. The mixing and storage requirements shall be the same as is required for a standard weigh-batch plant.

(c) Drum-Mix Plant. The amount of aggregate and asphaltic material entering the mixer and the rate of travel through the mixing unit shall be so coordinated that a uniform mixture of the specified grading and asphalt content will be produced.

Temporary storing or holding of the asphaltic mixture by the surge-storage system will be required during the normal day's operation. Overnight storage will not be permitted unless authorized on the plans or in writing by the Engineer. The mixture coming out of the surge-storage bin shall be of equal quality to that coming out of the mixer.

7. Construction Methods.

(1) Tack Coat. The surface upon which the tack coat is to be placed shall be cleaned thoroughly to the satisfaction of the Engineer. The surface shall be given a uniform application of tack coat using asphaltic materials of this specification. This tack coat shall be applied, as directed by the Engineer, with an approved sprayer at a sufficient rate to coat the entire paving surface uniformly. All contact surfaces of curbs and structures and all joints shall be painted with a thin uniform application of tack coat. During the application of tack coat, care shall be taken to prevent splattering of adjacent pavement, curb and gutter and structures. The tack coat shall be rolled with a pneumatic tire roller when directed by the Engineer.

(2) Transporting Asphaltic Concrete. The asphaltic mixture shall be hauled to the work site in tight vehicles previously cleaned of all foreign material. The dispatching of the vehicles shall be arranged so that all material delivered is placed and all rolling completed during daylight hours unless otherwise shown on the plans. In cool weather or for long hauls, covering and insulating of the truck bodies may be required. If necessary, to prevent the mixture from adhering to the body, the inside of the truck may be given a light coating of release agent satisfactory to the Engineer.

(3) Placing.

(a) Asphaltic concrete shall be placed only when the temperature of the surface on which the asphaltic concrete is to be placed is at least 27 C, unless otherwise approved by the Engineer. The mixture shall not be placed on a wet or damp surface. The asphaltic mixture shall be dumped and spread on the approved prepared surface with the spreading and finishing machine. When properly compacted, the finished pavement shall be smooth, of uniform texture and density and shall meet the requirements of the typical cross sections and the surface tests. In addition, the placing of the asphaltic mixture shall be done without tearing, shoving, gouging or segregating the mixture and without producing streaks in the mat.

Unloading into the finishing machine shall be controlled so that bouncing or jarring the spreading and finishing machine shall not occur and the required lines and grades shall be obtained without resorting to hand finishing.

Unless otherwise shown on the plans, dumping of the asphaltic mixture in a windrow and then placing the mixture in the finishing machine with windrow pick-up equipment will be permitted. The windrow pick-up equipment shall be operated in such a manner that substantially all the mixture deposited on the roadbed is picked up and loaded into the finishing machine without contamination by foreign material. The windrow pick-up equipment will be so operated that the finishing machine will obtain the required line, grade and surface without resorting to hand finishing. Any operation of the windrow pick-up equipment resulting in the accumulation and subsequent shedding of accumulated material into the asphaltic mixture will not be permitted.

(b) In order to achieve a continuous operation, the speed of the paver shall be coordinated with the production of the plant. If the paver is stopped for more than five minutes, or there is a five minute or longer interval between the completion of delivery by one truck and the beginning of delivery by the next truck, the paver shall be pulled away from the mat in order

for the rollers to compact the area in accordance with the temperature limitations given hereinafter under compaction. A transverse construction joint shall be made by a method approved by the Engineer. If, in the opinion of the Engineer, sporadic delivery of material is adversely affecting the mat, the Engineer may require paving operations to cease until acceptable methods are provided to minimize starting and stopping of the paver.

The hopper flow gates of the spreading and finishing machine shall be adjusted to provide an adequate and consistent flow of material. These shall result in enough material being delivered to the augers so that they are operating approximately 85 percent of the time or more. The augers shall provide means to supply adequate flow of material to the center of the paver. Augers shall supply an adequate flow of material for the full width of the mat, as approved by the Engineer. Augers should be kept approximately one-half to three-quarters full of mixture at all times during the paving operation.

(c) Adjacent to flush curbs, gutters and structures, the surface shall be finished uniformly high so that when compacted it will be slightly above the edge of the curb or structure.

(d) Construction joints of successive courses of asphaltic material shall be offset at least 150 millimeters. Construction joints on surface courses shall coincide with lane lines, or as directed by the Engineer.

(e) If a pattern of surface irregularities or segregation is detected, the Contractor shall make an investigation into the causes and immediately take the necessary corrective action. With the approval of the Engineer, placement may continue for no more than one full production day from the time the Contractor is first notified and while corrective actions are being taken. If the problem still exists after that time, paving shall cease until the Contractor further investigates the causes and the Engineer approves further corrective action to be taken.

(4) In-Place Compaction Control. In-place compaction control is required for all mixtures. The temperature of asphaltic concrete just prior to compaction shall be at least 135 C. The wheels of compactors shall be wetted with water or, if necessary, soapy water to prevent mix pick-up during rolling.

The Engineer may change the rolling procedures if in his judgment the change is necessary to improve in-place compaction. The compactors shall be operated with the drive wheel in the forward position. Vibratory rollers shall be operated in the mode required by the Engineer. The compactors shall not be used in vibratory mode for courses of 25 millimeters or less in nominal thickness. The two vibratory compactors shall be used for initial breakdown and be maintained no more than 91 meters behind the paver. The remaining two compactors shall follow as closely behind the initial breakdown as possible. As many passes as needed shall be made with the second set of compactors to obtain compaction to within the air void range required herein. All compaction shall be completed before the temperature of the asphaltic concrete falls below 104 C.

Unless otherwise shown on the plans, air void control shall be required for all mixtures. Asphaltic concrete shall be placed and compacted to contain from 5 to 9 percent air voids. The percent air voids will be calculated using the theoretical maximum specific gravity of the mixture determined according to Test Method Tex-227-F. Roadway specimens, which shall be either cores or sections of asphaltic pavement, will be tested according to Test Method Tex-207-F. The nuclear-density gauge or other methods which correlate satisfactorily with results obtained from project roadway specimens may be used when approved by the Engineer. Unless otherwise shown on the plans, the Contractor shall be responsible for obtaining the required roadway specimens at his expense and in a manner and at locations selected by the Engineer.

If the percent air voids in the compacted placement is greater than 9 percent but is 10 percent or less, production may proceed with subsequent changes in the construction operations and/or mixture. If the air void content is not reduced to between 5 and 9 percent within one production day from the time the Contractor is notified, production shall cease. At that point, a test section as described below shall be required.

If the percent air voids is more than 10 percent, production shall cease immediately and a test section shall be required as described below.

In either case, the Contractor shall only be allowed to place a test section of one lane width, not to exceed 322 meters in length, to demonstrate that compaction to between 5 and 9 percent air voids can be obtained. This procedure will continue until a test section with 5 to 9 percent air voids can be produced. Only two (2) test sections per day will be allowed. When a test section producing satisfactory air void content is placed, full production may then resume.

If the percent air voids is determined to be less than 5 percent, immediate adjustments shall be made to the plant production by the Contractor, as approved by the Engineer, within the tolerances as outlined in Subarticle 4.(4), so that an adequate air void level results.

The Contractor is encouraged to perform supplemental compaction testing for his own information.

(5) Ride Quality. Unless otherwise shown on the plans, ride quality will be required in accordance with Special Specification, "Ride Quality for Pavement Surfaces".

(6) Opening to Traffic. The pavement shall be opened to traffic when directed by the Engineer. The Contractor's attention is directed to the fact that all construction traffic allowed on the pavement open to the public will be subject to the State laws governing traffic on highways.

If the surface ravels, flushes, ruts or deteriorates in any manner prior to final acceptance of the work, it will be the Contractor's responsibility to correct this condition at his expense, to the satisfaction of the Engineer and in conformance with the requirements of this specification.

8. Measurement. The quantity of crumb rubber modified asphaltic concrete will be measured by the composite mass or composite volumetric method.

(1) Composite Mass Method. Crumb rubber modified asphaltic concrete will be measured by the megagrams of the composite "Crumb Rubber Modified Asphaltic Concrete" of the type actually used in the completed and accepted work in accordance with the plans and specifications for the project. The composite asphaltic concrete mixture is hereby defined as the asphalt-rubber, aggregate and additives as noted on the plans and/or approved by the Engineer.

If mixing is done by a drum-mix plant, measurement will be made on scales as specified herein.

If mixing is done by a weigh-batch plant or modified weigh-batch plant, measurement will be determined on the batch scales unless surge-storage is used. Records of the number of batches, batch design and the mass of the composite "Crumb Rubber Modified Asphaltic Concrete" shall be kept. Where surge-storage is used, measurement of the material taken from the surge-storage bin will be made on truck scales or suspended hopper scales.

(2) Composite Volumetric Method. The crumb rubber modified asphaltic concrete will be measured by the cubic yard of compacted "Crumb Rubber Modified Asphaltic Concrete" of the type actually used in the completed and accepted work in accordance with the plans and specifications for the

project. The composite crumb rubber modified asphaltic concrete mixture is hereby defined as the asphalt-rubber, aggregate and additives as noted on the plans and/or approved by the Engineer. The volume of the composite crumb rubber modified asphaltic concrete mixture shall be calculated by the following formula:

$$V = W/1000*Ga$$

V= Cubic meters of compacted “Crumb Rubber Modified Asphaltic Concrete”

W= Total mass of crumb rubber modified asphaltic concrete in kilograms

Ga= Average actual specific gravity of three molded specimens as prepared by Test Method Tex-206-F and determined in accordance with Test Method Tex-207-F.

If mixing is done by a drum-mix plant, the Mass “W” will be determined by scales as specified herein.

If mixing is done by a weigh-batch plant or modified weigh-batch plant, and surge-storage is not used, mass will be determined by batch scales and records of the number of batches, batch designs and mass of asphalt-rubber and aggregate shall be kept. Where surge-storage is used, measurement of the material taken from the surge-storage bin will be made on truck scales or suspended hopper scales.

(3) Ride Quality. Ride quality will be measured as described in Special Specification, “Ride Quality for Pavement Surfaces”.

9. Payment.

(1) The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for the “Crumb Rubber Modified (CRM) Asphaltic Concrete” of the aggregate gradation type specified.

Measurement Method	**Bid Item**	**Unit of Measure**
Composite Mass	CRM-Asphaltic Concrete	Megagram
Composite Volumetric	CRM-Asphaltic Concrete	Meter

The payment based on the unit bid price shall be full compensation for quarrying, furnishing all materials, additives, freight involved, for all heating, mixing, hauling, cleaning the existing base course or pavement, tack coat, placing, rolling and finishing crumb rubber modified asphaltic concrete mixture, and for all manipulations, labor, tools, equipment and incidentals necessary to complete the work.

(2) When Surface Test Type-B, as specified in Special Specification, “Ride Quality for Pavement Surfaces”, is used, a bonus or deduction for each 0.1609 kilometers section of each travel lane will be calculated in dollars and cents. A running total of this will be determined for each day’s production. The bonus or deduction for ride quality will be paid for separately from the payment for the material placed.

(3) All templates, straightedges, core drilling equipment, scales and other weighing and measuring devices necessary for the proper construction, measuring and checking of the work shall be furnished, operated and maintained by the Contractor at his expense.

SPECIAL SPECIFICATION

ITEM 5160

TIRES FOR USE IN EMBANKMENT

1. **Description.** This work shall consist of placing and compacting tire chip and/or shred fill in accordance with this specification and Item 132, "Embankment" in reasonably close conformity with the lines, grades, thicknesses and typical cross sections, as shown on the plans. Instrumentation to monitor the performance of the tire chip fills will be installed by the Departments designated representative in conjunction with this work. The Contractor shall anticipate delays due to instrumentation installation and cooperate with the Engineer as necessary to allow time for the instrumentation to be successfully installed and tested.

2. **Materials.**

(1) General. The material shall be made from scrap tires which shall be shredded into the Type(s) designated on the plans. The material shall be produced by a shearing or cutting process. Tire particles produced by a hammer mill will not be allowed. The tire particles shall be free on any contaminates such as oil, gasoline, diesel, grease, etc. That could leach into the ground water. In no case shall the tire particles contain the remains of tires that have been subjected to a fire. Type a tire particles will be mixed with soil and Type B tire particles will be a cell enclosed in geotextile.

Tire particles which become contaminated and/or otherwise deemed unacceptable by the Engineer as a result of the activities of this contract shall be removed or processed as directed by the Engineer at no additional cost.

(2) Tire Particles. The gradation shall be measured in accordance with Test Method Tex-401-A, except that the sample size shall be as shown and sample preparation shall be by drying in the 60 C (140 F) oven to a constant weight. Any tire particle shall contain no more than one (1) side wall. Free loose metal not encased in rubber shall not exceed one (1) percent by mass.

Type A		**Type B**	
Master Grading	**(% Passing)**	**Master Grading**	**(% Passing)**
100 mm (4")	100 min.	300 mm (12")	100 min.
75 mm (3")	95 min.	200 mm (8")	75 min.
50 mm (2")	50 min.	37.5 mm (1.5")	25 max.
4.75 mm (No. 4)	15 max.	4.75 mm (No. 4)	1 max.
Sample size = 4.5 kg	(10 lb) min.	Sample size = 11.4 kg.	(25 lb) min.

(1) Material Storage. Tire particles shall be stored in an area acceptable to the Engineer.

3. **Equipment.**

The machinery, tools and equipment necessary for proper prosecution of the work shall be on the project and approved by the Engineer prior to the beginning of construction operations for this Item. All machinery, tools and equipment used shall be maintained in a satisfactory working condition.

4. **Construction Methods.**

(1) General. It is the primary requirement of this specification to secure an embankment with tire particles as noted on the plans. It shall be the responsibility of the Contractor to regulate the sequence of his work, to provide the depths as shown on the plans, maintain the work and rework the courses as necessary to meet these requirements.

(2) Subgrade Preparation. The subgrade that will underlie the tire particle course shall meet the grade tolerance, compaction and other requirements set forth in item 132, "Embankment".

(3) Geotextiles. The tire particles cell shall be enclosed in a layer of geotextile as shown on the plans. The geotextile shall meet the requirements of D-9-6200, Type I, and shall be installed with a minimum 450 mm (18 inch) overlap. Holes or tears in geotextile shall be repaired or replaced as directed by the Engineer. Payment for geotextiole shall be considered incidental to construction of the tire particle cell.

(4) **Placing.**

(a) **Tire Particle Cell.** The compacted thickness of any tire particle layer shall be as directed by the Engineer and not exceed 300 mm (12 inches). Each layer of the tire particles shall be placed over the full width of the section to the dimensions as shown on the plans. The tire particles shall be spread with track mounted bulldozers, rubber tired motor graders, backhoes, or other equipment as needed to obtain a uniform layer thickness. The tire particles shall be well mixed, with no pockets of either fine or coarse tire particles. Segregation of large or fine particles will not be allowed. Security against vandalism will be required for tire particle stockpiles and tire cells until the stockpiles are depleted and the cell is covered with embankment. Tire particle courses will not be placed on frozen ground.

(a) Tire particles Mixed with Embankment. A layer of uncompacted tire particles shall be placed in a uniform layer (300 mm/12 inches max.) as directed by the Engineer. A layer of embankment soil of equal uncompacted thickness shall be placed in a uniform layer on top of the tire particles. The two layers shall be mixed by scarifier, ripper teeth or methods and equipment as approved by the Engineer. The tire particles shall be well mixed with soil in a uniform layer as directed by the Engineer. Each layer of mixed tire particles and soil will be sampled for uniformity.

Embankment and tire particles shall be mixed off site when directed by the Engineer.

(5) **Shaping and Compacting.**

(a) **Tire Particle Cell.** Each lift of a tire particle cell be compacted with six passes of a vibratory smooth drum roller with a minimum static weight of approximately 9000 kilogarms (20,000 Pounds), unless otherwise directed by the Engineer. If the top of any tire particle layer becomes contaminated by the addition of foreign materials, the contaminated material shall be processed or removed as directed by the Engineer.

The surface of each layer shall be maintained during compaction operations in such a manner that a uniform texture is produced and the tire particles are firmly keyed together.

The completed side slopes and surface of the tire article course shall be brought to a condition of uniform stability and compaction. To compensate for settlement of the tire particles caused by the weight of the overlying soil, the top surface of the tire particle fill shall be overbuilt as shown on the plans. The side slopes of the tire particle fill shall be overbuilt by the amount shown on the plans at the top of the slope. A tolerance of 75 mm (3 inches) below the required garde and cross section will be allowed.

After the embankment has been completed and the final subgrade elevations have been achieved, a minimum of 30 days shall have lapsed for tire consolidation before final paving is allowed within 61 meters (200 ft.) of the bridge abutment unless otherwise approved by the Engineer.

(b) **Tire Particles Mixed With Embankment.** Tire particles mixed with embankment shall be shaped as approved by the Engineer. Tire particles mixed with embankment shall be compacted by "Ordinary Compaction" method as stated in Item 132, "Embankment". The embankment soil to be mixed with tire particles shall be a granular material with 100% passing the 9.5 mm (3/8 inch) sieve according to Test Method Tex-401-A and a bar Linear shrinkage not to exceed two (2) when tested according to Test Method Tes-107-E.

(c) **General.** Tire particle compaction within one 91) meter (3 ft.) of instrumentation and fill over conduits shall be accomplished with a walk behind vibratory smooth drum, vibratory tamping foot or vibratory pad-foot roller, with a minimum static weight of 680 kilogram (1,500 lbs.). Vibratory plate compactors are ineffective for compacting tire particles and will not be allowed. Wheeled vehicles shall not be allowed to drive over conduit placed within the tire particle fill, unless there is a minimum of 0.6 meter (2 ft.) fill over the conduit.

The Contractor shall take all necessary precautions to prevent damage, distribute or movement of any monitoring device, once installed. The Contractor shall immediately notify the Engineer of any instrumentation damage, disturbance or movement.

5. **Measurement.** The tire particle course placed in accordance3 with the widths and thicknesses shown on the plans and compacted as specified will be measured by the cubic meter in vehicles as delivered on the road.

6. **Payment.** The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Tires for Use in Embankment", of the type specified. This price shall be full compensation for furnishing and installing geotextile; placing, compacting, reworking, removal and reprocessing if needed; recompacting if needed; and for all labor, tools, equipment and incidentals necessary to complete the work.