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16. Abstract

In accordance with the original ISTEA mandate (1991) to use crumb tire rubber in pavements, Alaska would be required to use about 250 tons of used tire rubber starting in 1994 and increasing to about 1,000 tons of rubber in 1997 and each year thereafter. A number of pavements using crumb rubber modifiers have been built in the state and have been in service for periods of 8 to 15 years. Knowledge of the behavior of these rubber-modified pavements under extreme climatic conditions, particularly in relation to their low temperature cracking resistance, is necessary for future design and construction of rubberized pavements in Alaska.

This report presents results of a study to determine the low temperature cracking resistance of rubber modified pavements in Alaska in comparison with conventional asphalt concrete pavements. Laboratory studies were conducted on field specimens using the Thermal Stress Restrained Specimen Test (TSRST). Tested materials include: 1) conventional HMA with AC 2.5 and AC 5; 2) PlusRide RUMAC with AC 5; 3) asphalt-rubber concrete with AC 2.5 (wet process); 4) rubberized asphalt-rubber concrete with AC 2.5 (wet/dry process); 5) gap-graded asphalt-rubber hot-mix with AR 4000 (wet process); and 6) dense-graded HMA with AR 4000. The improvement of low temperature performance in terms of fracture temperature and strength has been demonstrated for the rubberized mixes over conventional mixes. The resistance to thermal cracking was most significant for the asphalt-rubber and rubberized asphalt-rubber materials. Field observations and performance comparisons were made to confirm the laboratory made predictions.

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THERMAL CRACKING OF RUBBER MODIFIED PAVEMENTS

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DISCLAIMER

ABSTRACT

In accordance with the original ISTEA mandate (1991) to use crumb tire rubber in pavements, Alaska would be required to use about 250 tons of used tire rubber starting in 1994 and increasing to about 1,000 tons of rubber in 1997 and each year thereafter. A number of pavements using crumb rubber modifiers have been built in the state and have been in service for periods of 8 to 15 years. Knowledge of the behavior of these rubber-modified pavements under extreme climatic conditions, particularly in relation to their low temperature cracking resistance, is necessary for future design and construction of rubberized pavements in Alaska.

This report presents results of a study to determine the low temperature cracking resistance of rubber modified pavements in Alaska in comparison with conventional asphalt concrete pavements. Laboratory studies were conducted on field specimens using the Thermal Stress Restrained Specimen Test (TSRST). Tested materials include: 1) conventional HMA with AC 2.5 and AC 5; 2) PlusRide RUMAC with AC 5; 3) asphalt-rubber concrete with AC 2.5 (wet process); 4) rubberized asphalt-rubber concrete with AC 2.5 (wet/dry process); 5) gap-graded asphalt-rubber hot-mix with AR 4000 (wet process) and, 6) dense-graded HMA with AR 4000. The improvement of low temperature performance in terms of fracture temperature and strength has been demonstrated for the rubberized mixes over conventional mixes. The resistance to thermal cracking was most significant for the asphalt-rubber and rubberized asphalt-rubber materials. Field observations and performance comparisons were made to confirm the laboratory made predictions.

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1. INTRODUCTION

In accordance with the original ISTEA mandate (1991) to use crumb tire rubber in pavements, Alaska would be required to use about 250 tons of used tire rubber starting in 1994 and increasing to about 1,000 tons of rubber in 1997 and each year thereafter. These requirements have been suspended for 1994 and 1995 to provide time for studies of the beneficial and detrimental aspects of rubber recycling into pavements. A number of pavements using crumb rubber modifiers have been built in the state and have been in service for periods of 8 to 15 years. Knowledge of the behavior of these rubber-modified pavements under extreme climatic conditions, particularly in relation to their low temperature cracking resistance, is necessary for future design and construction of rubberized pavements in Alaska.

The main objective of this study is to determine the low temperature cracking resistance of rubber modified pavements in Alaska in comparison with conventional asphalt concrete pavements. Laboratory studies were conducted on field specimens using the Thermal Stress Restrained Specimen Test (TSRST) to assess the improvement of low temperature performance in terms of fracture temperature and strength. Field observations and performance comparisons were made to confirm the laboratory based predictions.

2. BACKGROUND

2.1 The Wet Process

The wet process is defined as any method that blends crumb rubber modifier (CRM) with asphalt cement prior to incorporating the resulting asphalt-rubber binder (AR) in the asphalt paving project (Heitzman 1992). The first reported application of natural rubber in asphalt cement occurred in the 1840's (Heitzman 1992). Further developments lead to the concept of adding crumb tire rubber to asphalt cement in the 1950's (Masters 1989). Although the benefits of using rubber as an additive to asphalt cement started to be recognized for a number of years after that, its use remained limited by the technical difficulties and expense associated with mixing the rubber and asphalt (Brown 1993).

In 1964, Charles M. McDonald developed an "asphalt-rubber" material that consisted of a finely ground (No. 16 sieve to No. 25 sieve) vulcanized crumb tire rubber that is mixed with asphalt cement at temperatures ranging between 350^{o}F and 400^{o}F. The rubber reacts with the asphalt cement to form a thick elastomer, which is then diluted with about 5 percent kerosene (Mcdonald 1966 &1971). This material was applied in 1964 as a "test patch" to Sky Harbor Airport in Phoenix and on US. Route 666. Performance monitoring conducted between 1964 and 1967 indicated that these patches provided a good seal for the underlying cracks and minimized reflective cracking through the asphalt rubber surface (Brown 1993).

Presently, most applications of asphalt-rubber binders are in the form of AR chip seal, stress absorbing membrane (SAM) systems, stress absorbing membrane interlayer (SAMI) systems, crack and joint sealants, and hot-mix asphalt (HMA). The AR, in this case, is classified under two basic technologies: 1) The McDonald technology; and 2) the continuous blending technology. In the McDonald technology, 15 to 22 percent of ground tire rubber (between No. 16 and No. 30 sieve) is blended with AC 10 or AC 20 asphalt at elevated temperature ranging between 350°F and 400°F for one-half hour to one hour. The continuous blending technology, on the other hand, promotes the use of a finer rubber gradation in comparison with the McDonald technology. This will shorten the reaction time between CRM and the asphalt cement and will therefore allow mixing of the CRM and asphalt cement in a self-contained portable blending unit consisting of a primary mixing tank, a secondary mixing tank, and a booster heater. Typical CRM gradations used in both technologies are summarized in Tables 1 and 2.

2.2 The Dry Process

In the dry process, the crumb tire rubber is blended with the aggregates before adding the asphalt binder to the blended materials, producing a rubber modified hot mix asphalt concrete (RUMAC). In this case, mix production practices are similar to those used in conventional HMA. According to Esch (1982), the original concept was developed in the late 1960's by two Swedish companies, Skega AB and AB Vaegfoerbaetringar (ABV). The material application was patented under the trade name Rubit. This Swedish technology was later (in 1978) patented for use in the US under the trademark PlusRide (Takallou and Sainton 1992). The original mix incorporated about 3 to 4 percent of CRM (No. 16 to 1/4 in. sieve), by total weight of mix, into the HMA. Typical CRM gradations proposed by the Swedish companies and those used in Alaskan trial pavements between 1979 and 1981 are summarized in Table 3. Corresponding mix specifications are also presented in Table 4 (Esch 1982). It should be noted that the aggregate gradations in this case are gap-graded primarily in the 1/8 in. to 1/4 in. size range. This will allow the rubber particles to replace the aggregate particles that normally occupy this range. Experience indicates that unless this gap in the gradation curve is present, the rubber particles will resist compaction, which could result in excessive voids and low durability

Table 1: Suggested CRM Gradations (McDonald Technology) (Chehovits 1989)

Sieve Size	Percent Passing
No. 10	100
No. 16	75 - 100
No. 30	25 - 200
No. 50	0 - 40
No. 200	0 - 5

Table 2: Suggested CRM Gradations for Continuous Blending Technology (Chehovits 1989)

Sieve Size	Percent Passing
No. 60	98 - 100
No. 80	88 - 100
No. 100	75 - 100

Table 3: Original CRM Dry Process Gradation Specifications (Esch 1982)

Sieve Size	Alaska (1979-1980) % Passing	Alaska (1981) % Passing	ABV Combined Coarse and Fine % Passing	PlusRide (1981) % Passing
1/4 in.	-	-	100	-
No. 4	100	100	76 - 92	100
No. 10	15 - 35	15 - 36	28 - 36	28 -40
No. 20	-	10 - 25	10 - 24	-
No. 40	0 - 6	-	-	0 - 6
No. 200	0 - 2	-	-	-

of the resulting pavement. Gap-graded mixes have been used since the mid-1980's in a number of states, particularly Alaska, Washington, Minnesota, Oregon, Arizona, and California (Brown 1993). This technology is marketed at present as PlusRide II. Aggregate gradations specified in the PlusRide II system are illustrated in Table 5.

In addition to PlusRide RUMAC, a generic dry technology (also known as generic RUMAC) has evolved. The first generic dry system, also known as the TAK system, was developed by Takallou as a result of his research at Oregon State University (Takallou et al. 1985; Takallou and Sainton 1992). In this case, a dense-graded aggregate is used with only slight modification to accommodate less CRM content in comparison with PlusRide. Furthermore, the CRM used has a finer gradation such that the finer sizes of the crumb rubber reacts with the asphalt cement, whereas the coarser fraction of the crumb rubber helps maintain the improved elastic response of the resulting RUMAC. Generic systems for application of the dry process are in the public domain and do not require royalty payments. Field applications of such systems have been used in New York, Illinois, Florida, Kansas, Iowa, Oregon, California, and Ontario (Kandahl and Hanson 1993).

3. PERFORMANCE STUDIES

3.1 Experience in Alaska

In Alaska, the application of rubber-modified asphalt pavements started in 1979. Esch (1982) reported on the placement of seven rubberized pavements, totaling 2.5 lane-miles, using the PlusRide dry process between 1979 and 1981, and described the performance of these sections in relation to mixing, compaction, durability, fatigue, stability and flow, and tire traction and skid resistance. Eight additional sections totaling 28 lane-miles and using the same process were constructed between 1983 and 1986 in Anchorage.

Table 4: Recommended Specifications for PlusRide Paving Mixes (Esch 1982)

Characteristics	PlusRide 8	PlusRide 12	PlusRide 16
Average Daily Traffic	2,500	2,500 - 10,000	10,000
Minimum Thickness (in.)	0.75	1.5	1.75
Aggregate (Sieve Size, % Passing)	-	-	-
3/4 in.	-	-	100
5/8 in.	-	100	-
1/2 in.	-	-	65 - 80
3/8 in.	100	60 - 80	50 - 60
1/4 in.	60 - 80	30 - 42	30 - 42
No. 10	23 - 38	19 - 32	19 - 32
No. 30	15 - 27	13 - 25	12 - 23
No. 200	7 - 11	8 - 12	6 - 10
Preliminary Mix Design	-	-	-
% Rubber (Total Weight of Mix)	3.0	3.0	3.0
% Rubber (Total Volume of Mix)	6.7	6.7	6.7
% Asphalt (Total Weight of Mix)	7.5	7.5	7.5
% Asphalt (Total Volume of Mix)	20.2	20.2	20.2
Maximum Voids (%)	2	3	4

Table 5: Specifications for PlusRide II Mixes (Chehovits 1989)

Property	PlusRide 8	PlusRide 12	PlusRide 16
% Passing 3/4 in.	-	-	100
% Passing 5/8 in.	-	100	-
% Passing 3/8 in.	100	60 - 80	50 - 62
% Passing 1/4 in.	60 - 80	30 - 44	30 - 44
% Passing No. 10	23 - 38	20 - 32	20 - 32
% Passing No. 30	15 - 27	13 - 25	12 - 23
% Passing No. 200	8 - 12	8 - 12	7 - 11
% Asphalt (Total Weight of Mix)	8.0 - 9.5	7.5 - 9.0	7.5 - 9.0

Takallou et al. (1987) discussed the performance of rubber-modified asphalt pavements constructed between 1979 and 1986 in Alaska (Table 6). The experience of using the PlusRide dry process in Alaska can be summarized as follows:

a. PlusRide paving mixes have been applied successfully using both batch and drum-dryer plants and placed with conventional pavers and rollers.

b. In these mixes, 3 to 4 percent CRM was used, and 1 to 2 percent more asphalt was needed to attain a 3 percent void content or lower.

c. The PlusRide mix properties, specifically, Marshall stability, flow, and void content were very sensitive to changes in mineral aggregate gradation. These mixes typically demonstrated lower stability and higher flow-test results in comparison with HMA mixes.

d. Fatigue studies using the diametral split-tension test indicate that the fatigue life of PlusRide pavements could be more than 10 times greater than conventional mixes.

e. Compaction to the highest density with minimal void content is necessary for good performance. The recommended void content should be maintained at less than 5%.

f. The presence of the rubber in the PlusRide mix seems to minimize bleeding, since the rubber and asphalt combine to form a more elastic binder.

Table 6: Material Specifications and Mix Design Data for Alaska's Rubber Modified Pavements (Takallou et al. 1987)

Project	Carnation Fairbanks 1979	Seward Hwy Anchorage 1980	Peger Rd. Fairbanks 1981	Huffman Rd. Anchorage 1981	Lemon Road Anchorage 1983	Richardson Hwy 1985	New Seward Hwy 1985	A-St. 13th to Firewood Drive Anchorage 1985	C-St. 15th to Firewood Drive Anchorage 1985	O'Malley Rd. Anchorage 1986	Minn. Ext. Anchorage 1986	Airport Rd. Fairbanks 1986
Sieve Sizes												
3/4 in.	100	100	100	—	—	—	100	100	100	100	100	—
5/8 in.	—	—	—	—	100	100	—	—	—	—	—	100
1/2 in	—	78 - 94	—	—	—	—	—	—	—	—	—	—
3/8 in.	60 - 77	—	53 - 67	100	62 - 76	64 - 76	50 - 62	50 - 62	50 - 62	50 - 62	50 - 62	61 - 73
1/4 in.	—	43 - 57	—	—	32 - 42	30 - 44	34 - 44	30 - 44	30 - 44	30 - 44	30 - 44	30 - 40
# 4	45 - 59	29 - 43	28 - 42	47 - 60	—	49 -63	—	—	—	—	—	—
#10	29 - 41	22 - 34	20 - 32	30 - 42	22 - 32	19 - 32	21 - 29	20 - 32	20 - 32	20 - 32	20 - 32	20 - 26
#30	12 - 20	15 - 23	14 - 22	15 - 24	20 - 25	13 - 25	16 - 23	12 - 23	12 - 23	12 - 23	12 - 23	13 - 21
#200	4 - 10	5 -11	5 - 11	5 - 11	8 - 12	8 - 12	7 - 11	7 - 11	7 - 11	7 - 11	7 - 11	8 - 11
Asphalt												
% asphalt (total mix)	7.0 - 8.0	6.1 - 7.1	8.0 - 9.0	9.0 - 10.0	8.1 - 9.1	7.0 - 8.0	7.3 - 8.1	7.0 - 8.0	7.1 - 7.9	7.1 - 7.9	7.1 -7.9	7.0 - 8.0
% rubber (total mix)	3.0 - 3.5	3.0 - 3.5 &4.0	3.0	3.0	3.0	3.0	2.5	2.5	2.5	2.5	2.5	3.0
Asphalt type	AC-5	AC-5	AC-2.5	AC-5	AC-5	AC-2.5	AC-5	AC-5	AC-5	AC-5	AC-5	AC-2.5
Thickness (avg.)	2.25"	1.5 "	1.70"	0.75"	1.5"	2.0"	1.75"	2.0"	2.0"	1.50"	2.0"	1.50"
Base	2" AC	3" AC	Gravel	1.5" AC	7" ATB	8" base (D-1)	2" AC	3" ATB	3" ATB	2" AC & 3" ATB	2" AC & 3" ATB	1.5" AC
Length of paving (lane-ft)	212'	6,792'	649'	5,330'	5,075'	5,597'	10,243'	12,322'	9,610'	5,808'	22, 176'	78,144'
Mix Prop.												
Marshall Stability	320 lbs	440 lbs	270 lbs	370 lbs	820 lbs	350 lbs	800 lbs	870 lbs	870 lbs	870 lbs	870 lbs	330 lbs
@ % asphalt	7.5	7.0	8.5	8.5	8.6	7.5	7.7	7.5	7.5	7.5	7.5	7.5
% voids	3.0	2.3	1.7	3.0	1.1	2.1	1.8	1.4	1.4	1.1	1.1	1.8
Condition (1987 survey)	Good condition one pothole in 8 years	Overlaid 1982	Seal coated 1986	Good condition	Good condition minor potholes at one intersection	Very good condition	Very good condition one thermal crack in 1/2 mile after 2 winters	Very good condition	Very good condition	Minor intersection rutting	Good condition	slight to moderate flushing in mainline wheel

g. Increased rubber contents above 3 percent could cause durability problems if coupled with high void content. A case study illustrating this was reported by Esch (1982) on the durability performance of some sections of a rubber-asphalt overlay placed on the Old Seward Highway in Anchorage:

> The durability of the high-void rubber asphalt pavement placed on the Old Seward Highway in June 1980 was very low, particularly for those sections that had rubber contents above 3 percent. Raveling commenced soon after placement, and it was necessary to patch and eventually repave over the 4 percent rubber area. The center two-thirds of the roadway width over 3.5 percent rubber area also required repaving during September 1980. (p. 11)

h. Stopping distances were reduced on the average by 25 percent by the use of PlusRide pavements in comparison with conventional pavements. In addition, improved skid resistance and significant reduction in tire noise were also observed.

Rubber-modified pavements using the wet process were first applied in Alaska in 1988. These pavements were used in the construction of Danby Road, that served as part of the Geist Road Extension (renamed later as the Woodrow Johansen Expressway) in Fairbanks. Danby road was designed as a test site for rubber and latex modified asphalt pavements with and without a stress-absorbing membrane (SAM) underlayer. According to Reckard (1992), three types of modified asphalt concrete were included in the design for the northbound side of Danby Road; a conventional mix was specified for the southbound side. A total of seven types of pavements were placed as follows:

- 2 in. conventional hot-mix asphalt "control" (approx. 3,056 ft.)

- 2 in. asphalt-rubber concrete (i.e. wet process), (approx. 1,000 ft.)

- 2 in. asphalt-latex concrete (approx. 960 ft.)

- 2 in. to 3 in. rubberized asphalt-rubber concrete (i.e. combination wet-dry process) (approx. 406 ft.)

- 1-5/8 in. conventional hot-mix asphalt with 3/8 in. SAM (approx. 850 ft.)

- 1-5/8 in. asphalt-rubber concrete with a 3/8 in. SAM (approx. 730 ft.)

- 1-5/8 in. asphalt-latex concrete with a 3/8 in. SAM (approx. 810 ft.)

The pavement surface was underlain with 6 in. crushed aggregate base course and a 3 ft. of borrow containing not more than 7 percent fines. The SAM consisted of a bituminous surface treatment using a rubber-modified asphalt binder and 1/4 in. to 3/8 in. "chips". Design quantities were 0.70 gals/sq. yd. for the binder and 35 to 40 lbs/sq.yd. for the aggregate. AC 2.5 asphalt cement was used in all the paving mixes. The SAM binder consisted of 78 percent AC 2.5 asphalt cement, 4 percent extender oil, and 18 percent ground rubber particles. The asphalt cement was supplied by Mapco Petroleum, Inc. of North Pole, Alaska. The extender oil was Califux GP, sold by Witco Corporation of Oildale, California. The ground rubber was supplied by the Atlos Rubber Corporation, and was a mixture of about 5 parts of vulcanized, reclaimed tire rubber to 1 part "Tonson C112", a high natural rubber material.

Reckard (1992) described the placement and compaction of the rubberized asphalt-rubber mix as follows:

> The rubberized asphalt-rubber concrete section lies mostly on the deck of the new bridge over Noyes Slough. It could not be placed until after the bridge was completed; as a result this section was not paved until August 23, 1989, nearly a year after the rest of Danby Road. The sky was overcast that day; the

temperature was in the low 60's. The rubberized asphalt-rubber mix was very tender and began cracking, shoving and tearing under the rollers almost immediately. Additional rolling later in the day after the mix was cooler improved the mat's appearance, but it remained soft with considerable checking. Lengthy discussions were held to decide whether to remove and replace the material. The mat became harder and more stable over a period of days; by August 28 a consensus was reached that the pavement should be left in place. (p. 7)

No further performance studies were reported on the Danby Road test sections.

3.2 Experience in Other States

In other states, the widespread application of ground tire rubber in pavements started about 20 years ago in Arizona (Charania et al. 1991) mainly in the form of SAM and SAMI interlayer systems utilizing asphalt-rubber binders, with smaller quantities of asphalt-rubber used in hot-mix asphalt concrete, and as crack and joint sealant. Other applications of both the wet process and the dry process have been reported since 1988 in different states. These include: Arizona (Zanieski 1988; Kano and Charania 1989; Charania et al. 1991; Scofield 1989); California (Doty 1988; Van Kirk 1989); Connecticut (Larsen 1989); Florida (Page 1989; Ruth 1990); Massachusetts (Constantino et al. 1991); Minnesota (Allen and Turgeon 1990); Ontario, Canada (Lynch 1992); Texas (Asphalt Rubber Producers Group 1991; Estakhri et al. 1990); Washington (Anderson and Jackson 1992). A summary of main findings includes:

a. Stress absorbing membrane (SAM) and stress absorbing membrane interlayers (SAMI) could reduce, and in some cases, eliminate reflective crack propagation in overlays, at least in warmer climates. These membrane applications however, have not been effective in stopping transverse thermal cracking if the original cracks on the pavement surface have not been treated through the application of crack sealants. Appropriate treatment of original surface cracks would reduce the reflection of thermal cracks through the overlay.

b. Asphalt-rubber pavements seem to exhibit less spalling and secondary cracking than traditional pavements. They also significantly reduce reflective cracking of the alligator and block types.

c. In cold climate applications, asphalt-rubber pavements exhibit improved durability, flexibility, and temperature susceptibility in comparison to standard asphalt under the similar conditions.

d. Under certain conditions, asphalt-rubber pavements last at least twice as long as standard asphalt pavements, and in many cases three to four times longer. California Department of Transportation (Caltrans) guidelines on thickness equivalencies between asphalt-rubber hot-mix (gap graded) and conventional hot-mix asphalt concrete (dense graded) specify a thickness of the asphalt concrete overlay equal to 50% of the thickness requirements for a conventional hot-mix asphalt overlay.

e. The performance of rubber modified pavements using the PlusRide dry process, as reported from field observations, is controversial. Some field applications indicate beneficial effects of PlusRide overlays in terms of reducing both fatigue and thermal reflection cracking. However, reports on field performance of PlusRide in Minnesota (Allen and Turgeon 1990) indicate problems with raveling, in addition to no significant improvement in retarding reflective cracking.

Low temperature cracking is a major distress mode in Alaskan pavements because of extreme temperature conditions that could range, in some instances, from about 50°C below in winter to more than 40°C in summer. This results in large temperature gradients that create tensile stresses if the mix is constrained or unable to relieve these stresses by internal relaxation. Thermal cracking occurs when the tensile stress generated becomes equal to the tensile strength of the pavement. Numerous laboratory studies address low temperature cracking of asphalts and polymer modified binders and mixes (Ruth et al. 1982; Kandahl and Koehler 1987; Anderson et al. 1991; Bahia et al. 1992). A number of material properties have been identified in these studies as potential indicators of the thermal cracking resistance, such as stiffness, thermal tensile strain, and tensile strength. Recent studies by Jung and Vinson (1993); King et al. (1993); and Stock and Arand (1993), indicate that the Thermal Stress Restrained Specimen Test (TSRST), developed originally by Arand (1984), could be used to determine the fracture temperature and tensile strength at fracture of asphalt concrete mixes. In this regard, a combination of both the thermal stress build-up upon cooling, as obtained from TSRST, and tensile strength variation over the same temperature range could be used to determine the fracture temperature, tensile strength at fracture, and the maximum tensile strength reserve (defined as the maximum difference between the thermal stress and tensile strength). These parameters can be used to compare the resistance of different asphalt concrete mixes to thermal cracking and to determine their corresponding ranking (Stock and Arand 1993).

A literature search using TRIS showed no published results for laboratory studies on low temperature cracking resistance of rubber modified pavements. In Alaska, a number of rubber modified pavements have been in service for periods ranging from 8 years to 15 years. These pavements provided an excellent source to investigate the low temperature cracking resistance of rubber modified asphalt mixes.

4. SITE SELECTION AND FIELD SAMPLING

4.1 Site Selection

Typical sites were selected for sampling and testing in Anchorage and Fairbanks where crumb tire rubber modifiers were incorporated in pavements. In Anchorage, ten sites were selected for pavements with conventional hot-mix asphalt (AC 5 asphalt binder) and rubberized pavement sections (PlusRide RUMAC). These sites were located on the following roads:

a. Minnesota Drive

- Conventional hot-mix asphalt section, 1300 ft before C Street (southbound; paved 1986)
- Conventional hot-mix asphalt section, 600 ft before Lang Drive (southbound; paved 1986)
- Rubberized section, 300 ft south of Diamond Blvd. (southbound; paved 1986)
- Rubberized section, 600 ft past RR overpass (southbound; paved 1986)

b. N. Seward Highway

- Conventional hot-mix asphalt section, 1000 ft past 36th Avenue (northbound; paved 1987)
- Rubberized section, 600 ft past on-ramp from Tudor Road (northbound; paved 1985)

c. A-Street

- Conventional hot-mix asphalt section, 500 ft past Northern Lights Blvd. (northbound; paved 1986)
- Rubberized section, 200 ft south of Chester Creek (northbound; paved 1985)

d. C-Street

- Conventional section, 1500 ft south of 36th Avenue (southbound; paved 1986)
- Rubberized section, 500 ft north of Fireweed Lane (southbound; paved 1985)

In Fairbanks, the following five sites were chosen:

a. Danby Road, between the Johansen Expressway Exit and College Road

- Conventional hot-mix aphalt section (approx. 3,056 ft; paved 1988)
- Asphalt-rubber concrete section (approx. 1,000 ft; paved 1988)
- Rubberized asphalt-rubber concrete section (approx. 406 ft; paved 1989)

b. Frontage road at Airport and University

- Conventional hot-mix asphalt (constructed prior to 1979; no exact paving date was available)
- Rubberized asphalt concrete section (PlusRide RUMAC; 212 ft; paved in 1979)

A summary of construction specifications, material specifications, and mix design data for both the Anchorage and Fairbanks field sections are presented in Appendices A-E.

4.2 Field Sampling

Field sampling consisted of sawing 2 ft by 2 ft slabs at selected locations of the pavement sections. Each slab was then cut *in situ* into 6 beams, 4 in. by 24 in. approximately, with thickness equal to the depth of the pavement section. The beam length was selected to span in the longitudinal direction of the pavement (i.e. traffic direction) which is consistent with the direction of maximum thermal stresses during cooling of the pavement surface. The following is a summary of the total number of beams from each section:

Anchorage

Minnesota Dr.	Rubberized (PlusRide)	31 beams
	Conventional	30 beams
N. Seward Hwy	Rubberized (PlusRide)	15 beams
	Conventional	28 beams
A Street	Rubberized (PlusRide)	15 beams
	Conventional	15 beams
C Street	Rubberized (PlusRide)	16 beams
	Conventional	11 beams

Fairbanks

Danby St.	Rubberized (wet method)	24 beams
	Rubberized (wet-dry method)	24 beams
	Conventional	24 beams
Frontage Road (Airport Way and University)	Rubberized (PlusRide)	12 beams
	Conventional	12 beams

5. CONDITION SURVEY

The sampled field pavement sections were surveyed for evidence of thermal cracking. Surveying was conducted at locations where field specimens were obtained. The length of the section surveyed was about 250 ft from both sides of the sampling location (i.e. total length of 500 ft). In many cases, the length of the section surveyed was governed by its total length, which could be less than 500 ft. All pavements surveyed in Anchorage consisted of older pavements that had been overlaid with 2 in. thick conventional hot-mix asphalt or with rubberized asphalt concrete surfaces. In Fairbanks, the locations on Danby Road were not overlaid and had original pavement surface thickness (rubberized or conventional) of about 2 inches. On the other hand, pavement sections on Frontage Road consisted of 2 in. original asphalt concrete surface, 1.5 in. asphalt concrete overlay, and a 1.5 in. second overlay of asphalt concrete or rubberized asphalt concrete surface. Condition survey data, including mix and section properties for both Anchorage and Fairbanks sections are included in Appendices F and G, respectively. The following is a summary of temperature cracking observations:

5.1 Anchorage Sites

a. On Minnesota Drive, no thermal cracks were observed on the two conventional sections surveyed. Transverse cracking, however, occurred in one of the two rubberized sections at one location only. No cracking was observed within 250 ft on both sides of the sampling spot.

b. On N. Seward Highway, transverse cracking for the conventional pavement was observed at about 15 ft intervals, in comparison with 75 ft for the rubberized section.

c. On A-Street, transverse cracks were observed at intervals of about 100 ft in case of the conventional pavement and 60 ft for the rubberized section. The width of the cracks seemed to be reduced in the rubberized section to a maximum of 1/4 in. in comparison with a maximum of 1/2 in. for the conventional pavement.

d. On C-Street, the spacing between transverse cracks in the rubberized section was on the average equal to 120 ft with maximum width not exceeding 1/4 inches. The conventional pavement exhibited transverse cracking with spacing equal to 150 ft and widths up to 1/2 inches.

In all the above cases, for both the conventional and rubberized pavements, transverse cracks extended across the total width of the pavement.

5.2 Fairbanks Sites

1. On Danby Street, the conventional sections exhibited transverse cracking at intervals between 16 ft and 20 ft. The asphalt-rubber pavement (wet process) had transverse cracks at intervals of about 120 ft. In the rubberized asphalt-rubber pavement (wet/dry method) two transverse cracks spaced at 20 ft were observed over the 300 ft length of the section.

2. On the Frontage Road, the conventional asphalt concrete overlay exhibited block type cracking in the transverse and longitudinal direction. The transverse cracks were spaced at about 10 ft intervals. Longitudinal cracks were observed 8 ft away from both edges of the pavement. This block pattern in the overlay could be associated with reflection cracking of the older underlying pavement. In case of the PlusRide overlay, the spacing of the transverse cracks was approximately 24 ft, whereas the longitudinal

cracking pattern remained essentially unchanged. The width of the cracks seemed to range from less than 1/4 in. to a maximum of 1 in. for both the conventional and the rubberized sections. This site had a total length of only 212 ft.

6. LABORATORY TESTING

6.1 Testing Program

The Thermal Stress Restrained Specimen Test (TSRST) provides an excellent mean of determining both the fracture temperature and fracture strength of asphalt concrete and rubber modified asphalt concrete materials. A number of specimens obtained from representative sites with both conventional asphalt concrete pavements and rubber modified pavements have been used in the testing program. In this project, specimens selected from Fairbanks (Danby Road) and Anchorage (N. Seward Hwy, C Street) have been tested. Additional tests using California mixes were also performed for comparison purposes.

Testing was conducted on the following mixes:

a. Conventional hot-mix asphalt (HMA), Anchorage; AC 5 asphalt

b. Rubberized asphalt mix using dry process (PlusRide), Anchorage

c. Conventional hot-mix asphalt (HMA), Fairbanks; AC 2.5 asphalt

d. Asphalt-rubber concrete (ARC), Fairbanks

e. Rubberized asphalt-rubber concrete (R-ARC), Fairbanks

f. Conventional dense-graded hot-mix asphalt (HMA), California; AR-4000 asphalt

g. Asphalt Rubber Hot Mix - Gap Graded (ARHM) , California; AR-4000 asphalt blended with 20% CRM, and extender oil, and mixed with gap-graded aggregate according to Caltrans specifications.

The California mixes were prepared using AR-4000 binder (similar to AC 20) and were included in this study to compare the influence of binder viscosity on thermal cracking resistance. A summary of California HMA and ARHM specifications are presented elsewhere (Raad et al. 1993).

A summary of the specimens tested using TSRST is presented in Table 7. The corresponding mix properties and material specifications for both the Anchorage and Fairbanks specimens are presented in Appendices F and G, respectively.

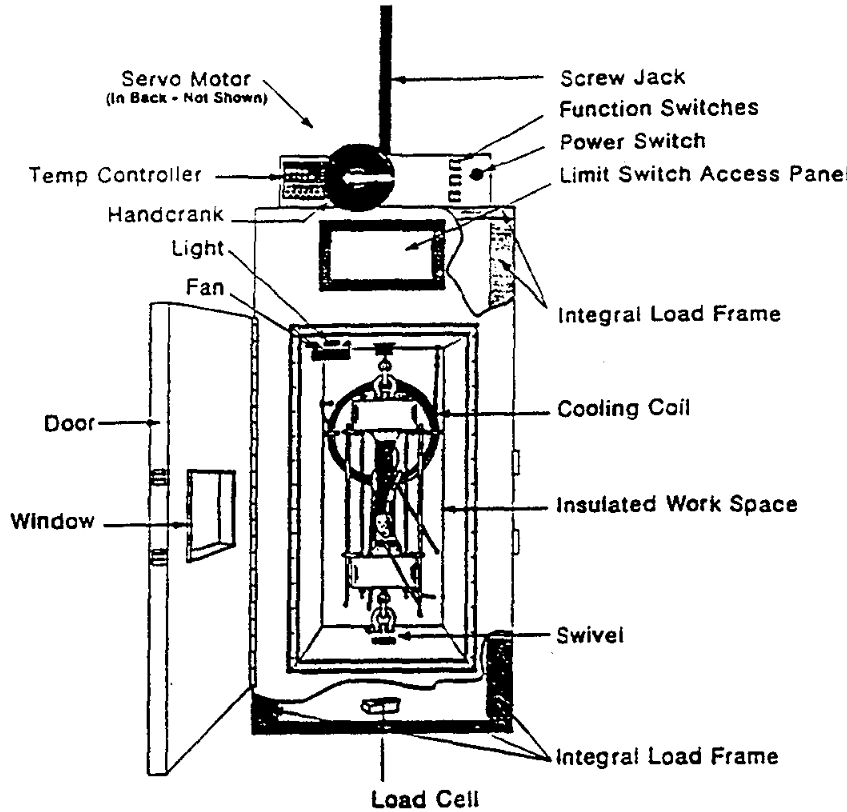
6.2 Testing Procedure

Tests were conducted on prismatic specimens that were cut into approximately 2 in. by 2 in. by 10 in. samples, from larger beam specimens obtained from different sites. These specimens were tested according to TSRST procedures. In this case, both ends of the specimen were held fixed as it was cooled from a laboratory temperature of 22^{o}C, at a rate averaging 8^{o}C/hr. As the specimen temperature drops, thermal stresses build up, and fracture occurs when the thermal stress becomes equal to the fracture strength. Both fracture temperature and fracture strength were recorded. A graphical representation of TSRST equipment and typical variation of tensile stress build-up in the specimen with specimen temperature is shown in Fig. 1.

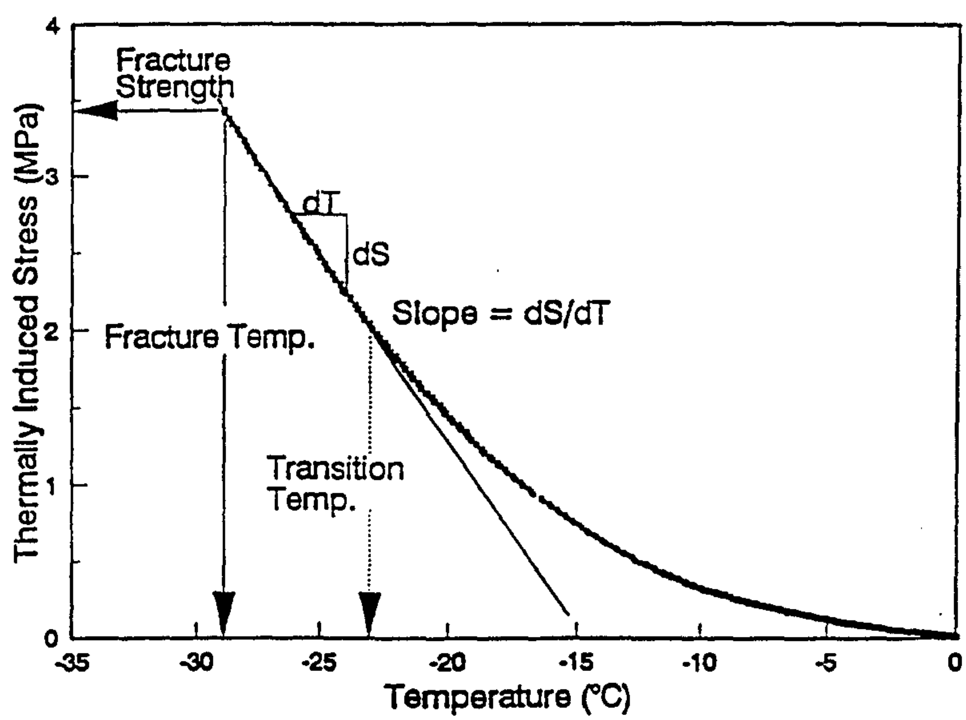
Table 7
Material Data for Anchorage, Fairbanks and California TSRST Specimens

Location	Material	Sample No.	Density (pcf)
C Street, Anchorage	HMA	C-2-1	141.9
C Street, Anchorage	HMA	C-2-2	142.1
C Street, Anchorage	HMA	C-2-3	142.0
N.Seward Hwy, Anchorage	PlusRide	S-1-1	142.8
N.Seward Hwy, Anchorage	PlusRide	S-1-3	142.5
N.Seward Hwy, Anchorage	PlusRide	S-1-4	141.3
N.Seward Hwy, Anchorage	PlusRide	S-1-5	143.1
Danby St., Fairbanks	HMA	5E	146.4
Danby St., Fairbanks	HMA	5F	147.2
Danby St., Fairbanks	HMA	5G	146.9
Danby St., Fairbanks	HMA	5H	148.3
Danby St., Fairbanks	ARC	4G	145.8
Danby St., Fairbanks	ARC	4H	145.5
Danby St., Fairbanks	ARC	4J	145.2
Danby St., Fairbanks	R-ARC	9B2	142.7
Danby St., Fairbanks	R-ARC	9C-1	142.6
Danby St., Fairbanks	R-ARC	9G	143.1
Danby St., Fairbanks	R-ARC	9H	143.1
Danby St., Fairbanks	R-ARC	9K-1	141.9
California	ARHM	RD5	145.4
California	ARHM	RD6	145.6
California	ARHM	RF5	143.8
California	ARHM	RF6	145.1
California	HMA	CD5	150.4
California	HMA	CD6	150.4
California	HMA	CE5	150.5
California	HMA	CE6	150.8

HMA = Conventional Hot-Mix Asphalt
PlusRide = Rubber Modified Hot-Mix Asphalt (RUMAC) ; Dry Method
ARC = Asphalt-Rubber Concrete ; Wet Method
R-ARC = Rubberized Asphalt-Rubber Concrete ; Wet/Dry Methods
ARHM = Asphalt-Rubber Hot Mix (Gap Graded)



(a) Schematic of TSRST Apparatus



(b) Typical Test Results for Monotonic Cooling Rate

Figure 1 Thermal Stress Restrained Specimen Test

7. RESULTS

All TSRST data are presented in Appendix H. A summary of all TSRST results for both conventional and rubberized mixes is shown in Tables 8 -10. Practically, the two most significant parameters obtained are fracture strength and fracture temperature. A summary including average fracture temperature, average fracture strength, and rank using fracture temperature as a criterion is presented in Table 11. Average fracture temperature data are also compared in Fig. 2. Results indicate the following:

a. Rubber modification significantly improved the resistance to thermal cracking, particularly when the wet process was used. Both Fairbanks rubberized mixes, the rubberized asphalt-rubber mix (wet/dry process) and the asphalt-rubber mix, maintain the best thermal cracking performance with fracture temperatures of -47°C and -42°C respectively. Among the Alaskan mixes, the conventional hot-mix asphalt (Anchorage) ranked last with a fracture temperature equal to -26°C. Using PlusRide (Anchorage) did not improve significantly the thermal cracking resistance, as it resulted in lowering the fracture temperature by about 2°C.

b. As expected, asphalt mixes with lower viscosity have better resistance to thermal cracking than higher viscosity mixes. For example, the conventional Anchorage AC 5 mix has a fracture temperature of -26°C in comparison with -31°C for the Fairbanks AC 2.5 mix. In this case, the use of AC 2.5 mix reduces the fracture temperature by about 5°C. On the other hand, using rubber as a modifier in the Fairbanks mix (ARC, wet process) would further reduce the fracture temperature by about 11°C. In this particular case, rubber modification using the wet process seems to have more significant influence on the reduction of fracture temperature in comparison with binder viscosity reduction from AC 5 to AC 2.5.

Table 8. Multi-Parameter Summary of TSRST Results for Anchorage

	Anchorage, Alaska						
	Hot-Mix Asphalt			PlusRide			
	C-2-1	C-2-2	C-2-3	S-1-1	S-1-3	S-1-4	S-1-5
Cross section area (sq. in.)	3.86	3.9	4.01	3.65	3.35	3.57	3.57
Number of observations	387	430	421	456	419	645	382
Cooling rate (deg C/hr)	-8.56	-8.34	-8.3	-8.74	-8.67	-8.92	-8.81
Regression coeff. for cooling rate	0.999	1	1	0.999	0.998	0.999	0.999
Fracture strength (psi)	279	333	227	258	276	238	242
Fracture temperature (deg C)	-27.9	-26	-24.8	-27.4	-29.5	-28.4	-27.8
First slope (psi/deg C)	-1.55	-1.29	-0.69	-0.56	-1.31	-1.43	-1.44
Regression coeff. for 1st slope	0.599	0.841	0.734	0.876	0.959	0.853	0.81
Second slope (psi/deg C)	-20.5	-22.07	-15.53	-18.4	-18.96	2.45	-17.89
Regression coeff. for 2nd slope	0.998	0.999	0.999	0.999	0.994	0.928	0.988
Tangent transition temperature (deg C)	-13.4	-10.7	-9.4	-12.6	-15.7	-65.5	-14.9
Bisector transition temperature (deg C)	-17.6	-15	-14.2	-17	-20.3	-23.9	-18.6

Table 9. Multi-Parameter Summary of TSRST Results for Fairbanks

	Fairbanks, Alaska											
	Hot-Mix Asphalt				ARC			Rubberized ARC (Wet/Dry)				
	5E	5F	5G	5H	4G	4H	4J	9B2	9C_1	9G	9H	9K_1
Cross section area (sq. in.)	3.47	3.53	3.50	3.45	3.41	3.45	3.51	2.70	2.64	2.70	2.70	2.86
Number of observations	479	517	487	396	706	448	598	512	533	437	677	600
Cooling rate (deg C/hr)	-7.5	-9.01	-8.73	-9.11	-8.61	-9.01	-8.38	-9.01	-8.8	-8.94	-9.05	-8.53
Regression coeff. for cooling rate	0.968	1	0.999	0.996	0.993	0.999	1	0.998	1	0.999	0.996	1
Fracture strength (psi)	435	322	417	372	457	373	369	585	586	219	424	551
Fracture temperature (deg C)	-32.8	-32.7	-30.2	-28.9	-47.1	-38.3	-41.4	-45.0	-45.1	-38.6	-52.3	-43.7
First slope (psi/deg C)	-1.62	-0.45	-0.45	-0.66	-0.42	-1.33	-0.24	-0.57	-1.16	-0.84	-0.39	-0.48
Regression coeff. for 1st slope	0.76	0.613	0.718	0.726	0.845	0.851	0.631	0.755	0.945	0.907	0.779	0.912
Second slope (psi/deg C)	-35.39	-18.73	-29.50	-26.59	5.64	-22.6	-20.05	-27.75	-31.28	-16.17	-21.74	-25.8
Regression coeff. for 2nd slope	0.875	0.995	0.996	0.992	0.458	0.944	0.999	0.835	0.962	0.953	0.954	0.999
Tangent transition temperature (deg C)	-19.3	-14.6	-15.6	-16.5	-74.3	-21.3	-20.9	-26.1	-26.8	-25.5	-29.4	-23.2
Bisector transition temperature (deg C)	-23.4	-19.8	-21.40	-20.7	-32.6	-25.3	-25.6	-29.67	-31.5	-29.03	-35.50	-29.4

Table 10. Multi-Parameter Summary of TSRST Results for ARHM

	Asphalt-Rubber Hot Mix			
	RD		RF	
	RD5	RD6	RF5	RF6
Cross section area (sq. in.)	3.41	3.47	3.44	3.44
Number of observations	494	489	472	467
Cooling rate (deg C/hr)	-8.79	-8.74	-9.29	-8.62
Regression coeff. for cooling rate	1	1	1	1
Fracture strength (psi)	394	414	314	463
Fracture temperature (deg C)	-30.3	-30.1	-33.4	-33.5
First slope (psi/deg C)	-2.09	-2.14	-1.9	-2.53
Regression coeff. for 1st slope	0.917	0.936	0.938	0.956
Second slope (psi/deg C)	-20.79	-22.41	-21.05	-27.06
Regression coeff. for 2nd slope	0.999	0.999	0.989	0.998
Tangent transition temperature (deg C	-10.7	-12.2	-18.1	-17
Bisector transition temperature (deg C	-14.4	-17.6	-23.1	-22.3

Table 11: A Comparison of TSRST Average Fracture Strength and Fracture Temperature

Material	Fracture Strength (psi)	Fracture Temp. (^oC)	Rank
Conventional Mix, HMA, (Fairbanks)	387	**-31**	**4**
Asphalt Rubber Concrete, ARC, (Fairbanks)	400	**-42**	**2**
Rubberized Asphalt Rubber, R-ARC, (Wet/Dry), (Fairbanks)	536	**-52**	**1**
Conventional Mix, HMA (Anchorage)	278	**-26**	**6**
PlusRide (Anchorage)	254	**-28**	**5**
Conventional Mix, HMA, (California)	540	**-22**	**7**
Asphalt-Rubber Hot-Mix, ARHM, (California)	396	**-32**	**3**

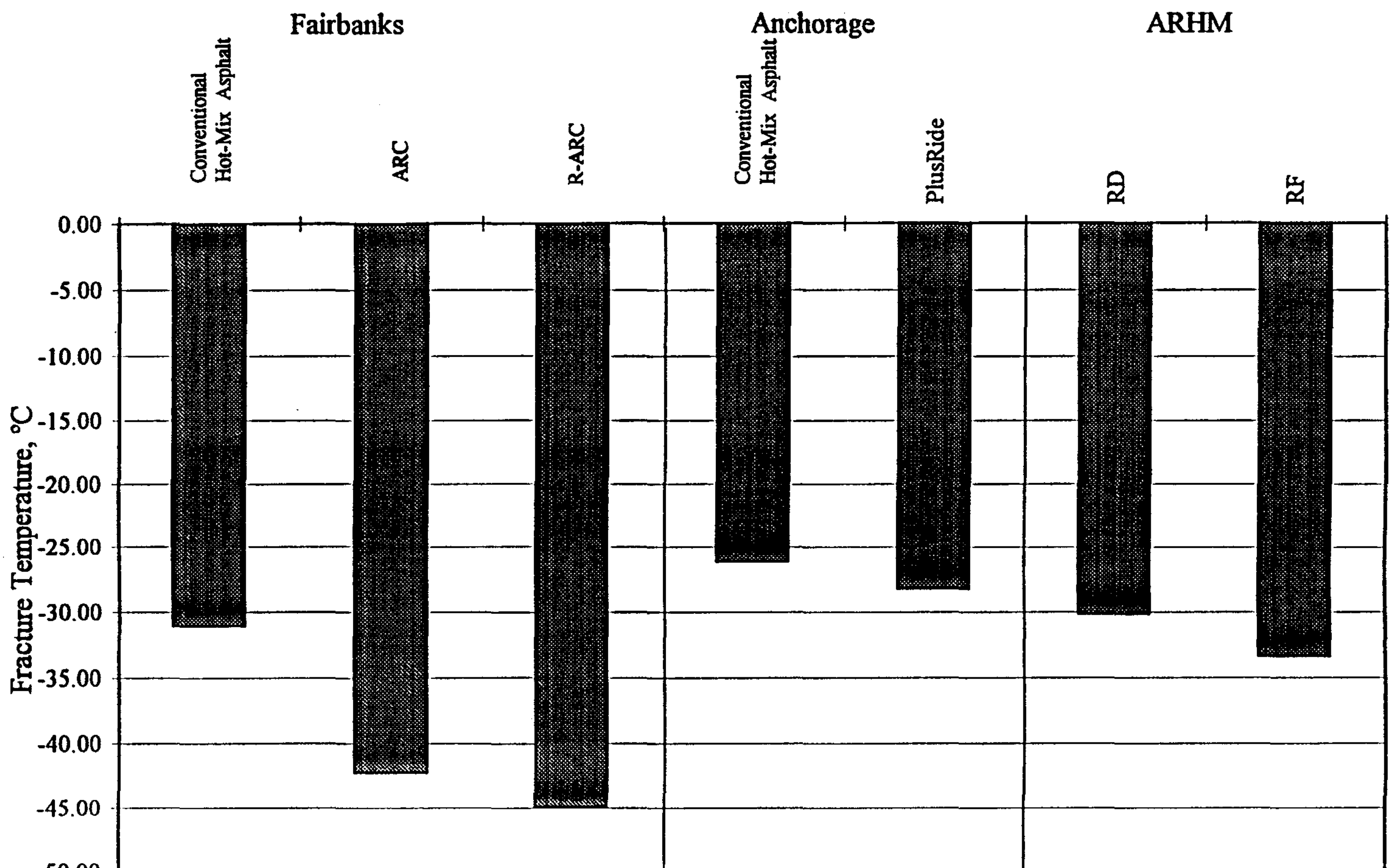


Figure 2. Comparison of Average Fracture Temperatures for Test Specimens

c. The use of rubber with relatively viscous binders (wet process) such as the AR 4000 as in the California mix, reduces the fracture temperature by about 10°C. In comparison, the use of rubber with the AC 2.5 reduces the fracture temperature on the average by 11°C. In other words, the use of rubber in the wet process application seems to result essentially in the same magnitude of reduction in fracture temperature for both high viscosity binders (e.g. AR 4000) and lower viscosity binders (e.g. AC 2.5).

d. High fracture strength does not necessarily imply greater resistance to thermal crack initiation. For example, the California HMA (Table 11), has the highest fracture strength but the lowest fracture temperature among all the mixes considered. Fracture temperature may be considered a good indicator for thermal crack initiation in the pavement surface, whereas fracture strength is more indicative of thermal crack spacing after the initiation of thermal cracking. Higher viscosity mixes could exhibit a larger build-up of tensile stress during cooling, and eventually may fracture at a higher temperature than mixes with lower viscosity. The ability of the mix to have low fracture temperature and high fracture strength is highly desirable. However, this seems to depend on the ability of the mix to maintain its "flexibility" at lower temperatures and relieve the build-up of tensile stresses through creep and stress relaxation during cooling.

e. Fracture strength may influence the spacing of the thermal cracks in the pavement. Higher fracture strength will result in larger crack spacing in general, provided the pavement temperature becomes lower than the mix fracture temperature and cracking starts to develop.

f. The difference between fracture strength at a given temperature and the thermal stress developed in a given mix is generally defined as the "reserve strength" of the material. The "reserve strength" could be used to predict field fatigue performance under combined traffic and temperature loading. Performance criteria using "reserve strength" concepts, however, have not been developed yet.

8. CONCLUSIONS AND RESEARCH NEEDS

The thermal cracking resistance of pavements is generally enhanced by using crumb tire rubber modifiers. The magnitude of improvement depends on the rubber modification process used and the viscosity of the asphalt binder. In Alaska, both the wet process and the PlusRide dry process could be used to increase thermal cracking resistance. The most beneficial effect was found when the wet process or the wet/dry process was used with the AC 2.5 binder. In this case, the fracture temperature predicted using TSRST reached a minimum in the range of -40°C and -46°C in comparison with about -32°C for the conventional AC 2.5 mix. These laboratory results are consistent with observed field thermal cracking behavior. Low temperature transverse cracks were observed at intervals between 16 ft and 20 ft for the conventional AC 2.5 pavement and at intervals of about 120 ft for the asphalt rubber pavement.

The use of PlusRide RUMAC seems to improve the thermal cracking resistance, but to a lesser extent than the wet process. This is evident from field performance observations where, for example, PlusRide sections in Fairbanks exhibited transverse cracking at intervals of 24 ft in comparison with 10 ft for the conventional AC 2.5 sections. In Anchorage, the observed crack intervals were larger and varied from 15 ft to 120 ft for the conventional AC 5 sections, and from 75 ft to 160 ft for the PlusRide sections. Laboratory test results indicate that the fracture temperature of Anchorage PlusRide mixes had an average value of -28°C, which is slightly lower than the average fracture temperature of -26°C for the conventional AC 5 mixes. The larger crack spacing observed in the Anchorage sections, compared with Fairbanks, is indicative of warmer winters in Anchorage.

Future research should concentrate on developing performance based mix specifications for rubber modified pavements, particularly in relation to the resistance of the mix to thermal cracking in addition to other distress modes such as fatigue and rutting. The application in this case of the SHRP binder and mix specifications to rubberized mixtures need to be investigated. Further testing at slower cooling rates more representative of actual field cooling rates may provide better comparisons between different rubber and mix types.

REFERENCES

1. Allen, H. S., and Turgeon, C. M. Evaluation of Plus Ride (Trademark), A Rubber Modified Plant Mixed Bituminous Surface Mixture. Final Report, Report No. 90-01, Minnesota Department of Transportation, January, 1990.

2. Anderson, K. W., and Jackson, N. W. Rubber Asphalt Pavements in the State of Washington. Special Technical Paper, Report No. WA-RD 268.1, Washington State Department of Transportation, March, 1992.

3. Bahia, H. U., Christensen, D. W., and Anderson, D. A. The Bending Shear Rheometer: A Simple Device for Measuring Low Temperature Rheology of Asphalt Binders. Proceedings, AAPT, Vol. 61, 1992.

4. Brown, R. History of Use of Crumb Rubber in Asphalt Paving Materials. Crumb Rubber Modifier Workshop-Design Procedures and Construction Practices- FHWA, March, 1993.

5. Charania, E., Cano, J. H., and Schnormeier, R. H. Twenty Year Study of Asphalt Rubber Pavements in Phoenix, Arizona. Transportation Research Record 1307, Transportation Research Board, National Research Council, Washington, D. C., 1991.

6. Chehovits, J. G. Design Methods for Hot-Mixed Asphalt Rubber Concrete Materials. Asphalt Rubber Producers Group National Seminar on Asphalt Rubber, Federal Highway Administration, 1989.

7. Constantino, P., Abraham, M. P., and Murray, D. Evaluation of Asphalt-Rubber Overlay of Old Concrete, Sterling, Massachusetts. Asphalt Producers Group, 1991.

8. Doty, R. N. Flexible Pavement Rehabilitation Using Asphalt-Rubber Combinations. Transportation Research Record 1196, Transportation Research Board, National Research Council, Washington, D. C., 1990.

9. Esch, D. C. Construction and Benefits of Rubber-Modified Asphalt Pavements. Transportation Research Record 860, TRB, National Research Council, Washington, D. C., 1982.

10. Estakhri et al. Use, Availability and Cost-Effectiveness of Asphalt Rubber in Texas. Final Report, Texas Transportation Institute, Texas A&M University, Report No. TX-91/1902-1F, September, 1990.

11. Heitzman, M. A. State of the Practice - Design and Construction of Asphalt Paving Materials with Crumb Rubber Modifier. FHWA Report No. FHWA-SA-92-022, May, 1992.

12. Jung, D., and Vinson, T. S. Low Temperature Cracking Resistance of Asphalt Concrete Mixtures. Proceedings, AAPT, Vol. 62, 1993.

13. Kandahl, P., and Hanson, D. Crumb Rubber Modifier (CRM) Technologies. Crumb Rubber Modifier Workshop-Design and Construction Practices- FHWA, March, 1993.

14. Kandahl, P., Koehler, W. Effect of Rheological Properties of Asphalts on Pavement Cracking. Asphalt Rheology: Relationship to Mixture, ASTM Special Technical Publication 941, Philadelphia, 1987.

15. Kano, J. O., and Charania, E. The Phoenix Experience Using Asphalt-Rubber. Asphalt Rubber Producers Group, Proceedings, National Seminar on Asphalt Rubber, Kansas City, MO., 1989.

16. King et al. Influence of Asphalt Grade and Polymer Concentration on the Low Temperature Performance of Polymer Modified Asphalt. Proceedings, AAPT, Vol. 62, 1993.

17. Larsen, D. A. Eight - year Performance Evaluation of an Asphalt-Rubber Hot Mix Pavement. National Seminar on Asphalt Rubber, Kansas City, MO., October, 1989.

18. Lynch, D. F., and Northwood, R. P. The Waste Tire Paving Demonstration Project at Thamesville, Ontario. Proceedings, TAC Annual Conference, Vol. 6, Winnipeg, September, 1992.

19. McDonald, C. H. A New Patching Material for Pavement Failures. Highway Research Record 146, HRB, National Research Council, Washington, D. C., 1966.

20. McDonald, C. H. An Elastomer Solution for "Alligator" Pattern on Fatigue Cracking in Asphalt Pavements. Paper Presented at International Symposium on Use of Rubber in Asphalt Pavements, Salt Lake City, UT, 1971.

21. Masters, M. F. Cost Comparisons Using Conventional Methods of Rehabilitation Versus Methods Using Asphalt-Rubber Systems. Asphalt Rubber Producers Group National Seminar on Asphalt Rubber, Federal Highway Administration, 1989.

22. Page, G. C. Florida's Experience Utilizing Ground Tire Rubber in Asphalt Concrete Mixtures. Asphalt Rubber Producers Group, Proceedings, National Seminar on Asphalt Rubber, Kansas City, MO., October, 1989.

23. Raad, L., Saboundjian, S., and Corcoran, J. Remaining Fatigue Life Analysis: A Comparison Between Conventional Dense Graded Asphalt Concrete and Gap-Graded Asphalt Rubber Hot Mix. Transportation Research Record 1388, TRB, National Research Council, Washington, D. C., 1993.

24. Reckard, M. Asphalt with Rubber Additives: Construction Report. Experimental Feature in Construction Project AK86-03, Alaska Department of Transportation and Public Facilities, 1991.

25. Ruth, B. E., Bloy, L. L., and Arital, A. A. Predictions of Temperature Cracking at Low Temperatures. Proceedings, AAPT, Vol. 51, 1982.

26. Ruth, B. E. Executive Summary of Information Compiled from Investigations and Demonstration Projects Pertained to the Use of Ground Tire Rubber in Highway Construction. Technical Report, Report No. FDOT 99700-7520-010, Gainsville Engineering and Industrial Experiment Station, Florida University, 1990.

27. Scofield, L. A. The History, Development, and Performance of Asphalt Rubber at ADOT. Final Report, Report No. AZ-SP-8902, Arizona Department of Transportation and Public Facilities, December, 1989.

28. Stock, A. F., and Arand, W. Low Temperature Cracking in Polymer Modified Binders. Proceedings, AAPT, Vol. 62, 1993.

29. Takallou, M. B., McQuillen, J., and Hicks, R. G. Effect of Mix Ingredients on Performance of Rubber-Modified Asphalt Mixtures. FHWA Report No. FHWA-AK-RD-85-05, May, 1985.

30. Takallou, H. B., Hicks, R. G., and Esch, D. C. Use of Rubber-Modified Asphalt Pavements in Cold Regions. Prepared for Workshop on Paving in Cold Areas, Ottawa, Ontario, 1987.

31. Takallou, M. B., and Sainton, A. Advances in Technology of Asphalt Paving Materials Containing Used Tire Rubber. Transportation Research Record 1339, TRB, National Research Council, Washington, D. C., 1992.

32. Texas Asphalt Rubber Survey. Asphalt Rubber Producers Group, 1991.

33. Zanieski, J. Summary of Arizona Department of Transportation Experience with Asphalt Rubber. Final Report, Report No. FHWA-AZ88-818, Arizona Department of Transportation, August, 1988.

APPENDIX A

MIX DESIGN DATA SHEETS

AND

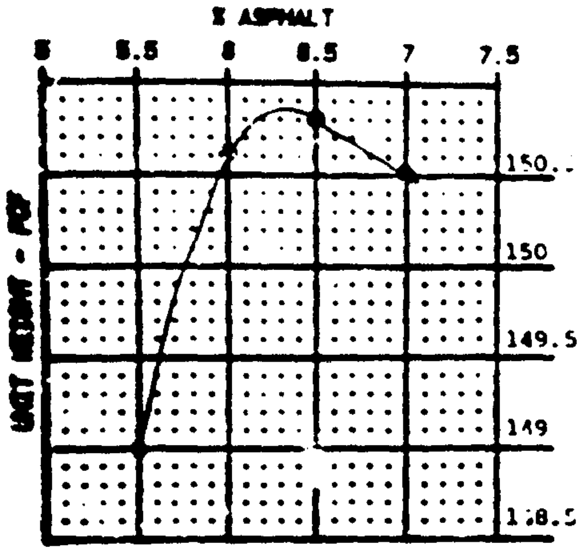
TYPICAL PAVEMENT SECTIONS

(ANCHORAGE)

REVISED

State of Alaska
Department of Transportation & Public Facilities
BITUMINOUS MIX DESIGN

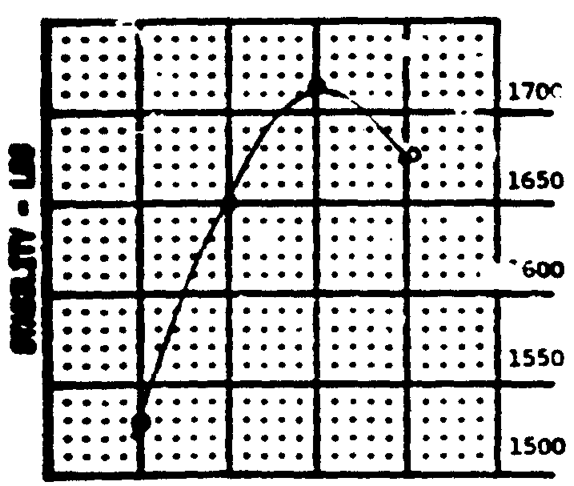
Project No. [illegible] Project Name [illegible] Safety Improve. Lab. No. 86A-1181
Materials Source(s) Central Paving Products Date Reported 7-6-86
Quality No.(s) 86A-812 Submitted By Kevin Braun Date Received 7-8-86

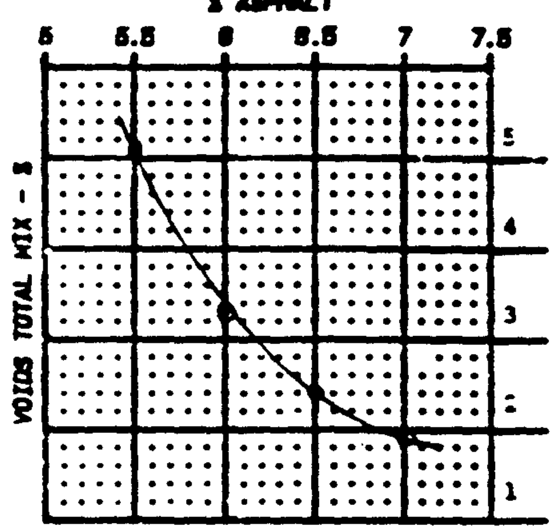


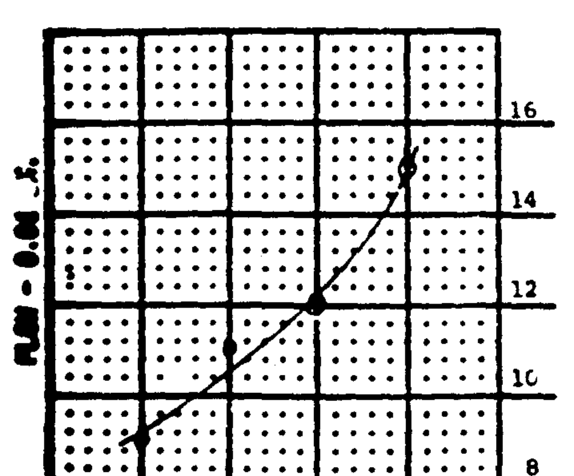
ASPHALT
Optimum [illegible] % by wt of:
☐ Dry Agg. ☒ Total Mix
Grade AC-5 Chev
SpG 1.022
Agg. Blend SpG 2.750
VOIDS
Filled 84 70-90
Total Mix 2.7 2-5
Stability 1700 1000+
Flow 11 8-18
Unit Weight 150.9 pcf
Anti-Strip Req'd 0.25 %
Max. Mix Temp. 280 F
Remarks:

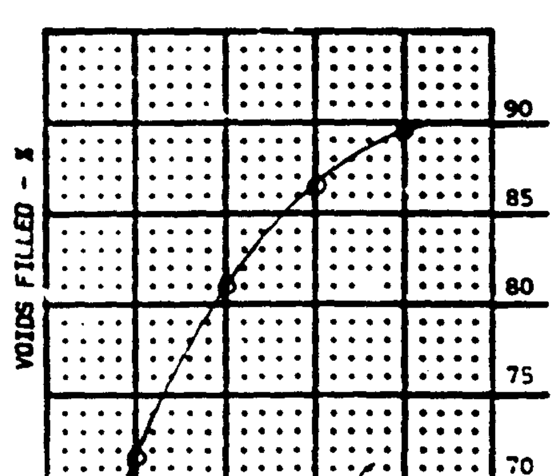
SIEVE ANALYSIS

SIEVE	% PASS	SPEC'S
1		
3/4	100	100
1/2	92	86-99
3/8	82	75-89
#4	61	55-66
#10	47	41-53
#40	26	22-30
#80	14	10-18
#200	6	4-9
% ASPHALT		5.8-6.8





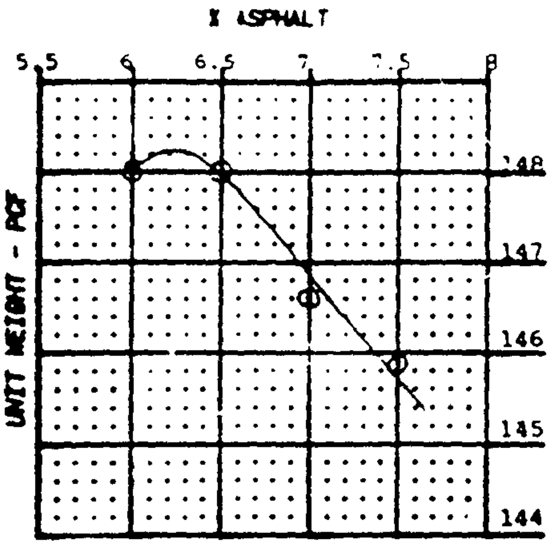




C.R.E.

State of Alaska
Department of Transportation & Public Facilities
BITUMINOUS MIX DESIGN

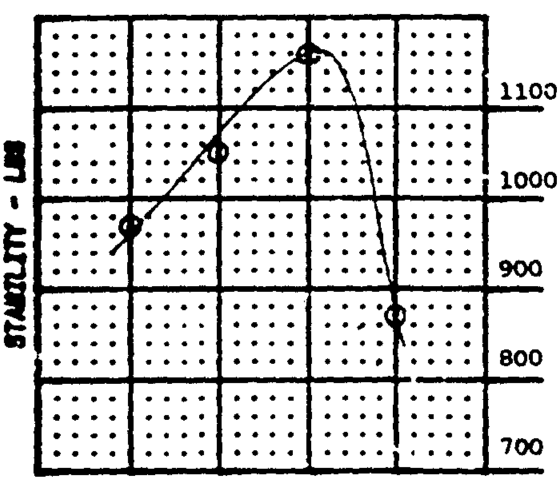
Project No. F-RS-042-1(78) Project Name Minnesota Ext. Phase II Lab. No. 86A-939
Materials Source(s) AS & G Date Reported 5-23-86
Quality No.(s) 86A-63 Submitted By Dale Edwards Date Received 5-15-86

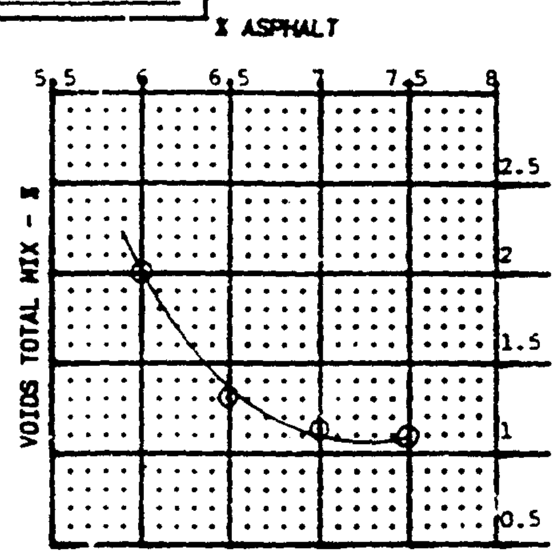


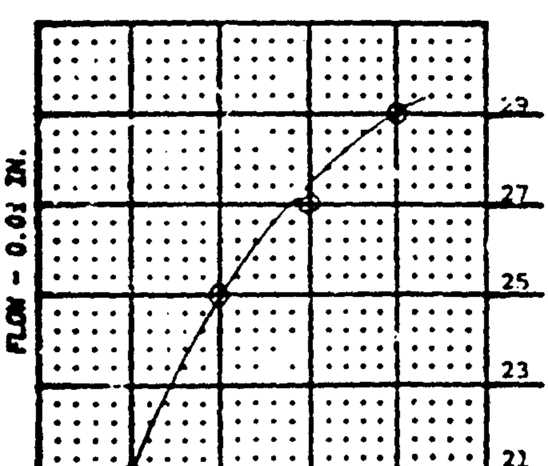
ASPHALT
Optimum 7.5 % by wt of: [ ] Dry Agg. [X] Total Mix
Grade Chev AC 5
SpG 1.022
Agg. Blend SpG 2.749
VOIDS
Filled 93.6 70-85
Total Mix 1.1 1-5
Stability 870
Flow 29 8-16
Unit Weight 145.9 pcf
Anti-Strip Req'd 0.25 %
Mix Temp. 320-350 F
Remarks: 2.5% Rubber by wt. of mix

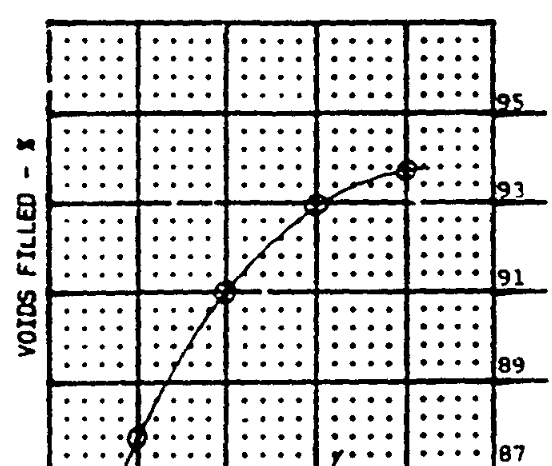
SIEVE ANALYSIS

SIEVE	% PASS	SPEC'S
1		
3/4	100	100
1/2		
3/8	56	50-62
1/4	38	32-44
#4		
#10	26	22-30
#30	17	13-21
#40		
#200	9	7-11
% ASPHALT		7.1-7.9









C.M.M.E.

06-15-87 Department of Transportation ... Job No. 92696231

BITUMINOUS MIX DESIGN REPORT

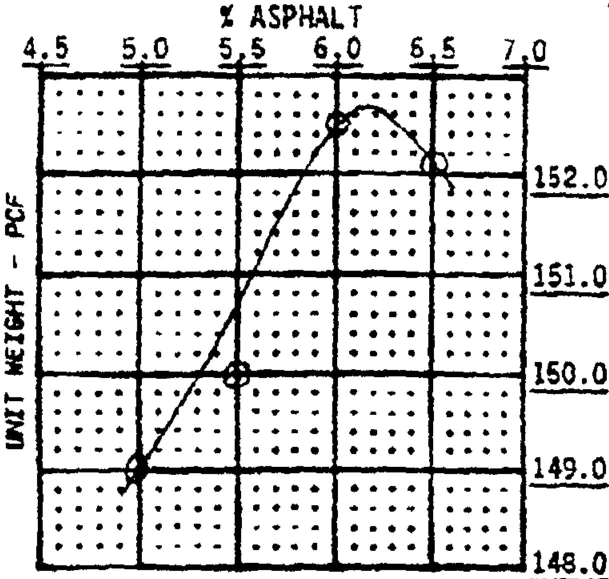
TEST OF Asphalt Concrete, Type III ITEM NO. 401(1) LAB NO. 87A-627
PROJECT NO. I-OA3-I(6) PROJECT NAME Seward Hwy. Rehab., 36th-4th FIELD NO. MD #2
SOURCE (s) CPP DATE RECEIVED 05-29-87
QUALITY NO. (s) 87A-595 SUBMITTED BY Wilder Const. DATE REPORTED 06-03-87

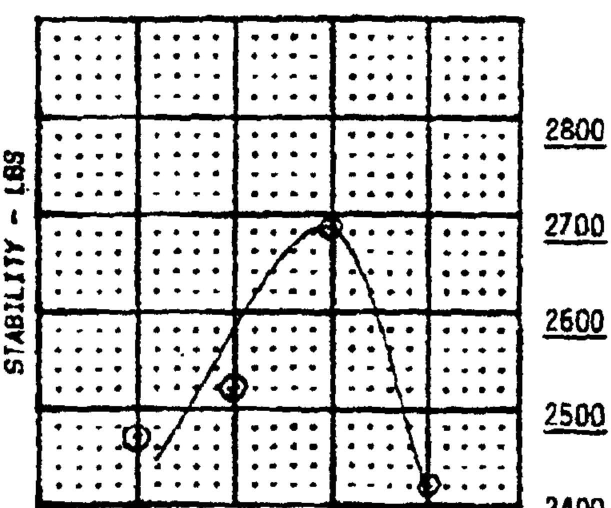
MARSHALL [_]50 [X]75 BLOW
Asphalt Chevron AC-10
Optimum 5.8 %
SpG 1.013
Agg. Blend SpG 2.749

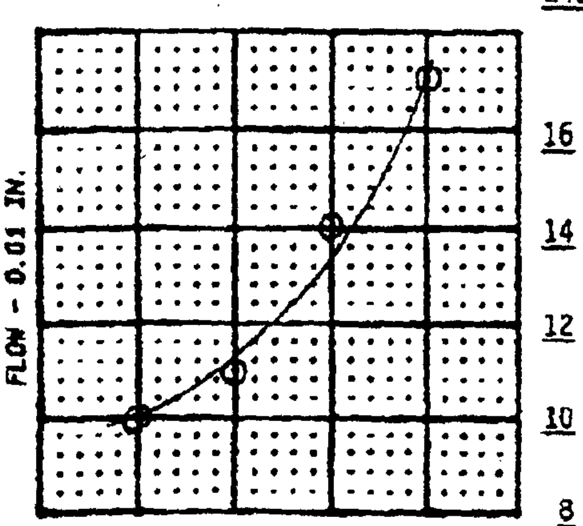
Voids		SPEC'S
Filled	84	75-95
Total Mix	2.4	1-5
Stability	2660	1500+
Flow	13	8-16
Unit Weight	151.8 pcf	
Anti-Strip Req'd.	0.25 %	
Max. Mix. Temp.	290 F	

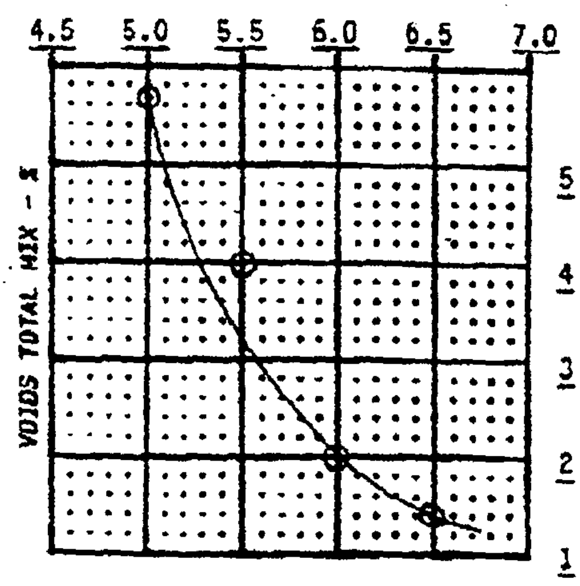
SIEVE	%PASS	SPEC'S
1"		
3/4"	—	—
5/8"	—	—
1/2"	100	100
3/8"	86	79-93
1/4"		
#4	62	55-69
#10	46	40-52
#40	22	18-26
#80		
#200	6	3-9

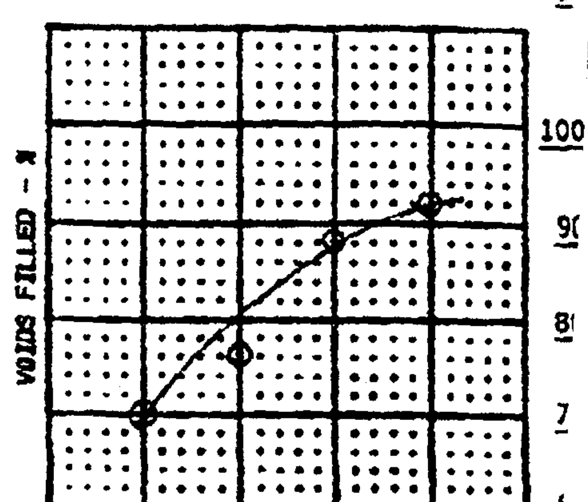
% ASPHALT BY WEIGHT OF [X] MIX [_] AGG. 5.3-6.3
REMARKS:











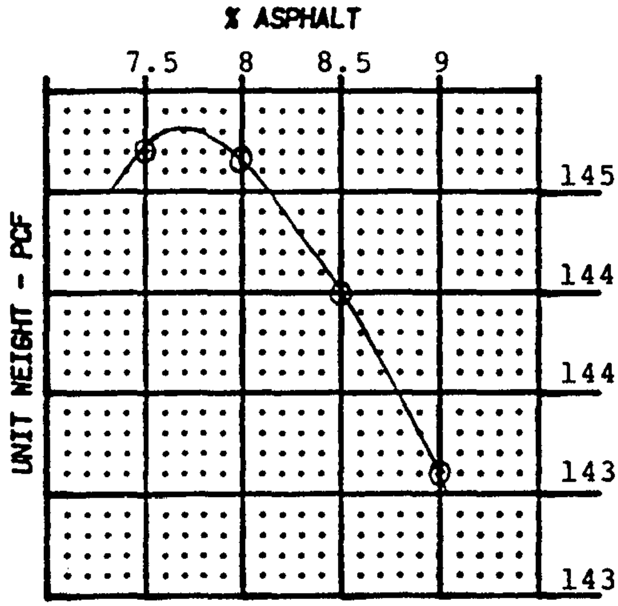
dl

Thomas L. Moses, CRME

sd

Departmen' of Transportation & Publ' Facilities
BITUMINOUS MIX DESIGN

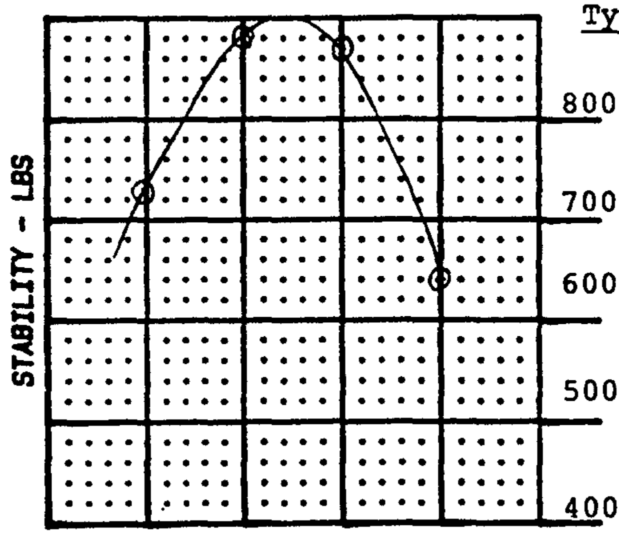
Project No. A83991 Project Name Seward Hwy. Rehab. Lab. No. 85A-980
Materials Source (s) ALAGCO Date Reported 6-14-85
Quality No. (s) 84A-1219, 153 Submitted By Paul Ross Date Received 6-12-85



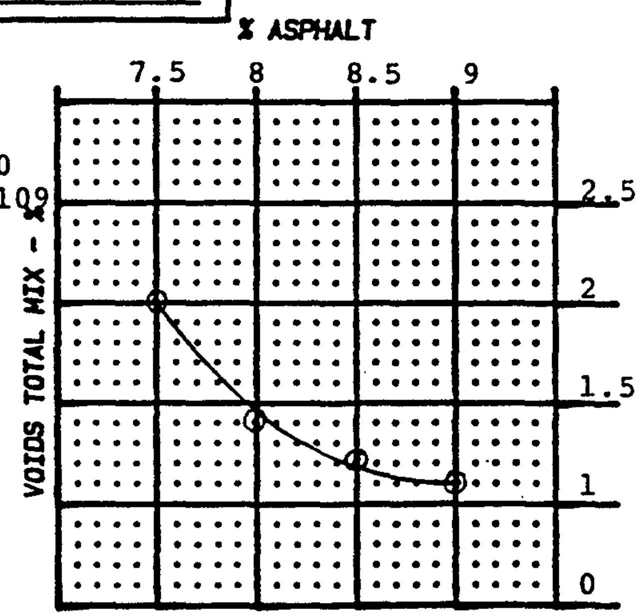
ASPHALT
Optimum 7.7 % by wt of:
[ ] Dry Agg. [X] Total Mix
Grade Chev AC-5
SpG 1.022
Agg. Blend SpG 2.766
VOIDS
Filled 91 70-85
Total Mix 1.8 1-5
Stability 800
Flow 25 8-16
Unit Weight 145.3 pcf
Anti-Strip Req'd 0.25 %
Max. Mix Temp. 350 F
Remarks: 2.5% rubber by Total Mix

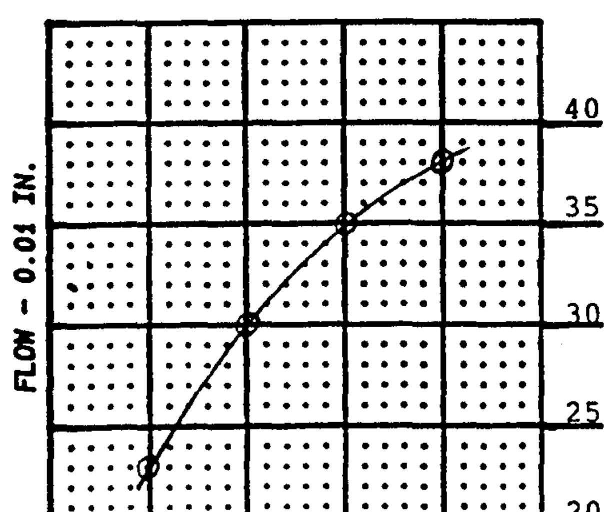
SIEVE ANALYSIS

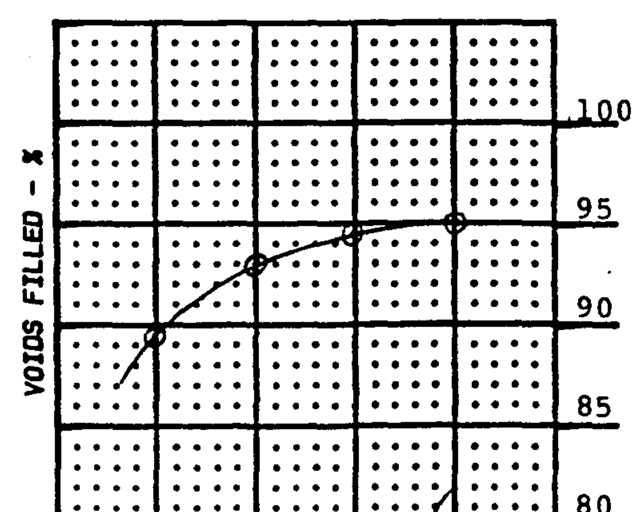
SIEVE	% PASS	SPEC'S
1		
3/4	100	100
1/2		
3/8	56	50-62
1/4	40	34-44
#4		
#10	25	21-29
#30	20	16-23
#40		
#200	9	7-11
% ASPHALT		7.3-8.1



Typical Batch
Agg.: 12931
Rubber: 360
Asphalt: 1109
Total 14400







C.R.M.E.

12
(1/71)

STATE OF ALASKA
DEPARTMENT OF HIGHWAYS
MATERIALS DIVISION
TEST REPORT

PRE-CONSTRUCTION (
CONSTRUCTION (
OUTSIDE TEST (

FIELD CONTROL (
CHECK SAMPLE (
PROGRESS RECORD (
FINAL RECORD (
INFORMATION (
QUALITY (

SAMPLE OF Rubber For Rubberized Asphalt

ITEM NO. 409

Laboratory Central No. 84A-1321

Project Name & No. Seward Hwy. Rehab. A83991 Date 09-18-84

Quantity represented ______ Identification ______ Received 09-17-84

Source of material ______ Submitted by Wilder Const.

Sampled from Bag Specification No. ______

TEST RESULTS **SPECIFICATIONS**

GRADATION Sieve	% Pass	Specifications
¼"	100	100
#4	98	76-100
#10	30	28-42
#20	16	16-24

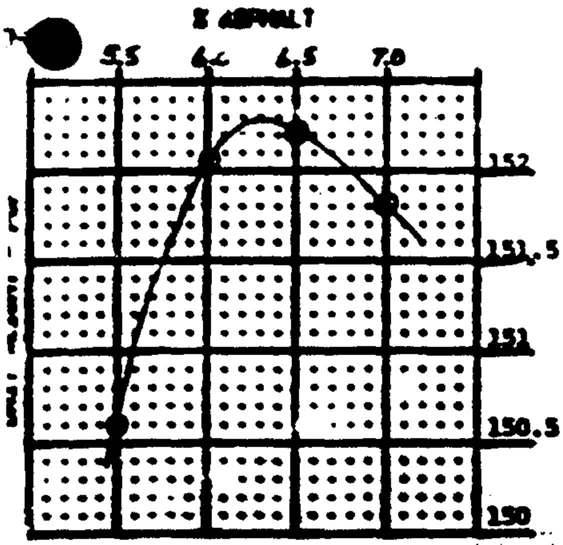
The material as submitted meets specifications.

Copies to:

Signature
Frank P. Narusch, CRME dq
Title

State of Alaska
Department of Transportation & Public Facilities
BITUMINOUS MIX DESIGN

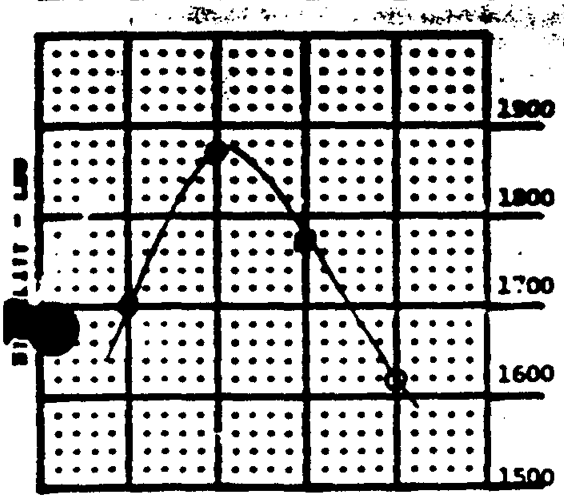
Project No. FM-0527-9 Project Name A-C Couplet Lab. No. 86A-809
Materials Source(s) Central Paving Products Date Reported 6-8-86
Quality No. (s) 86A-810 Submitted By Kevin Braun Date Received 5-6-86

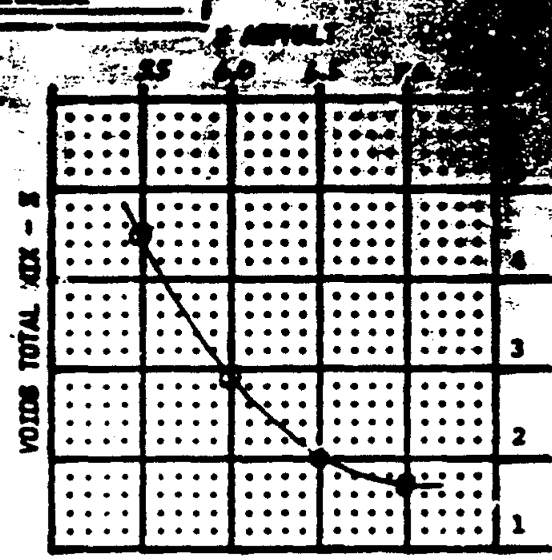


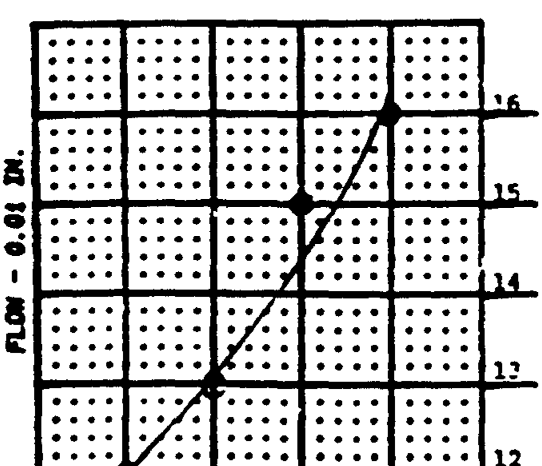
ASPHALT
Optimum 6.4 % by wt of: [x] Dry Agg. [ ] Total Mix
Grade Chev AC 5
SpG 1.021
Agg. Blend SpG 2.739
VOIDS
Filled 88 70-88
Total Mix 2 1-5
Stability 1800
Flow 14 8-18
Unit Weight 152.6 pcf
Anti-Strip Req'd 0.25 %
Max. Mix Temp. 290° F
Remarks:
50 Blow Marshall

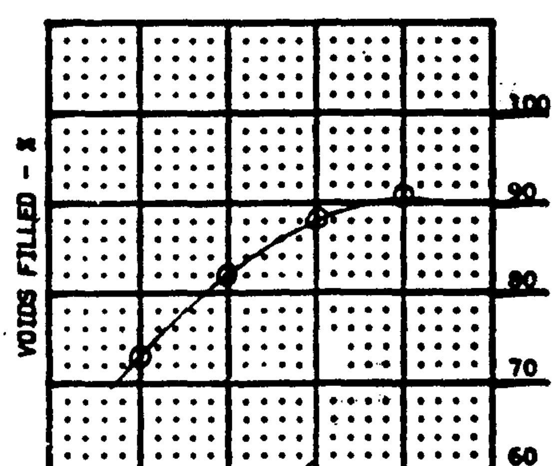
SIEVE ANALYSIS

SIEVE	% PASS	SPEC'S
1		
3/4	100	100
1/2		
3/8	78	70-85
#4	57	50-64
#10	43	37-48
#40	22	15-[illegible]
#200	6	3-[illegible]
% ASPHALT 5.5-6.5		



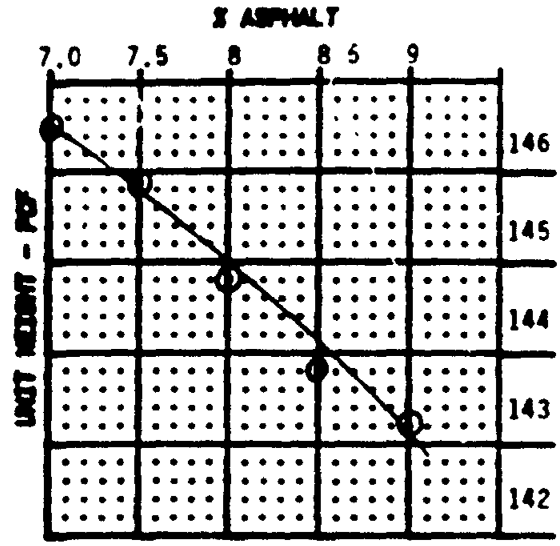






C.R.M.E.

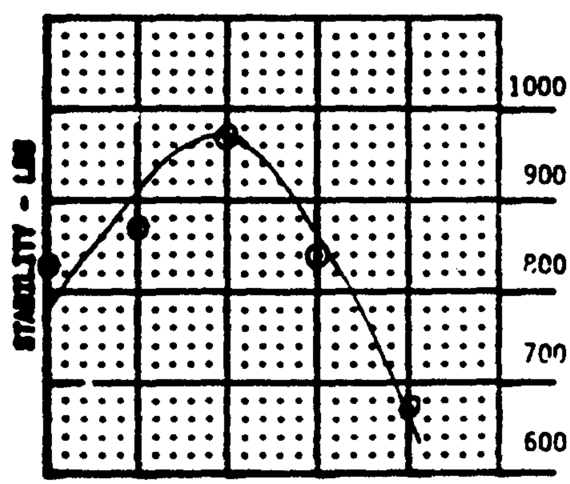
Project No. F-M-0527(9) Project Name A-C Coulet Lab. No. 85A-1323
Materials Source(s) CPP Date Reported 7-27-85
Quality No.(s) 84A-016 Submitted By CPP Date Received 7-25-85

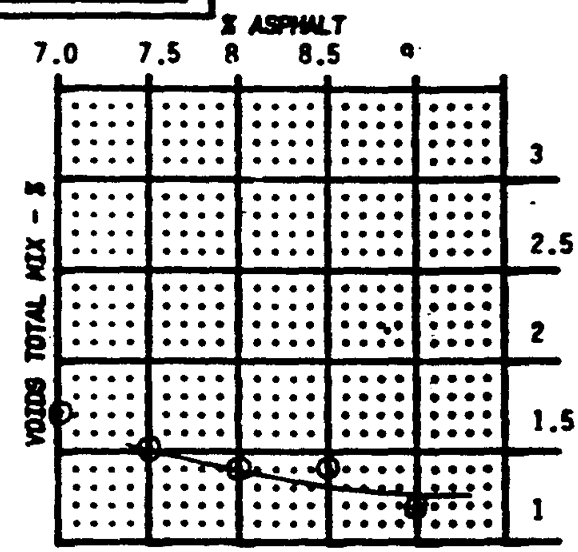


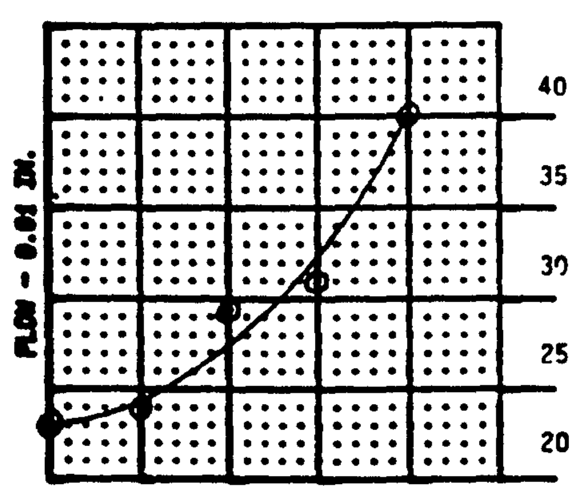
ASPHALT		
Optimum	7.5 % by wt of:	
[ ] Dry Agg. [X] Total Mix		
Grade	Chev. AC 5	
SpG	1.022	
Agg. Blend SpG	2.758	
VOIDS		
Filled	92	70-85
Total Mix	1.5	1-5
Stability	870	
Flow	25	8-18
Unit Weight	145.9	pcf
Anti-Strip Req'd	0.25	%
Max. Mix Temp	350°	F
Remarks:	2.5% Rubber by weight mix	

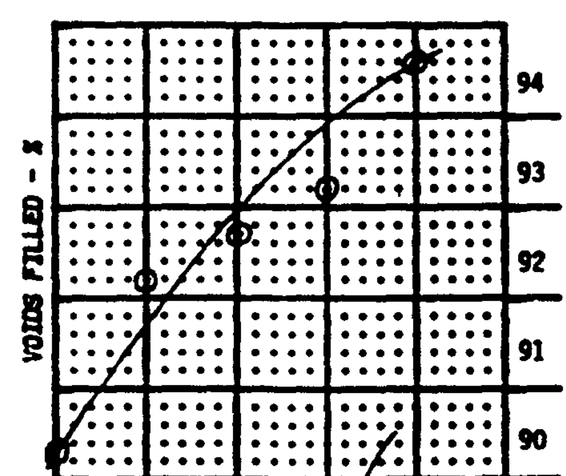
SIEVE ANALYSIS

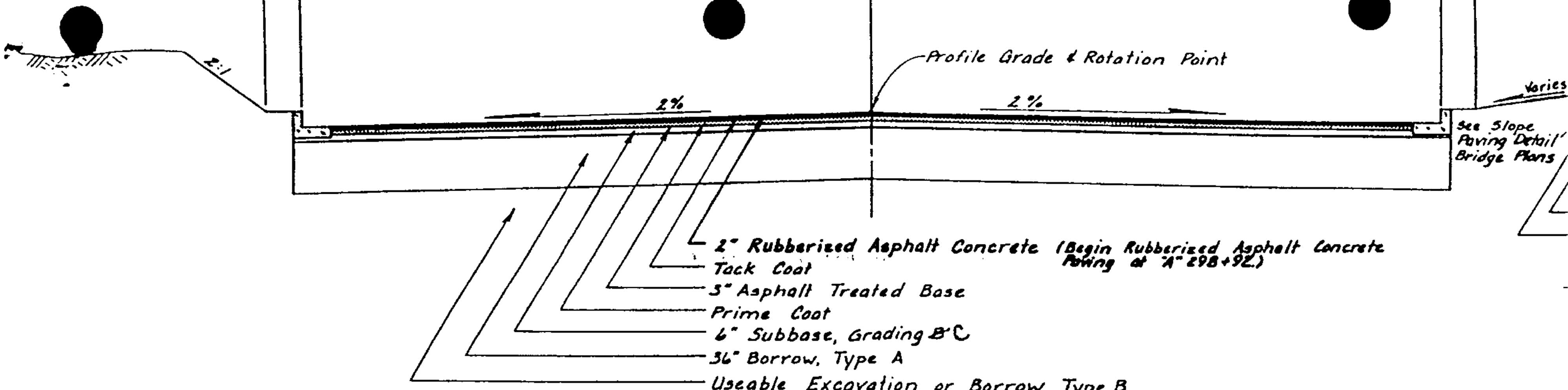
SIEVE	% PASS	SPEC
1		
3/4	100	100
1/2		
3/8	56	50-62
1/4	37	30-44
#4		
#10	26	20-32
#30	19	12-23
#40		
#200	8	7-11
% ASPHALT		7.0-8.0





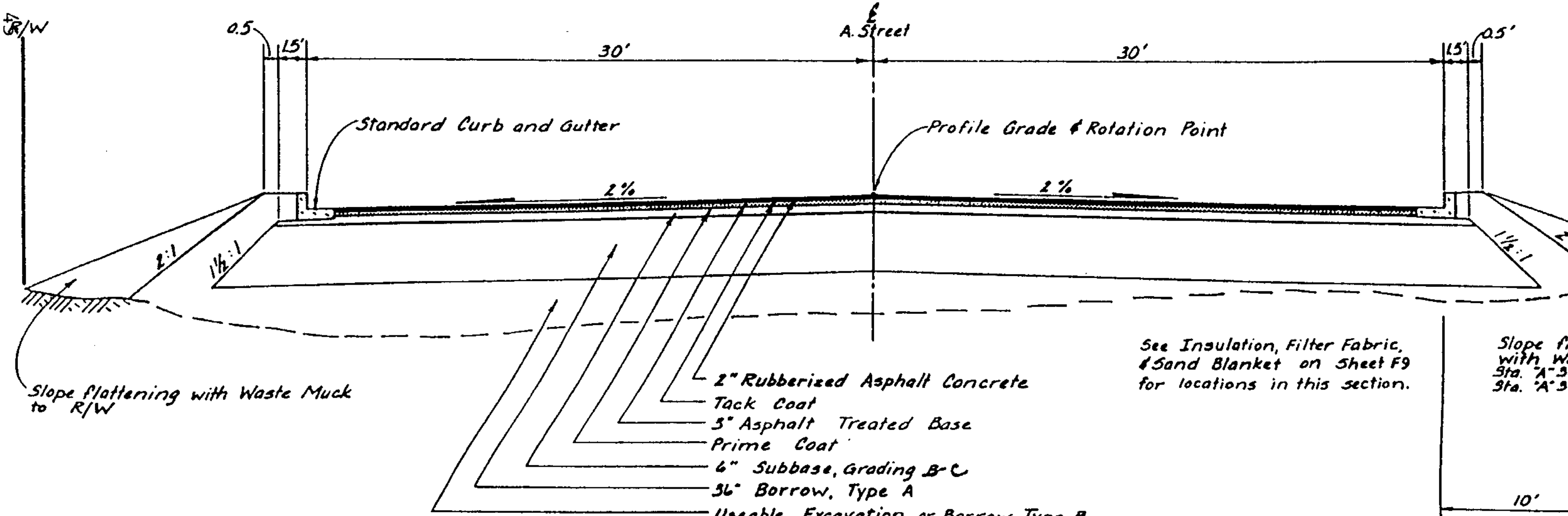






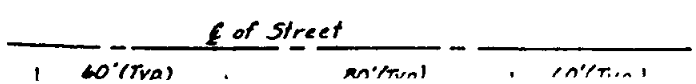
A-5 / F8 **TYPICAL CUT SECTION A STREET**

"A" STA. 300+35± TO "A" STA. 332+25±

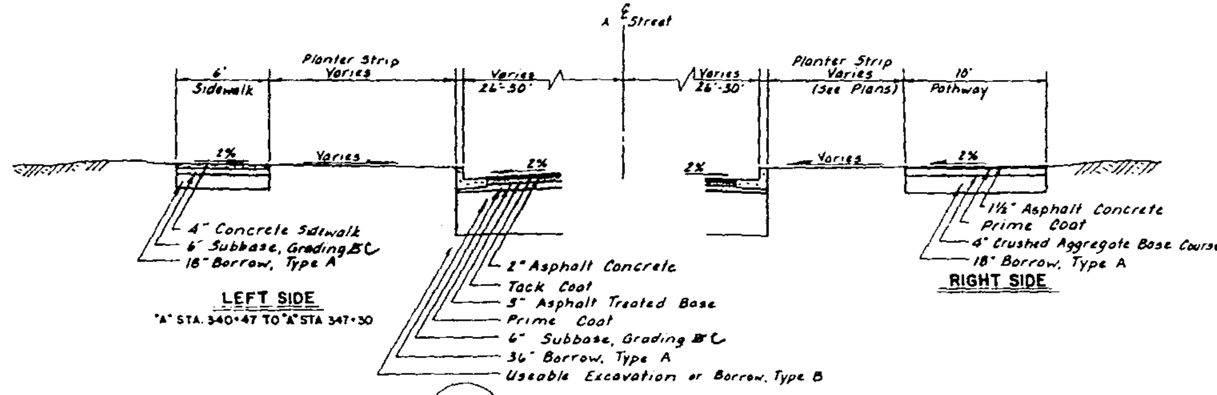


A-5 / F8 **TYPICAL FILL SECTION A STREET**

"A" STA. 308+31 TO "A" STA. 332+25



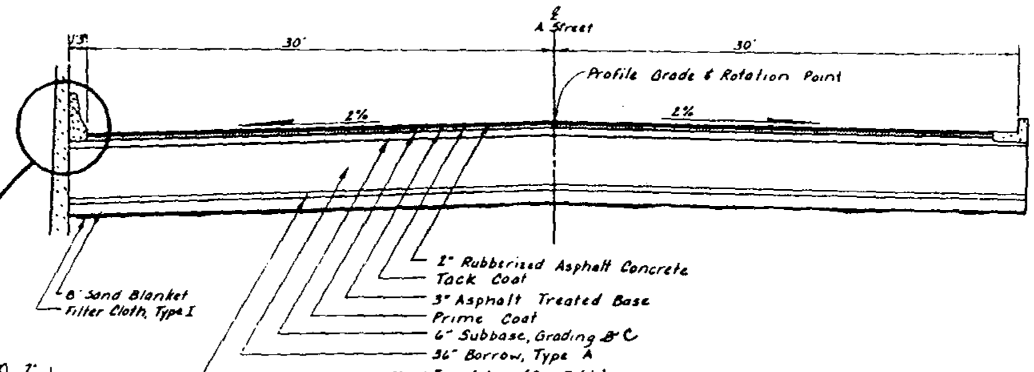
REVISIONS			STATE	PROJECT DESIGNATION	YEAR	SHEET	
No	Date	Description	ALASKA	FM-0527 (9)	1984	F9	2



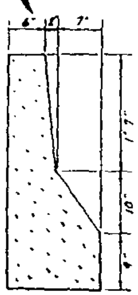
LEFT SIDE
"A" STA. 340+47 TO "A" STA 347+30

RIGHT SIDE

A-7 / F9 TYPICAL SECTION A STREET
"A" STA 339+00 TO "A" STA. 351+26



A-8 / F9 TYPICAL RETAINING WALL SECTION
A STREET
"A" STA 298+90± TO "A" STA 300+35± (FIREWEED WALL) SEE SHEET F-34 FOR WALL TRANSITION DETAILS
"A" STA 332+25± TO "A" STA 335+69.95 (15TH. AVE.) SEE SHEET F-35 FOR WALL TRANSITION DETAILS



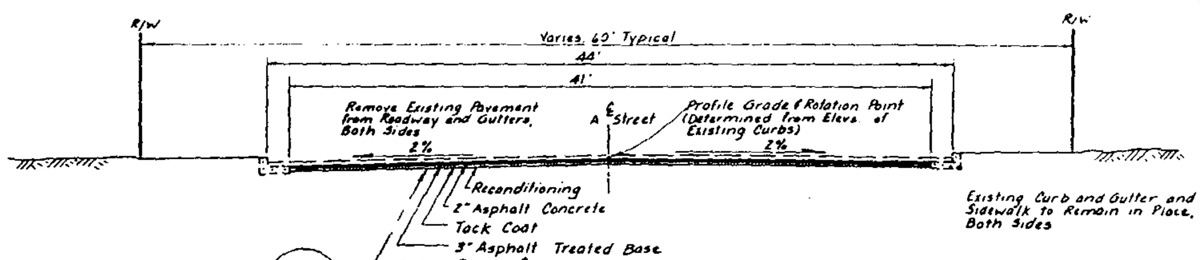
WALL SECTION CURB DETAIL

Notes:
1 Curb rests on top of Subbase.
2 Curb back rests against retaining wall, but is not connected to the wall.
3 See Bridge Plans for Retaining Wall Details at the 15th. Ave. Wall.
4 See Std. Dwgs. B-04.00 and B-05.00 for Fireweed Wall.

INSULATION, FILTER FABRIC SAND BLANKET SCHEDULE

THICKNESS	STATION TO STATION
2"	"A" 301+50 to "A" 302+00
4"	"A" 302+00 to "A" 305+00
2"	"A" 305+00 to "A" 305+50
2"	"A" 331+00 to "A" 331+50
4"	"A" 331+50 to "A" 338+00
2"	"A" 338+00 to "A" 338+50

Note: See Special Provision 635-2.01 for alternatives

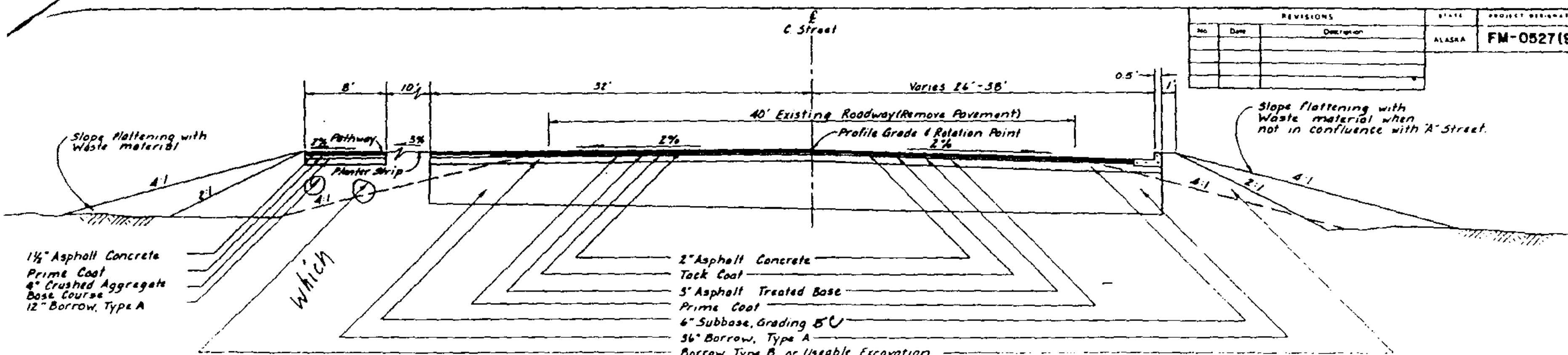


A-9 / F9 TYPICAL SECTION A STREET
"A" STA 354+50± TO "A" STA 376+30

STATE OF ALASKA
DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES

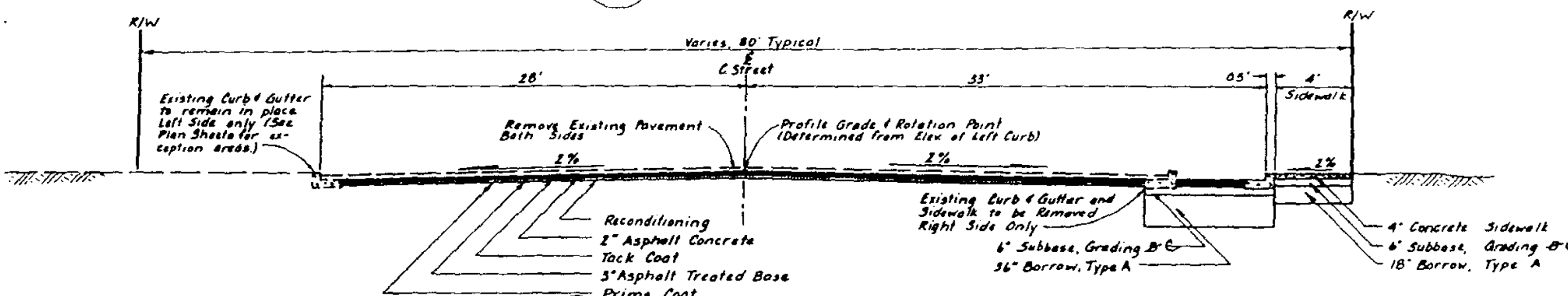
A-C COUPLET
TYPICAL SECTIONS
A STREET

REVISIONS			STATE	PROJECT DESIGNATION	YEAR	SHEET NO.	TOTAL SHEETS
No.	Date	Description	ALASKA	FM-0527(9)	1984	F10	282

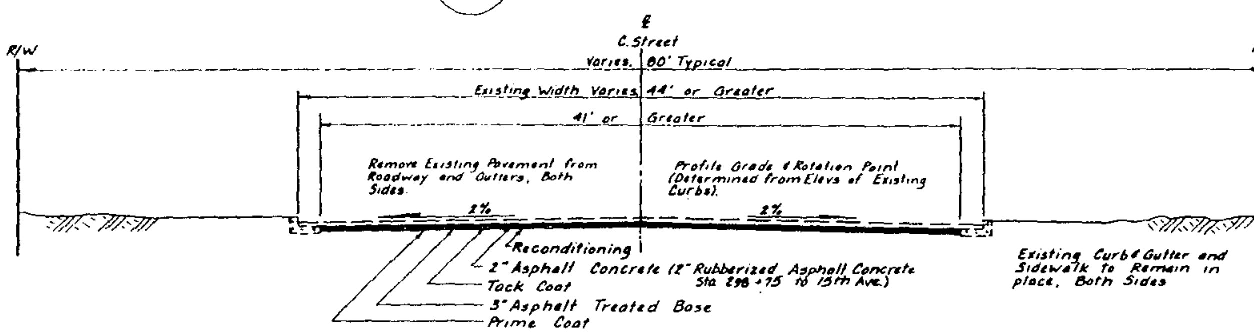


C-1 / F10 **TYPICAL SECTION C STREET**
"C" STA. 244+80 TO 36TH AVE.

47



C-2 / F10 **TYPICAL SECTION C STREET**
BENSON BLVD TO "C" STA. 289+75±

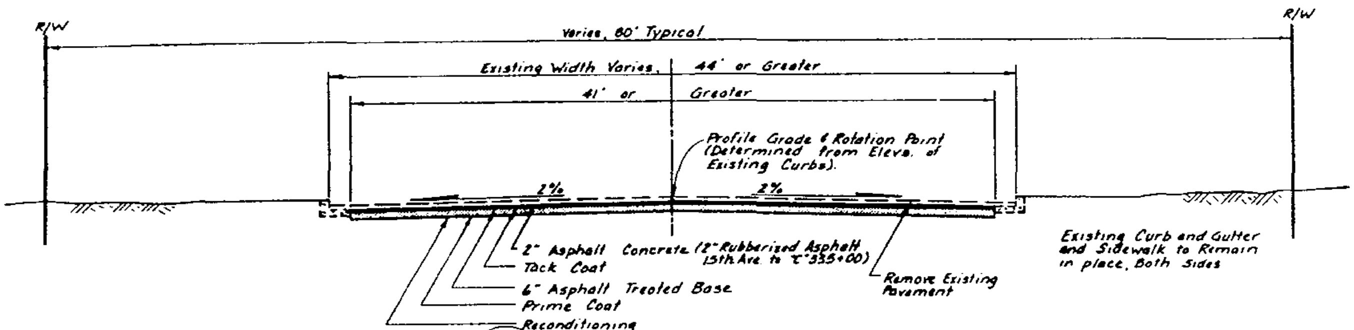


C-3 / F10 **TYPICAL SECTION C STREET**
36TH AVE. TO BENSON BLVD.
"C" STA. 289+75± TO 15TH AVE.

STATE OF ALASKA
DEPARTMENT OF TRANSPORTATION
AND
PUBLIC FACILITIES

A-C COUPLET
TYPICAL SECTIONS
C STREET

REVISIONS			STATE	PROJECT DESIGNATION	YEAR	SHEET NO.
No.	Date	Description	ALASKA	FM0527 (9)	1984	F11



C-4 / F11 **TYPICAL SECTION C STREET**

15TH. AVE. TO 6TH. AVE.

Note: 6" layer of Asphalt Treated Base shall be constructed in two equal lifts. Tack Coat may be required by the Engineer between the two lifts.

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STATE OF ALASKA
DEPARTMENT OF TRANSPORTATION
AND
PUBLIC FACILITIES

A-C COUPLET

TYPICAL SECTIONS
C STREET

APPENDIX B

PLUSRIDE ASPHALT GUIDE SPECIFICATIONS

AND

MIX DESIGN PROCEDURE

(ANCHORAGE)

ALL SEASONS SURFACING CORP.

2281 116th Avenue N.E., SUITE 2, Bellevue, Washington 98004-3015
(206) 454-3830

March 14, 1985

David C. Esch, P.E.
Chief of Highway Research
Dept. of Transportation
2301 Peger Road
Fairbanks, AK 99701

Dear Dave:

Per our conversation, enclosed are copies of our revised PlusRide® Asphalt Guide Specifications and Design Mix procedure for your use and information.

Thank you for your comments.

Sincerely,

Robert N. Linden, P.E.
Chief Engineer

RNL:nw
Encl.

PLUS RIDE ASPHALT

GUIDE SPECIFICATIONS
FOR
PLUSRIDE® ASPHALT

DESCRIPTION

1.01 General

This work shall consist of furnishing and placing PlusRide® Asphalt, a rubber modified asphalt concrete, which is a mixture of granulated rubber, asphalt cement and mineral aggregate, in accordance with these specifications and in reasonably close conformity with the lines, grades, thickness and details shown on the plans or as established by the Engineer.

Attention is directed to sections 2.01, 2.03 and 2.04 of these specifications. The aggregate gradations are coarse and gap graded, which generally requires addition of a mineral filler to meet the gradation requirements. PlusRide® Asphalt is produced and placed with standard equipment, however, a system must be provided for introduction of the granulated rubber and any required mineral filler.

PlusRide® Asphalt is a patented process licensed by:

All Seasons Surfacing Corporation
2281 116th Avenue N.E. Suite 2
Bellevue, Washington 98004-3015
(206) 454-3830

The Contractor is hereby advised that the following specifications are based on a patented process. Upon award of the contract, the Contractor shall execute a License Agreement with the Licensor, which grants use of the process in return for payment of a royalty fee of $__________ per ton of total mixture, or square yard of finished pavement. Upon award, such license agreement shall be bound as part of the agreement for this contract and shall become a part thereof.

2.01 Job-Mix Formula

After a representative quantity of aggregate has been produced and not less than fifteen (15) calendar days before production of the rubber modified bituminous mix begins, the Contractor shall submit to the Engineer his proposed job-mix formula. Representative samples shall then be taken from the stockpiled materials, and the final job-mix formula established by the Engineer, based upon laboratory design procedures.

The job-mix formula shall include definite single values for:

1. The percentage of aggregate passing each specified sieve, based on the dry weight of the aggregate.

2. The percentage of bituminous material to be added, based on the total weight of the mixture.

3. The granulated rubber percentage shall be three percent (3%), based upon the weight of total mixture.

In addition to the aggregate sample furnished above, the contractor shall furnish the Engineer with one (1) gallon of the proposed asphalt cement and ten (10) pounds of granulated rubber meeting the requirements of section 2.02.

Should a change in source of material be found necessary, a new job-mix formula will be established in the same manner as described above. All mix furnished for the project shall conform to the approved job-mix formula within the following range of tolerances:

Sieve Size	Tolerance Percent Passing
3/8" or 1/4"	± 6
U.S. No. 10 or U.S. No. 30	± 4
U.S. No. 200	± 0.5
Asphalt Percent	± 0.4
Rubber Percent	± 0.15*

*Not determinable by extraction testing.

2.02 Granulated Rubber

The granulated rubber shall be ambient ground whole tires or buffings of passenger or truck tires. (Heavy equipment tires shall not be used.) It shall be cubical or thread-shaped and individual rubber particles, irrespective of diameter, shall not be greater in length than 5/16". The maximum allowable moisture content is 2%.

The granulated rubber shall conform to the following gradation requirements:

Sieve Size	Percent Passing by Weight
1/4"	100
U.S. No. 4	76-100
U.S. No. 10	28-42
U.S. No. 20	16-24

The rubber granulator shall furnish written certification of compliance with the foregoing specifications. In addition, each delivery shall be sampled (not less than one sample for each 20 tons) and a dry sieve analysis performed to ensure that the rubber granules meet gradation requirements. The sampling and testing must be completed and the rubber granules approved for use before any of the delivery is incorporated into the PlusRide® Asphalt mixture.

2.03 Aggregates

Aggregates shall conform with the physical requirements for those aggregates used in conventional asphalt pavement surface courses. The aggregate retained on the U.S. No. 10 sieve shall have a minimum fracture requirement of 75% with at least one mechanically fractured face. The percentage of fracture shall be determined by count on all designated screen sizes. This aggregate shall conform to the following gradation requirements:

Sieve Size	PlusRide® 8	PlusRide® 12	PlusRide® 16
	(Percent Passing by Weight)		
3/4"			100
5/8"		100	-
3/8"	100	60-80	50-62
1/4"	60-80	30-44	30-44
U.S. No. 10	23-38	20-32	20-32
U.S. No. 30	15-27	13-25	12-23
U.S. No. 200	8-12	8-12	7-11

The PlusRide® Asphalt mixtures must be gap graded to allow space for the rubber granules. For the PlusRide® 12 and PlusRide 16 mixtures, this gap grade is defined by restricting the amount of aggregate passing the 1/4" sieve and retained on the No. 10 sieve to be twelve percent plus or minus four percent (12% ± 4%).

Before being fed to the drier, the aggregate shall be separated into two or more sizes and stored separately. When two or three sizes are used, the aggregate shall be separated on screens of such size that the quantity drawn from each storage is at least 20% of the total aggregate amount.

In placing the aggregate in storage or in moving from storage to the cold feed bins, any method which causes segregation, degradation, or the combining of materials of different gradings shall not be permitted. Any segregated or degraded material shall be re-screened or wasted.

2.04 Mineral Filler

A mineral filler is usually required to meet the minus 200 mesh material requirements. The Contractor shall submit a representative sample of the mineral filler material to the Engineer for his approval and use in establishing the final job-mix formula. The plant shall be equipped to feed the mineral filler into the mixer within an accuracy of ± 0.5% of the job mix formula.

Mineral filler shall conform to the requirements of AASHTO Designation M17 and in addition shall have a specific gravity of not less than 2.50.

2.05 Asphalt

The grade of paving asphalt shall be established by the Engineer.

The asphalt content required shall be within the following range:

PlusRide® 8	PlusRide® 12	PlusRide® 16
(Percent by Total Weight of Mixture)		
8.0 - 9.5	7.5 - 9.0	7.5 - 9.0

The optimum asphalt content within the specified range shall be determined by the mix design.

CONSTRUCTION

3.01 Bituminous Mixing Plants

Mixing plants shall conform to the standard requirements except that the following shall be added:

(a) Requirements for Batch Plants:

The amount of granulated rubber shall be determined by weighing on springless dial scales, or by a method which uniformly feeds the mixer within ± 0.15 percent of the required amount indicated in Section 2.01.

Bags of granulated rubber may be used for proportioning provided the batch size is adjusted to use whole bags of rubber. No partial bags will be allowed.

(b) Requirements for Drum Mixing Plants:

Granulated rubber introduced into the mixer shall be drawn from storage bins by a continuous mechanical feeder which will uniformly feed the mixer within ± 0.15 percent of the required amount indicated in Section 2.01.

The continuous feed system shall have a ready means of accurately calibrating the system.

Satisfactory means shall be provided to have a positive interlocking control between the flow of the granulated rubber and aggregates.

The plant shall be equipped with a heat shield or other means to prevent the open flame from coming in contact with the granulated rubber.

3.02 Mixing

The Contractor shall prepare a work plan describing his planned procedures for mixing and placing the material. The plan shall include such details as the method of introducing rubber granules into the mixture, mixing times, temperatures and equipment. Mixing of the material will not be allowed to begin until the work plan has been approved in writing by the Engineer.

The plant cold feed system shall be calibrated. Aggregate samples shall be taken in a manner satisfactory to the Engineer to verify that the mixture is within the combined aggregate gradation specifications before beginning the job-mix production.

Standard mixing procedures shall apply except as follows:

For batch plants, the aggregates and granulated rubber shall be combined and mixed thoroughly for a minimum of 15 seconds, prior to introducing the asphalt. The asphalt, aggregate and rubber granulate shall be mixed to achieve a uniform distribution of all materials and coating of the aggregate and granulated rubber by asphalt.

The completed mixture shall conform to the job-mix formula within the allowable tolerances specified in Section 2.01. If the mixture is outside the tolerance limits, on two (2) consecutive mixture samples, a plant and/or aggregate adjustment must be made to bring the mixture within the tolerance limits.

The temperature at mixing shall be as follows:

Asphalt Cement 325°F. maximum

The temperature of the mix at discharge shall be between 325°F and 360°F. for batch plants and 300°F. to 350°F. for drum mixer plants.

3.03 Hauling, Spreading and Finishing

The standard requirements for hauling equipment should be followed. When directed by the Engineer, the mixture shall be covered with a tarpaulin to prevent rapid mixture cooling.

The mixture shall be placed at a temperature of not less than 300°F. as measured in the paving machine. The maximum compacted lift thickness shall be 2 inches.

A tack coat shall be applied of SS-1, SS-1h, CSS-1, or CSS-1h emulsified asphalt or asphalt cement at the rate of 0.06 to 0.08 gallons per square yard of residual asphalt.

The mixture shall be laid upon an approved surface and spread and struck off to grade with self-propelled asphalt pavers conforming to standard specifications. The mixture shall not be placed when it is raining or on any wet surface, or when the average ground temperature is less than 45°F., or when weather conditions prevent the proper handling or finishing of the mixture. Where hand placement or raking is required, it should be done immediately because the mixture becomes stiff and difficult to rake at lower temperatures.

3.04 Compaction

Asphalt rollers and compaction procedures shall conform with standard requirements and supplemented with the following:

Breakdown compaction should begin immediately behind the paving machine. However, some delay may be required to prevent roller pickup. The roller drums must be kept well watered and a wetting agent may be necessary to decrease the occurrence of roller pickup.

Breakdown compaction shall be accomplished using a 10-12 ton vibratory or static steel roller. The roller must apply a minimum force of 250 pounds per linear inch of drum width to the pavement surface.

An 8-10 ton tandem steel roller shall be used for finish rolling. Finish rolling of the mat shall continue until the temperature of the mat has dropped below 140°F or until elastic movement under the roller is no longer observed.

The proper rolling procedure shall be established with a control strip to determine equipment and number of coverages necessary to obtain the target density. The target density, as a percentage of maximum theoretical density, shall be 95% to 98% (2% to 5% air voids).

MEASUREMENT AND PAYMENT

4.01 Measurement

Measurement of PlusRide® Asphalt concrete pavement will be by the ton (S.Y.) and will include the granulated rubber, mineral aggregate, paving asphalt and other components of the mix.

4.02 Payment

The unit contract price per ton (S.Y.) for "PlusRide® Asphalt Concrete Pavement" shall be full compensation for furnishing all labor, equipment, materials, supplies and royalties required for the construction of this material as specified. (Separate pay items for asphalt cement, granulated rubber and mineral filler are often recommended.)

This process is protected by Patents and Patents Pending.

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PLUSRIDE® ASPHALT MIX DESIGN

GENERAL

PlusRide® Asphalt is a resilient/elastic mixture. The conventional properties of stability and flow DO NOT APPLY for the mix design.

THE OBJECTIVE of the design is to determine the gradation of aggregates, asphalt and rubber that yields a mix having:

1) A LOW VOID CONTENT in the compacted mix. The voids should be in the range of 2% - 4%, with 3% being the normal design content.

2) A RICH ASPHALT/FILLER RATIO. Asphalt and filler are used to fill voids. The MIX MUST HAVE a rich asphalt content to insure a workable mixture and durable pavement.

3) A high coarse aggregate content, gap graded to provide space for the rubber granules in the compacted mixture, to form a dense, durable and stable mixture.

PREPARATION OF TEST SPECIMENS

Aggregates - Determine stockpile gradation and select a grading well within the gradation specification band. Adjust the gap grading in the following range for PlusRide® 12 or 16:

Passing 1/4" sieve retained No. 10 sieve - 12% maximum or less

or

Passing No. 4 sieve retained No. 10 sieve - 10% maximum or less

A mineral filler is usually required to meet the minus

200 requirement. When a mineral filler is needed, the type and quantity to be used in production MUST BE USED IN THE MIX DESIGN.

Asphalt - (Range of 7.5% to 9.0%/wt. of total mix) Select the paving grade asphalt generally used in the project area. A guide for selecting the trial contents is the rule of thumb that PlusRide® Asphalt requires at least 1-1/2% to 2% more asphalt than a conventional mixture of similar size and type aggregates.

Rubber - (3%/wt. of total mix) Obtain a sample of rubber granules from the approved rubber supplier for the project. Obtain the average rubber gradation from the supplier and/or perform a sieve analysis on a representative amount of the rubber (i.e. 60 pound bag full).

Because of segregation and often times, production by a combination of granulated whole tires and tire buffings, small samples for mix design purposes are provided in coarse and fine components. Sieve each component for recombining to match the rubber supplier's gradation.

PREPARATION OF MIXTURES

* Combine the aggregate fractions for the selected gradation and quantity desired. As an example, the weight of aggregate for a 1200 gram specimen is calculated as follows:

SAMPLE WT.	1200 GRAMS
8% AC/Wt. of Mix	- 96 GRAMS
3% Rubber/Wt. of Mix	- 36 GRAMS
AGGREGATE WT.+ Mineral Filler (if REQ'D)	1068 GRAMS

Heat the aggregates and asphalt in a 320°F. oven.

* Combine the rubber fractions to match the rubber supplier's gradation and a weight equal to 3% of the

specimen weight. (i.e. 36 grams for a 1200 gram specimen)

* Place the heated aggregates and rubber granules in the mixing bowl and dry mix for 15 seconds. Add the desired amount of asphalt and wet mix for the standard mixing time. Put the mixture in a pan or suitable container and place in the oven. Raise the temperature to 320°F. and hold for 1 hour.

PREPARATION OF MOLD AND HAMMER

* Use clean specimen mold assemblies and compaction hammer. Grease the interior of the molds with a high temperature grease such as Dow Corning high vacuum grease. Place the molds and base plates in the 320°F. oven. Heat the hammer face on a hot plate to a temperature of 300°F.-320°F.

* Filter papers stick to the specimens and should not be used, unless some method is available for removal, such as a knife and high temperature flame. Alternatives to filter paper are release paper or a greased manila paper. The specimens can be made without paper, and if so, the base plates and hammer face should also be greased.

COMPACTION OF SPECIMENS

* Marshall Compaction Assembly - Remove the 1200 gram batch from the oven (after 1 hour) and compact immediately. Apply 50 blows each side with a Marshall hammer assembly.

* Kneading Compactor Assembly - Remove the 1200 gram batch from the oven (after 1 hour) and place the mix in the pre-heated molds. Using a compaction pressure of 250 psi, immediately apply 20 blows with the spacer and 150 blows without the spacer. Following compaction, place the specimen and mold in the press and level off with a 1,000 psi load.

* To prevent expansion of the compacted specimen, immediately remove the base plate and set it over a 3 7/8" diameter x 1" thick wood plug. Place another wood plug on top of the specimen and weight with at least five pounds (a stack of three old briquettes is sufficient).

* Allow the weighted specimens to cool to 120°F. - 140°F. and remove from the molds. If they are allowed to sit in the molds overnight or longer, ease of removal can be increased by first putting them in a 320°F. oven for five minutes.

DETERMINATION OF VOID CONTENT

* The theoretical maximum specific gravity may be determined by several methods; the Rice method being the most common. If the theoretical maximum specific gravity is calculated, use a value of 1.19 for the specific gravity of the rubber.

* After the specimens have cooled to room temperature, determine the bulk specific gravity and calculate the percent air voids. If the percent of air voids is too high, increase the amount of asphalt and filler and/or adjust the aggregate gradation and prepare another set of trial mixtures. Once a satisfactory air void content has been attained, it is often helpful to saw the specimens in half for examination to aid verification and selection of the job mix asphalt content.

FIELD TESTING

* On large projects, construction of a test section two days in advance of paving is recommended. The proper compaction equipment and rolling pattern can then be determined. If a nuclear densometer is used for compaction control, pavement cores at the same location should be taken

to verify the nuclear densometer readings. The cores can be sawn in half for visual observation.

The test section also provides an opportunity to obtain aggregate and/or mixture samples for verification of specification plant production. Asphalt extraction can be accomplished with standard methods, however, the time required is usually lengthened. When an aggregate sieve analysis is made of the extracted mixture, it is not necessary to remove the rubber, because the small percent of rubber content does not significantly change the results. If extraction of the rubber is desired, use a solution with a heavy specific gravity to facilitate separation and flotation of the rubber to the surface where it can be removed with a fine mesh sieve; however, a loss of 0.3% to 0.5% is normal. It is best to verify the proper rubber percentage at the cold feed.

ALL SEASONS SURFACING CORPORATION
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ASSC2
3/85

APPENDIX C

CONSTRUCTION AND MIX SPECIFICATIONS

FOR

DANBY ROAD SITES

(FAIRBANKS)

Nothing in the above shall be construed to limit the placement of the crushed aggregate base course, and pavement on portions of the project, provided such portions are constructed full width and in specification.

SECTION 401

ASPHALT CONCRETE PAVEMENT

401-2.01 Composition of Mixtures. Add the following:

Asphalt content as determined by Alaska T-23 shall be corrected for moisture content as follows: Determine the water content of a representative portion of the Asphalt Concrete Paving Mixture according to Alaska T-25 "Standard Method of Test for Determination of Moisture in Hot Asphalt Pavement Mixes" or AASHTO T-110 "Test for Moisture of Volatile Distillates in Bituminous Paving Mixtures". The percentage of Water determined by AASHTO T-110 or Alaska T-25 shall be subtracted from the percentage of Asphalt determined by Alaska T-23. This shall be the percent asphalt by weight of dry aggregate of the Asphalt Concrete Paving Mixture.

401-3.01 Weather Limitations. Add the following: No asphalt pavement will be placed between September 15th and May 15th.

401-3.10 Mixing. Delete the third and fourth paragraphs in their entirety and substitute the following:

Dryer Drum Mixing. The temperature of the asphaltic mixture at discharge from the mixer shall be within mixing temperature tolerances determined by Alaska T-17.

All hot mix Asphalt Plants (excluding Dryer Drum). The temperature of the aggregate at the time of adding asphalt cement shall be within the mixing temperature tolerances determined by Alaska T-17.

401-3.12 Compaction. Delete the seventh paragraph and substitute the following: Compaction Control of asphalt pavements shall be by "Method 3", the "Compaction by Relative Density" method, as described in the Standard Specifications. Relative density shall be determined by Alaska Test Method T-18 or ASTM-D-2950.

Delete subparagraph 3 of the last paragraph and add the following:

3. Control by Relative Density. Rolling shall continue until all roller marks are eliminated and a minimum of 95 percent of the job mix formula design density is obtained.

401-4.01 Method of Measurement. Delete the first sentence of the last paragraph in its entirety and substitute the following: Asphalt Cement AC-2.5 and Anti-stripping additive shall be furnished by the Contractor. ~~as~~

required by the Job Mix Design and will not be paid for directly but will be considered incidental to other pay items.

SECTION 403

PRIME COAT

403-2.01 Asphalt Material. Add the following to the first paragraph: The Contractor has the option of using CSS-1 Emulsified Asphalt or MC-30 Liquid Asphalt for Prime Coat. Once selected, the Contractor must place the same kind of prime coat material under all the pavement test sections. (See Special Provisions Sections 408 thru 411), and will not be allowed to switch prime coat asphalt type, between test sections.

403-3.01 Weather Limitations. Add the following to the first paragraph: When using CSS-1 Emulsified Asphalt for Prime Coat, change the above temperature to 60°F.

403-3.04 Application of Asphalt Material. Add the following: After the grading and compaction of the base course has been completed, the surface shall be tight bladed to loosen the surface prior to the application of the prime. If required by the Engineer, the surface shall be recompacted after the application of the prime.

It shall be the responsibility of the Contractor to assure that no damage occurs to the primed surface prior to paving. Any areas of rutting or spalling will be repaired in accordance with Section 403-3.03 and reprimed, as directed by the Engineer, at the Contractor's expense prior to paving.

The primed area for pavement covered under Section 401 of the specifications shall at no time exceed that which can be covered by the following day's paving operation.

In the event that the prime coat areas for pavements covered under Sections 408, 409, 410, and 411 are constructed with MC-30, the placement of the hot mix shall be made 7 days after the prime application to allow a complete cure of the MC-30 prime.

Unless otherwise directed by the Engineer, the application rates shall be:

MC-30 Liquid Asphalt	0.20 gallon/square yard
*CSS-1 Emulsified Asphalt	0.40 gallon/square yard

*(after being diluted with an equal amount of water.)

If CSS-1 Emulsified Asphalt is used for prime coat, it shall be diluted with an equal amount of water and mixed. The mixing temperature of the water shall be 60° - 70°F, and the quality shall be such that asphalt will not separate from the emulsion before application.

403-5.01 Basis of Payment. Add the following: Either option shall be paid for at the same unit price and no adjustment in price shall be allowed. Payment for CSS-1 Emulsified Asphalt shall not include the weight of the water used for dilution.

Following "Payment will be made under", change to read:

Pay Item No.	Pay Item	Pay Unit
403(1)	Prime Coat	Ton

Add the following sections:

SECTION 408

ASPHALT-RUBBER CONCRETE PAVEMENT (TYPE A SURFACING) AND RUBBERIZED ASPHALT-RUBBER CONCRETE PAVEMENT (TYPE D SURFACING)

408-1.01 Description. This work consists, depending upon pay item involved, of the furnishing and mixing of aggregate, asphalt-rubber and/or aggregate-size rubber at a central mixing plant, or the acquisition of a prepared mixture from an approved commercial source, and the hauling, spreading, and compacting of the mixture, all as specified in the contract and in reasonably close conformity with the lines, grades, and thicknesses shown in the plans or established by the Engineer.

408-2.01 Composition of Mixtures. At least fifteen (15) days prior to the pre-production meeting (Subsection 408-3.17), the Contractor shall submit a representative 200 pound sample of the aggregate, and a 3 gallon sample of the asphalt-rubber, and a 50 pound sample of the aggregate-size rubber (for rubberized asphalt-rubber concrete only) proposed for use in the mix. From tests on these samples the Engineer shall establish the Job Mix Designs which shall become a part of the contract and shall be followed unless modified in writing by the Engineer. Changes in the Job Mix Design warranted by changes in the aggregate or sources of aggregate shall be submitted by the Contractor in the same manner as the original submittal.

All plants shall be furnished with a safe and suitable means of obtaining aggregate samples. These samples shall be taken from a point in the plant operation which best represents the blended aggregate before asphaltic material is added to the aggregate mix.

Failure to comply with gradation requirements will necessitate adjustments of the mix by the Contractor and subsequent retesting until specifications are met.

All mixes furnished for the project shall conform to the approved Job Mix Designs with the following ranges of tolerances:

Sieve Size of Item	Tolerances Percent Passing
3/8"	±6
No. 4	±6
No. 10	±4
No. 40	±4
No. 200	±2
Asphalt Percent	±0.4

Pavement that does not meet these specifications must be removed and replaced with pavement meeting the specifications of this section. Price adjustments for the purpose of accepting pavements which do not meet the specifications of this section, will not be allowed.

The acceptance of aggregates meeting the requirements of these specifications will be based on representative samples taken at one or more of the following locations:

1. Individual hot bins.
2. Combined aggregates prior to adding asphalt or rubber.

408-2.02 Aggregates. Aggregate gradation shall conform to Subsection 703-2.15 for the asphalt-rubber concrete pavement. Aggregate gradation shall conform to Subsection 409-2.02 for the Rubberized asphalt-rubber concrete pavement.

408-2.03 Filler. Filler shall conform to the requirements of Subsection 703-2.06.

408-2.04 Asphalt Materials. Asphalt materials shall conform to the requirements of Subsection 401-2.04, except as modified herein.

The asphalt cement shall be AC-2.5 with an extender oil added to form a modified asphalt material that is chemically compatible with the rubber material to be blended with it. Generally, the extender oil will be approximately 2% of the total asphalt-rubber blend, by weight. The Contractor shall supply certified test results for the extender oil.

EXTENDER OIL:

Extender oil shall be a resinous, high flash point aromatic hydrocarbon meeting the following test requirements:

Viscosity, SUS @ 100°F	(ASTM D-88)	2500 min.
Flash Point, COC, °F	(ASTM D-92)	390 min.
Molecular Analysis	(ASTM D-2007)	
Asphaltenes, % by weight		0.1 max.
Aromatics, % by weight		55.0 min.

408-2.05 Asphalt-Rubber Blend

The ground rubber and "modified asphalt" shall be combined in a ratio of 20±2% rubber to 80±2% modified asphalt and reacted for a sufficient time at 400±25°F to produce a product with the following properties:

Viscosity, at 400°F (Brookfield Viscometer)	1200 cps max.
Softening Point (R&B)(ASTM-D36)	100°F min.
Flex Temperature (90° Bend Test)	10°F max.

The Flex Temperature or 90° Bend Test consists of bending a specimen (1/8" x 1" x6") to a 90° angle over a mendrel in 2 seconds without cracking. The test method can be obtained at Materials Section of Department of Transportation at Peger Road, Fairbanks, Alaska.

The certified test results for the above properties by a recognized laboratory shall be required for the approval of the Engineer.

In the event a delay occurs when the product is ready to be applied, the heat shall be turned off until the job resumes.

The ground rubber shall conform to the requirements of Section 703-2.16.

The proper equipment needed for asphalt-rubber blending shall be as specified in Section 411-3.01.

The asphalt-rubber supplier shall furnish to the Engineer by no later than 7 days before the beginning of mixing the asphalt-rubber, mix formulation which shall contain the following information:

Asphalt Cement

Grade of asphalt
Source of asphalt

Ground Rubber

Total ground rubber content, weight % of asphalt-rubber mixture
Rubber type(s) and content of each type (if blended), weight % of combined rubber.

Asphalt Modifier

Type of modifier
Quantity of modifier, weight % of total blend.

408-2.06 Aggregate Size Rubber. Aggregate size rubber particles shall conform to the requirements of Subsection 703-2.14.

CONSTRUCTION REQUIREMENTS

408-3.01 Weather Limitations. No mix shall be placed when free water is on the surface, or when the base material is frozen.

Air temperature at the paving site shall be measured in the shade away from heat sources. No asphalt pavement shall be placed unless the air temperature is over 50 degrees F and rising. In any case paving shall be limited to placement between May 15 and September 15. Paving before May 15 or after September 15 will not be allowed.
408-3.02 Stockpiling. Stockpiling shall conform to Subsection 401-3.02.

408-3.03 Asphalt Plants. Asphalt plants shall conform to the requirements of Subsection 401-3.03.

The Contractor is advised that these plants may require modifications to accommodate the use and/or storage of the asphalt-rubber material. If a commercial source of the asphalt rubber is used to supply the material, the supplier should be contacted for direction concerning possible plant modifications, material processing requirements and material storage stipulations. It is the Contractor's responsibility to exercise suitable caution in handling and processing the material to provide a finished product in conformance with the specifications.

408-3.04 Hauling Equipment. Hauling equipment shall conform to Subsection 401-3.04, except as noted below.

Truck beds shall be clean of materials such as dirt, mud and aggregates. Just prior to the loading of the mixture, the truck bed shall be sprayed with a light application of a soapy solution or a silicone emulsion (oiling with kerosene or diesel fuel will not be permitted). When directed by the Engineer, the mixture shall be covered with a canvas or similar covering to prevent rapid cooling.

408-3.05 Asphalt Pavers: Asphalt pavers shall conform to Subsection 401-3.05. Asphalt pavers shall have augers the full width of the paver. The paver shall have a vibrating screed for the full paving width.

408-3.06 Roller: Only the steel-wheeled roller shall be used for compaction. The requirement on the steel-wheeled roller shall conform to Subsection 401-3.06. Only water or soap solution can be dispersed on the rollers in case of mixture pick-up.

408-3.07 Condition of Surface. The surface shall conform to Subsection 401-3.07.

A prime coat shall be applied to existing gravel-unpaved surfaces prior to paving and in accordance with Section 403. In the event that the prime coat is constructed with MC-30, the placement of the hot mix shall be made at least 7 days after the prime application to allow a complete cure of the prime.

A tack coat of CSS-1 shall be applied to the stress absorbing membrane (SAM) surface before placement of the asphalt-rubber mix in accordance with Section 402 Tack Coat. The rate of application of the undiluted emulsion shall be 0.10 to 0.13 gallons per square yard (0.20 to 0.26 gallons per square yard for diluted emulsion). Tack coat will be paid for as prime coat under Pay Item 403(1). The pay quantity shall be for the undiluted emulsion.

408-3.08 Not used.

408-3.09 Preparation of Aggregates. Aggregates shall be prepared in accordance with Subsection 401-3.09.

408-3.10 Mixing. In rubberized asphalt-rubber concrete production, the required amount of aggregate-size rubber shall be added to the aggregate in accordance with Section 409-3.10 and Job Mix Design. The binder shall be an asphalt-rubber blend and shall be handled the same way in both mixes.

The asphalt-rubber binder shall be at a temperature of 350°F to 375°F when pumped and metered into the mixing plant. The aggregate (with granulated rubber particles for rubberized asphalt-rubber concrete) shall be dried and heated to provide a paving mixture immediately after mixing, that is, when discharged from the pugmill or drier-drum mixer, at a temperature of 350°F to 375°F and has a moisture content not exceeding 1.0 percent by weight of mixture. The mixing operation shall be that necessary to achieve a satisfactory mixture which shall be established by the manufacturer's representative based on the procedure for determining percentage of coated particles described in ASTM D 2489-67. The mixing shall be set to achieve a percent of coated particles of not less than 95 percent. The exact procedures and requirements shall be followed in accordance with the Job Mix Design. The percent of aggregate size rubber shall conform to the requirements of 409-3.10.

408-3.10A Surge Bins. Surge Bins shall conform to Subsection 401-3.10A.

408-3.11 Spreading and Finishing. Spreading and finishing shall conform to Subsection 401-3.11 and as noted herein. Unless otherwise directed by the manufacturer's representative, the mixture shall be spread at a temperature of not less than 320°F.

408-3.12 Compaction. Compaction shall conform to Subsection 401-3.12. Compaction control will be by (3) Control by Relative Density. All compaction rolling shall be completed before the temperature of the mixture cools to 265°F. For breakdown rolling, no vibratory action shall be used. Finish rolling shall continue until the mat temperature cools to 140°F, for rubberized asphalt-rubber concrete.

408-3.13 Joints. Joints shall conform to the requirements of Subsection 401-3.13.

408-3.14 Pavement Samples. Pavement samples shall be obtained if required in accordance with Subsection 401-3.14.

408-3.15 Surface Tolerances. Surface tolerance shall conform to the requirements of Subsection 401-3.15.

408-3.16 Thickness Requirements. Thickness requirements shall conform to the requirements of Subsection 401-3.16.

408-3.17 Pre-Production Meetings. The Contractor and the mix supplier shall meet with the Resident Engineer and the Regional Materials Engineer prior to any mixing or placement of the rubberized mixture. The purpose of this meeting is to review the procedures for the production and placement of the mix.

408-3.18 Fog Seal. A fog seal shall be applied if directed by the Engineer. The seal shall be a 50-50 mixture of CSS-1 and water applied at a rate determined by the Engineer. Payment will be made under Section 403 as prime coat.

408-4.01 Method of Measurement. Asphalt-Rubber Concrete and Rubberized Asphalt-Rubber Concrete will be measured by the ton in accordance with Section 109. Batch weights will not be permitted as a method of measurement, unless the alternative provisions of Sections 401-3.03,1,a are met, in which case the cumulative weight of all batches will be used for payment. The tonnage used shall be the weight used in the accepted pavement and no deduction will be made for the weight of asphalt material and rubber in the mixture.

Asphalt cement and rubber particles in the mixture will not be measured for payment separately, they shall be compensated for in the cost of Asphalt-Rubber Concrete, and Rubberized Asphalt-Rubber Concrete.

408-5.01 Basis of Payment. The accepted quantity determined as provided above shall be paid for at the contract price per unit of measurement for the pay item listed below complete in place.

Pay Item No.	Pay Item	Pay Unit
408(1)	Asphalt-Rubber Concrete	Ton
408(2)	Rubberized Asphalt-Rubber Concrete	Ton

SECTION 409

RUBBERIZED ASPHALT CONCRETE PAVEMENT (TYPE E SURFACING)

409-1.01 Description. This work consists of the furnishing and mixing of aggregate, asphalt, and aggregate-size rubber at a central mixing plant, or the acquisition of a prepared mixture from an approved commercial source, and the hauling, spreading, and compacting of the mixture, all as specified in the contract and in reasonably close conformity with the lines, grades, and thicknesses shown in the plans or established by the Engineer.

409-2.01 Composition of Mixtures. At least fifteen (15) days prior to the pre-production meeting (Subsection 409-3.17), the Contractor shall submit a representative 200 pound sample of the aggregate, a 50 pound sample of the aggregate-size rubber, and a 3 gallon sample of the asphalt proposed for use in the mix. From tests on these samples the Engineer shall establish the Job Mix Design which shall become a part of the contract and shall be followed unless modified in writing by the Engineer. Changes in the Job Mix Design warranted by changes in the aggregate or sources of aggregate shall be submitted by the Contractor in the same manner as the original submittal.

All plants shall be furnished with a safe and suitable means of obtaining aggregate samples. These samples shall be taken from a point in the plant operation which best represents the blended aggregate before asphaltic material is added to the aggregate mix.

Failure to comply with gradation requirements will necessitate adjustments of the mix by the Contractor and subsequent retesting until specifications are met.

All mixes furnished for the project shall conform to the approved Job Mix Design within the following ranges of tolerances:

Sieve Size or Item	Tolerances Percent Passing
3/8"	±6
No. 4	±6
No. 10	±4
No 40	±4
No. 200	±2
Asphalt Percent	±0.4

Pavement that does not meet these specifications must be removed and replaced with pavement meeting the specifications of this section. Price adjustments for the purpose of accepting pavements which do not meet the specifications of this section, will not be allowed.

The acceptance of aggregates meeting the requirements of these specifications will be based on representative samples taken at one or more of the following locations:

1. Individual hot bins.

2. Combined aggregates prior to adding asphalt or rubber.

409-2.02 Aggregates. Aggregate gradation shall conform to Subsection 703-2.13.

409-2.03 Filler. Filler shall conform to the requirements of Subsection 703-2.06.

409-2.04 Asphalt Materials. Asphalt cement type AC-2.5 in the amount specified in the Job Mix Design shall be required for the pavement mixture. Asphalt cement type AC-2.5 and emulsified asphalt CSS-1 shall conform to the applicable requirements of Section 702, Asphalt Materials.

409-2.05 Aggregate-Size Rubber. Rubber particles shall conform to the requirements of Subsection 703-2.14.

CONSTRUCTION REQUIREMENTS

409-3.01 Weather Limitations. No mix shall be placed when free water is on the surface, or when the base material is frozen.

Air temperature at the paving site shall be measured in the shade away from heat sources. No asphalt pavement shall be placed unless the air temperature is over 50°F and rising. In any case, paving shall be limited to placement between May 15 and September 15. Paving before May 15 or after September 15 will not be allowed.

409-3.02 Stockpiling. Stockpiling shall conform to Subsection 401-3.02.

409-3.03 Asphalt Plants. Asphalt plants shall conform to the requirements of Subsection 401-3.03.

409-3.04 Hauling Equipment. Hauling equipment shall conform to Subsection 401-3.04.

409-3.05 Asphalt Pavers. Asphalt pavers shall conform to Subsection 401-3.05. Asphalt pavers shall have augers the full width of the paver. The paver shall have a vibrating screed for the full paving width.

409-3.06 Roller. Roller types and sizes shall conform to Subsection 401-3.06.

409-3.07 Condition of Surface. The surface shall conform to Subsection 401-3.07.

A prime coat shall be applied to gravel unpaved surfaces prior to paving and in accordance with Section 403.

A tack coat of [redacted]hall be applied on a [redacted] before placement of the rubberized mix in accordance with Section 402 Tack Coat. The rate of application of the undiluted emulsion shall be 0.10 to 0.13 gallons per square yard (0.20 to 0.26 gallons per square yard for a diluted emulsion). Tack coat will be paid for as prime coat under Pay Item 403(1). The pay quantity shall be for the undiluted emulsion.

409-3.08 Preparation of Asphalt Material. Preparation of asphalt material shall be in accordance with Subsection 401-3.08.

409-3.09 Preparation of Aggregates. Aggregates shall be prepared in accordance with Subsection 401-3.09.

409-3.10 Mixing. The dried aggregates shall be combined in the mixer in the amount of each fraction of aggregates required to meet the Job Mix formula. The asphalt material shall be measured or gauged and introduced into the mixer in the amount specified by the Job Mix formula.

After the required amount of aggregate has been introduced into the mixer, the required rubber content shall be added and the materials mixed thoroughly for 15 to 30 seconds prior to introducing the asphalt. The materials shall then be mixed for 30 to 45 seconds until a complete and uniform coating of the particles and a thorough distribution of the asphalt material throughout the aggregate is secured.

The temperature range of the mix at discharge from the mixer shall be 375°F maximum and 350°F minimum.

The Job Mix Design percentage of the asphalt cement to be added to the aggregate shall be between 7.5 and 10.0 percent of the weight of the total mix. The percentage of aggregate-size rubber shall be 2.5 percent by weight of the total mix. The exact percentages to be used shall be fixed by the Engineer on the basis of a project mix design.

Anti-stripping additives shall be used in an amount of 0.25 percent by weight of the asphalt cement used in the approved Job Mix Design.

409-3.11 Spreading and Finishing. Spreading and finishing shall be in accordance with Subsection 401-3.11.

409-3.12 Compaction. Compaction shall conform to Subsection 401-3.12 of the 1981 Standard Specifications. Finish rolling shall continue until the mat temperature cools to 140°F.

409-3.13 Joints. Joints shall conform to the requirements of Subsection 401-3.13.

409-3.14 Pavement Samples. Pavement samples shall be obtained if required in accordance with Subsection 401-3.14.

409-3.15 Surface Tolerances. Surface tolerance shall conform to the requirements of Subsection 401-3.15.

409-3.16 Thickness Requirements. Thickness requirements shall conform to the requirements of Subsection 401-3.16.

409-3.17 Pre-Production Meetings. The Contractor and the mix supplier shall meet with the Resident Engineer and the regional materials engineer prior to any mixing or placement of the rubberized mixture. The purpose of this meeting is to review the procedures for the production and placement of the mix.

409-3.18 Fog Seal. A fog seal shall be applied if directed by the Engineer. The seal shall be a 50-50 mixture of CSS-1 and water applied at a rate determined by the Engineer. Payment will be made under Section 403 as prime coat.

409-4.01 Method of Measurement. Rubberized-Asphalt Concrete will be measured by the ton in accordance with Section 109. Batch weights will not be permitted as a method of measurement, unless the alternative provisions of Sections 401-3.03,1,a are met, in which case the cumulative weights of all batches will be used for payment. The tonnage used shall be the weight used in the accepted pavement and no deduction will be made for the weight of asphalt material and rubber in the mixture.

Asphalt cement, anti-strip, and rubber particles in the mixture will not be measured for payment separately, they shall be compensated for in the cost of Rubberized- Asphalt Concrete.

409-5.01 Basis of Payment. The accepted quantity determined as provided above shall be paid for at the contract price per unit of measurement for the pay item listed below in place.

Pay Item No.	Pay Item	Pay Unit
409(1)	Rubberized Asphalt Concrete	Ton

SECTION 410

ASPHALT-LATEX CONCRETE PAVEMENT (TYPE C SURFACING)

410-1.01 Description. This work consists of the furnishing and mixing of aggregate, asphalt and latex rubber modifier at a central mixing plant, or the acquisition of a prepared mixture from an approved commercial source, and the hauling, spreading, and compacting of the mixture, all as specified in the contract and in reasonably close conformity with the lines, grades, and thicknesses shown in the plans or established by the Engineer.

410-2.01 Composition of Mixtures. At least fifteen (15) days prior to the pre-production meeting (Subsection 410-3.17), the Contractor shall submit a representative 200 pound sample of the aggregate, a 3 gallon sample of the asphalt, and a 2 gallon sample of latex rubber proposed for use in the mix. From tests on these samples the Engineer shall establish the Job Mix Design which shall become a part of the contract and shall be followed unless modified in writing by the Engineer. Changes in the Job Mix Design warranted by changes in the aggregate or sources of aggregate shall be submitted by the Contractor in the same manner as the original submittal.

All plants shall be furnished with a safe and suitable means of obtaining aggregate samples. These samples shall be taken from a point in the plant operation which best represents the blended aggregate before asphaltic material is added to the aggregate mix.

Failure to comply with gradation requirements will necessitate adjustments of the mix by the Contractor and subsequent retesting until specifications are met.

All mixes furnished for the project shall conform to the approved Job Mix Design within the following ranges of tolerances:

Sieve Size or Item	Tolerances Percent Passing
3/8"	±6
No. 4	±6
No. 10	±4
No. 40	±4
No. 200	±2
Asphalt Percent	±0.4

Pavement that does not meet these specifications must be removed and replaced with pavement meeting the specifications of this section. Price adjustments for the purpose of accepting pavements which do not meet the specifications of this section will not be allowed.

The acceptance of aggregates meeting the requirements of these specifications will be based on representative samples taken at one or more of the following locations:

1. Individual hot bins.
2. Combined aggregates prior to adding asphalt and latex rubber.

410-2.02 Aggregates. The aggregates shall conform to the requirement of Type II asphalt concrete as shown in Table 703-3 of Subsection 703-2.04.

410-2.03 Filler. Filler shall conform to the requirements of Subsection 703-2.06.

410-2.04 Asphalt Materials. Asphalt cement type AC-2.5 in the amount specified in the Job Mix Design shall be required for the pavement mixture.

Asphalt cement type AC-2.5 and emulsified asphalt CSS-1 shall conform to the applicable requirements of Section 702, Asphalt Materials.

410-2.05 Latex Rubber Modifier. The latex rubber shall be an unvulcanized styrene butadiene rubber in a water emulsion form meeting the following test requirements:

Property	Value
Styrene/Butadiene Ratio, by weight	23/77 - 32/68
Total Rubber Solids, % by Weight	60 - 72%
Allowable Variation for total Rubber Solids, % by Weight	±1%
Ash, % of Total Rubber Solids, ASTM D297, maximum	3.5%
Viscosity-Brookfield RVT, #3 Spindle, 20 rpm at 77°F, ASTM D 1417, Maximum	2000

The Contractor shall supply certified test results showing conformity with these specifications.

CONSTRUCTION REQUIREMENTS

410-3.01 Weather Limitations. No mix shall be placed when free water is on the surface, or when the base material is frozen.

Air temperature at the paving site shall be measured in the shade away from heat sources. No asphalt pavement shall be placed unless the air temperature is over 50 degrees F and rising. In any case paving shall be limited to placement between May 15 and September 15. Paving before May 15 or after September 15 will not be allowed.

410-3.02 Stockpiling. Stockpiling shall conform to Section 401-3.02.

410-3.03 Asphalt Plants. The asphalt plants shall conform to Section 401-3.03 with the following addition:

The Contractor is advised that the hot mix plants may require modifications. All hot mix asphalt plants shall be equipped with proper feeder to introduce latex-rubber modifier to the mix during mixing cycle in accordance with specifications of Section 410-3.10.

It is the Contractor's responsibility to exercise suitable caution in handling and processing all the materials to provide a finished product in conformance with the specifications.

410-3.04 Hauling Equipment. Hauling equipment shall conform to Subsection 401-3.04, except as noted below.

Truck beds shall be clean of materials such as dirt, mud and aggregates. Just prior to the loading of the mixture, the truck bed shall be sprayed with a light application of a soapy solution or a silicone emulsion (oiling with kerosene or diesel fuel will not be permitted). When directed by the Engineer, the mixture shall be covered with a canvas or similar covering to prevent rapid cooling.

410-3.05 Asphalt Pavers. Asphalt pavers shall conform to Subsection 401-3.05. Asphalt pavers shall have augers the full width of the paver. The paver shall have a vibrating screed for the full paving width.

410-3.06 Roller. Roller types and sizes shall conform to Subsection 401-3.06.

410-3.07 Conditioning of Existing Surface. Conditioning of existing surface shall conform to Subsection 401-3.07 with the following addition:

A prime coat shall be applied to the base course surface prior to paving and in accordance with Section 403.

A tack coat of CSS-1 shall be applied to SAM surface prior to the overlay of asphalt-latex concrete pavement in accordance with Section 402 Tack Coat. The rate of application of the undiluted emulsion shall be 0.10 to 0.13 gallons per square yard (0.2 to 0.26 gallon per square yard for a diluted emulsion). Tack Coat will be paid for as prime coat under Pay Item 403(1). The pay quantity shall be for the undiluted emulsion.

410-3.08 Preparation of Asphalt. Preparation of asphalt shall conform to the specifications of Subsection 401-3.08.

410-3.09 Preparation of Aggregates. Aggregates shall be prepared in accordance with Subsection 401-3.09.

410-3.10 Mixing. Mixing shall conform to the specification of Subsection 401-3.10 with the following addition and modifications.

For batch plants the latex-rubber modifier shall be introduced to the mixer no sooner than 12 seconds after the addition of the asphalt cement. Total mixing time should generally be about 34 seconds. The pugmill shall be suitably modified for latex-rubber feed. The latex-rubber emulsion may be fed manually to the mixer from a calibrated bucket using a funnel, after the proper amount of the emulsion is measured out. The feeding time for each batch shall be approximately 12 seconds.

For dryer drum mix plants, the latex-rubber modifier shall be introduced to the drum at a position 5' to 6' downstream from the point of addition of asphalt cement. The mixing drum shall be so modified that a steel feeder line of 3/4" diameter for latex rubber modifier is provided entering from the exit end of the drum running alongside the asphalt cement feeder line.

A dual-diaphragm air-driven pump shall be used for handling and feeding the latex-rubber modifier. High shear pumps shall not be used. This feeding system shall be capable of being calibrated to verify that the feeding rate of the latex-rubber is matched with the plant production rate. No adjustment for total mixing time of the dryer drum is necessary unless directed otherwise.

The intent of the above paragraph is to insure that the aggregate has been well coated by the asphalt cement prior to introduction of the latex-rubber.

The latex-rubber modifier shall be well mixed before adding to the mixer.

The amount of latex-rubber modifier shall be determined by latex-rubber solids content. The weight of latex-rubber solids shall be 3±0.3% of the total binder by weight (total binder is asphalt cement plus latex-rubber solids). The amount of AC-2.5 will then be 97±0.3% of the total binder content as determined from the mix design.

Change the first sentence of the third paragraph of Subsection 401-3.10 of the Standard Specifications to read: "The temperature of the asphaltic mixture at discharge from the mixer shall range from 355°F maximum to 310°F minimum.

Change the first sentence of the fourth paragraph of Subsection 401-3.10 of the Standard Specifications to read: "The temperature of the aggregate at the time of adding asphalt cement shall not be less than 310°F, nor more than 355°F.

410-3.10A Surge Bins. Surge bins shall conform to Subsection 401-3.10A.
410-3.11 Spreading and Finishing. Spreading and finishing shall conform to Subsection 401-3.11 and as noted herein.

Unless otherwise directed by the manufacturer's representative, the mixture shall be spread at a temperature of not less than 250°F.

410-3.12 Compaction. Compaction shall conform to Subsection 401-3.12. Compaction control will be by (3) Control by Relative Density.

410-3.13 Joints. Joints shall conform to the requirements of Subsection 401-3.13.

410-3.14 Pavement Samples. Pavement samples shall be obtained, if required, in accordance with Subsection 401-3.14.

410-3.15 Surface Tolerances. Surface tolerance shall conform to the requirements of Subsection 401-3.15.

410-3.16 Thickness Requirements. Thickness requirements shall conform to the requirements of Subsection 401-3.16.

410-3.17 Pre-Production Meeting. The Contractor and the mix supplier shall meet with the Resident Engineer and the regional materials engineer prior to any mixing or placement of the asphaltic mixture. The purpose of this meeting is to review the procedures for the production and placement of the mix.

410-3.18 Fog Seal. A fog seal shall be applied if directed by the Engineer. The seal shall be a 50-50 mixture of CSS-1 and water applied at a rate determined by the Engineer. Payment will be made under Section 403 as prime coat.

410-4.01 Method of Measurement. Asphalt-latex concrete will be measured by the ton in accordance with Section 109. Batch weights will not be permitted as a method of measurement, unless the alternative provisions of Sections 401-3.03,1,a are met, in which case the cumulative weight of all batches will be used for payment. The tonnage used shall be the weight used in the accepted pavement and no deduction will be made for the weight of asphalt material and latex-rubber in the mixture.

Asphalt cement and latex-rubber in the mixture will not be measured for payment separately, they shall be compensated for in the cost of Asphalt-Latex Concrete.

410-5.01 Basis of Payment. The accepted quantity determined as provided above shall be paid for at the contract price per unit of measurement for the pay item listed below, complete in place.

Pay Item No.	Pay Item	Pay Unit
410(1)	Asphalt-Latex Concrete	Ton

SECTION 411

ASPHALT RUBBER SAM (TYPE B SURFACING)

411-1.01 Description. This work consists of furnishing the materials and the construction of a stress-absorbing membrane interlayer (SAM) on a prepared surface in conformity with the plans.

A tack coat of CSS-1 shall be applied to the SAM surface prior to the placement of the overlay in accordance with Section 402 Tack Coat. The rate of application of the undiluted emulsion shall be 0.1 to 0.13 gallons per square yard (0.20 to 0.26 gallons per square yard for a diluted emulsion). Tack coat will be paid for as prime coat under Pay Item 403(1). The pay quantity shall be for the undiluted emulsion.

411-2.01 Asphalt Materials. Asphalt materials shall conform to Subsection 408-2.04.

411-2.02 Asphalt-Rubber Blend. The ground rubber and modified asphalt shall be combined in a ratio of 20±2% rubber to 80±2% modified asphalt and reacted for a sufficient time at 400 ± 25°F to produce a product with the following properties:

Viscosity at 400°F (Brookfield Viscometer)	1200 cps max.
Softening Point (R&B), ASTM-D36	100°F min.
Flex Temperature (90° Bend Test)	10°F max.

The Flex Temperature or 90° Bend Test consists of bending a specimen (1/8" x 1" x 6") to a 90° angle over a mendrel in 2 seconds without cracking. The test method can be obtained at Materials Section of Department of Transportation at Peger Road, Fairbanks, Alaska.

The certified test results for the above properties by a recognized laboratory shall be required for the approval of the Engineer.

The ground rubber shall conform to the requirements of Section 703-2.16.

In the event a delay occurs when the product is ready to be applied, the heat shall be turned off until the job resumes.

The asphalt-rubber supplier shall furnish to the Engineer by no later than 7 days before the beginning of mixing the asphalt-rubber mix formulation which shall contain the following information:

Asphalt Cement

Grade of asphalt
Source of asphalt

Ground Rubber

Total ground rubber content, weight % of asphalt-rubber mixture rubber type(s) and content of each type (if blend), weight % of combined rubber.

Asphalt Modifier

Type of modifier
Quantity of modifier, weight % of total blend

411-2.03 Aggregates. Aggregates and blotter material shall conform to the requirements of Section 703-2.17 and 703-2.18 respectively.

CONSTRUCTION REQUIREMENTS

411-3.01 Equipment.

A. Asphalt-Rubber Equipment

All equipment utilized in production and application of the asphalt-rubber shall be as described as follows:

1. An asphalt heating tank with hot oil heat transfer to heat the asphalt cement to the necessary temperature for blending with the rubber. This unit shall be equipped with a thermostatic heat control device.

2. A mechanical blender for proper proportioning and thorough mixing of the asphalt and rubber together to produce the specified rubber content. This unit shall have both an asphalt totalizing meter (gallons) and a flow rate meter (gallons per minute).

3. A truck or trailer mounted self-powered distributor equipped with a heating unit, a mixing unit capable of maintaining proper mixture of asphalt and rubber within ±0.05 gallon per square yard of the specified rate, and a fully circulating spray bar capable of applying asphalt-rubber without a streaked or otherwise irregular pattern.

4. The distributor also shall include a tachometer, pressure gauges, volume measuring devices and a thermometer.

A "bootman" shall accompany the distributor and ride in a position so that all spray bar nozzles are in full view and readily accessible for unplugging.

B. Cover Material Spreader

The cover material (chip) spreader shall be a self-propelled machine with an aggregate receiving hopper in the rear, belt conveyors to carry the aggregate to the front, and a spreading hopper equipped with full-width distribution auger and spread roll. The spreader shall be in good mechanical condition and be capable of applying the cover material uniformly across the spread at the specified rate.

C. Hauling Equipment

Trucks for hauling cover material shall be tailgate discharge and shall be equipped with a device to lock onto the hitch at the rear of the aggregate spreader. Haul trucks shall also be compatible with the aggregate spreader so that the dump bed will not push down on the spreader when fully raised or have too short a bed which results in aggregate spillage while dumping into the receiving hopper.

D. Rolling Equipment

A minimum of three (3) self-propelled pneumatic-tired rollers shall be used for the required rolling of the cover material. The pneumatic-tired rollers shall carry a minimum loading of 3,000 pounds on each wheel and an air pressure of 100 ±5 pounds per square inch in each tire.

E. Self propelled rotary power broom shall be used for pavement cleaning and excess cover material removal.

F. If blotter material (sand) is to be applied, a hopper or whirl-type tailgate spreader shall then be required.

411-3.02 Asphalt-Rubber Mixing and Reaction. The temperature of the asphalt shall be between 350°F and 425°F at the addition of the rubber. The asphalt and rubber shall be combined and mixed together in a blender unit and reacted in the distributor for a period of time as required by the Engineer which shall be based on laboratory testing by the asphalt-rubber supplier. The temperature of the asphalt-rubber mixture shall be above 375°F during the reaction period.

When a job delay occurs after full reaction, the asphalt-rubber may be allowed to cool. The asphalt-rubber shall be reheated slowly just prior to application but not to a temperature exceeding 400°F.

411-3.03 Application of Asphalt-Rubber Material. Placement of the asphalt-rubber shall be made only under the following conditions:

1. The paving surface temperature is not less than 50°F and rain is not imminent. Asphalt-rubber shall not be placed between September 15 and May 15.

2. The paving surface is clean and absolutely dry,

3. In the event that the paving surface is primed with MC-30, the placement of the asphalt-rubber shall be made seven (7) days after the prime application to allow the MC-30 a chance to cure completely.

4. The wind conditions are such that excessive blowing of the spray bar fans is not occurring, and

5. All construction equipment such as asphalt-rubber distributor, aggregate spreader, haul trucks with cover material, and rollers are in position and ready to commence placement operations.

6. The asphalt-rubber mixture shall be applied at a temperature of 375°F to 425°F at a rate of 0.60 ±0.05 gallon per square yard. Transverse joints shall be constructed by placing building paper across and over the end of the previous asphalt-rubber application. Once the spraying has progressed beyond the paper, the paper shall be removed immediately and disposed of as directed by the Engineer. All longitudinal joints shall be overlapped a minimum of 4 inches.

411-3.04 Application of Cover Coat Material. Cover material shall be applied immediately to the asphalt-rubber after spreading at a rate of 35 to 40 pounds per square yard. Spreading shall be accomplished in such a manner that the tires of the trucks or aggregate spreader at no time contact the uncovered and newly applied asphalt material.

At the time of application to the asphalt-rubber, cover material shall be clean and dry.

Immediately after the cover coat material is spread, any deficient areas shall be covered by additional material.

411-3.05 Compaction. Sufficient rollers shall be used for the initial rolling to cover the width of the aggregate spread with one pass. The first pass shall be made immediately behind the aggregate spreader, and if the spreading is to be stopped for an extended period, the spreader shall be moved ahead or off to the side so that all cover material may be immediately rolled. Four complete passes with rollers shall be made with all rolling completed within 1 hour after the application of the cover material.

411-3.06 Application of Blotter Material. Blotter material meeting the requirements of Section 703-2.18 may be required immediately after the initial pass of the rollers (usually 4 to 6 pounds per square yard) to prevent asphalt-rubber bleed-through and pick-up or cover aggregate turnover and pick-up. The use, rate and locations for blotter material shall be designated by the Engineer. The blotter material shall be uniformly applied using equipment specified in Section 411-3.01.

At the time of application, the blotter material shall be clean and dry.

411-3.07 Traffic Control. Traffic shall be kept off the newly paved surface until it has had time to set properly. When it is necessary that hauling trucks and other construction equipment must travel on the newly paved surface which is not adequately set, the speed of this equipment shall not exceed 15 miles per hour. The minimum traffic free period shall not be less than 30 minutes.

411-3.08 Removing Loose Cover Material. The sweeping may begin when the product has adequately set. If dislodgement occurs as a result of high temperatures or other causes, cover material sweeping shall be discontinued until such time as there will be satisfactory retention of cover material.

A final sweeping shall be done and any remaining loose cover material removed just prior to the placement of the asphalt concrete overlay.
411-4.01 Method of Measurement. The quantity of rubber-asphalt SAM to be paid for shall be the number of square yards placed, measured in place, to the nearest square yard.

411-5.01 Basis of Payment. The accepted quantity determined as provided above shall be paid for at the contract price per unit of measurement for the pay item listed below, complete in place.

Pay Item No.	Pay Item	Pay Unit
411(1)	Asphalt-Rubber Stress Absorbing Membrane (SAM)	Square Yard

SECTION 501
STRUCTURAL CONCRETE

501-1.01 Description. Add the following: This work shall include the precasting, transporting and erection of the precast arch ribs, precast headwalls and precast wingwalls for the Noyes Slough Arch Structure. At the option of the Contractor and at no additional cost to the Department, all or part of the precast members may be cast-in-place. If this option is selected, then detail drawings shall be submitted for approval to the Engineer. The submission shall be made 30 days in advance of the scheduled pour and shall show all changes in details from contract drawings.

Concrete for precast members shall be Class "A".

501-3.01 Proportioning. Revise Table 501-1 as follows: For Class A, Class S, and Class AA Concrete, Coarse Aggregate AASHTO Gradation, delete "No. 4 and ".

Delete the first two notes below Table 501-1, which are prefaced by asterisks.

501-3.07 Finishing Concrete Surfaces. Add the following: Those concrete surfaces where indicated on the plans shall have an exposed aggregate finish as provided by Part 5.

reflective thermoplastic, of the same color as the lines being referenced, spaced on 40 foot centers. Placement shall be made immediatly after the placement of pavement and prior to the final rolling in accordance with Section 670-3.06. Thermoplastic marking material shall meet the requirements of Section 712-2.14. All work and material required to accomplish the above will not be measured for payment but will be considered incidental to other items of work.

The 4" x 4" thermoplastic markings when placed, are intended only to provide a temporary reference to centerline and lane lines for the benefit of the traveling public and are not to be considered a substitute for preliminary spotting. This does not preclude their use if they are correctly located.

670-3.10 Tolerances for Lane Striping. Add the following: The final product alignment shall look smooth and professional without weaving or visual kinks, especially along curves.

Add the following:

4. Stripes on tangent shall not vary more than one inch laterally within a distance of 100 feet when using the edge of the stripe as a reference.

   Stripes on curves shall be uniform in alignment with no apparent deviations from the true curvature.

   No stripe shall vary more than four inches from the planned alignment when measured to the center of the stripe.

SECTION 702

ASPHALT MATERIALS

702-2.04 Application Temperatures. Add the following to Table 702-1:

Type and Grade of Material	Spray °F.
CSS-1	70-160

SECTION 703

AGGREGATES

703-2.12 Borrow. Under Borrow Type A, change 12% to 7% in the second paragraph.

The 12" of Borrow, Type A that is placed in the bike path shall consist of an evenly graded material with no aggregate larger than 3" in its longest dimension and with between 5% to 12% of the materials passing the No. 200 sieve. This material will not be paid for separately but will be paid for a regular Borrow, Type A under Pay Item 203(5B).

Add the following subsections:

703-2.13 Aggregate for Rubberized Asphalt Pavement.

Coarse Aggregate. Coarse aggregate (retained on the No. 4 sieve) shall be crushed stone or crushed gravel and shall conform to the quality requirements of AASHTO,-79-64 except that sodium sulfate soundness loss shall not exceed 9 percent or the magnesium sulfate soundness shall not exceed 12 percent. Aggregates shall have a minimum degradation value of 45 when tested in accordance with Alaska Test Method T-13. When crushed gravel is used it shall meet the pertinent requirements of AASHTO M62-74 and not less than 70 percent by weight of the particles retained on the No. 4 sieve shall have at least one fractured face. Percent fracture shall be determined by Alaska T-4.

Fine Aggregate. Fine aggregate (passing the No. 4 sieve) shall consist of natural sand, stone screenings, or slag screenings or a combination thereof, and unless otherwise stipulated, shall conform to the quality requirements of ASTM-D-1073.

The several aggregate fractions for the mixture shall be sized, graded, and combined in such proportions that the resulting composite blend meets the Type II asphalt concrete listed in Table 703-3 of the standard specifications.

703-2.14 Aggregate-Size Rubber. The granulated aggregate rubber shall be ground only from whole passenger or truck tires (heavy equipment tires shall not be used). It shall be cubical or thread-shaped individual rubber particles, irrespective of diameter, and shall not be greater in length than 5/16 inch. The granulated rubber shall conform to the following specifications:

Sieve Size	% Passing by Weight
1/4"	100
#4	82-100
#10	42-56
#20	33-41

The rubber granulator shall furnish written certification of compliance with the foregoing specifications. In addition, each delivery will be sampled (not less than one sample for each 20 tons) and a dry sieve analysis performed to ensure that the rubber granules meet gradation requirements. The sampling and testing must be completed and the rubber granules approved for use before any of the delivery is incorporated into the rubberized asphalt pavement.

703-2.15 Aggregate for Asphalt Rubber Concrete Pavement. The aggregate shall conform to the requirements of Type II asphalt concrete as shown in Table 703-3 of Subsection 703-2.04.

703-2.16 Ground Rubber for Asphalt Rubber Blend. The ground rubber shall meet the following gradations prior to being blended into the asphalt cement to create the asphalt rubber blend. The Contractor shall supply certified test results showing conformity with these specifications.

a. Composition. The rubber shall be a dry, free flowing blend of powdered reclaimed scrap tire rubber and ground vulcanized rubber.

b. Purity. The rubber shall contain no more than a trace of fabric, and shall be free of wire and other contaminant materials except that up to 4 percent of a dusting agent such as calcium carbonate or talc may be included to prevent the rubber particles from sticking together.

c. Size. The rubber shall contain no particle larger than 10 mesh or exceeding 0.150 inches in length.

d. Natural Rubber. The blended rubber compound will contain by weight a minimum of 25 percent natural rubber (ASTM-D-297).

e. Type. The ground rubber shall meet the following gradations:

Sieve Size	Percent Passing
No. 8	100
No. 10	100
No. 16	85-100
No. 30	40-80
No. 50	10-45
No. 100	0-10
No. 200	0-5

703-2.17 Cover Coat Aggregate for SAM. Aggregate shall be composed of clean, tough and durable particles of crushed rock, crushed gravel, or crushed slag conforming to gradation requirements as follows:

Sieve Size	Percent Passing
3/4 in. (19.0 mm)	---
1/2 in. (12.5 mm)	100
3/8 in. (9.5 mm)	85-100
1/4 in. (6.3 mm)	---
No. 4 (4.75 mm)	10-30
No. 8 (2.36 mm)	0-10
No. 16 (1.18 mm)	0-5
No. 200 (0.075 mm)	0-2

The sieves shall comply with the requirements of AASHTO M92 (ASTM E11).

The aggregate shall have a percent wear by the Los Angeles abrasion test, AASHTO T96 (ASTM C31), of not more than 40 percent.

703-2.18 Blotter Material for SAM

Blotter Material (if required)

The blotter material shall be a fine aggregate (sand) conforming to the following gradation requirements:

Sieve Size	Percent Passing
3/8 in. (9.5 mm)	100
No. 4 (4.75 mm)	80-100
No. 16 (1.18 mm)	45-80
No. 50 (0.300 mm)	10-30
No. 100 (0.150 mm)	2-10

The sieves shall comply with the requirements of AASHTO M92 (ASTM E11).

Add the following Subsection:

703-2.19 Select Material. This material shall have the same properties as specified for reinforced backfill under Section 206-2.01 and shall have a minimum density of 140 lb./cu. ft. at optimum moisture content.

SECTION 707

METAL PIPE

Add the following subsection:

707-2.07 Ductile Iron Pipe.

Ductile Iron Pipe shall conform to AWWA C-151. Water pipe shall be cement mortar lined and be of thickness Class 52. Sewer and storm drain pipe

APPENDIX D

TYPES OF SURFACING AND MIX DESIGN DATA

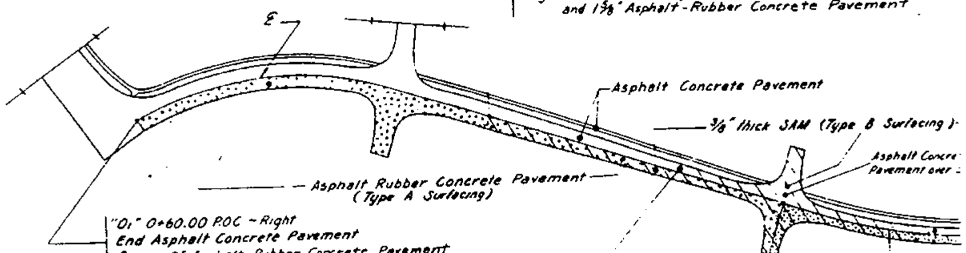
FOR

DANBY ROAD SITES

(FAIRBANKS)

STATE	PROJECT DESIGNATION	YEAR	SHEET NO.	TOTAL SHEETS
ALASKA	RS-RRS-M-0005(52)	1987	10	118

"L" 10+60.00 P.O.T. ~ Right
End 2" Asphalt-Rubber Concrete Pavement
Begin Stress Absorbing Membrane (3/8" thick SAM) and 1 5/8" Asphalt-Rubber Concrete Pavement

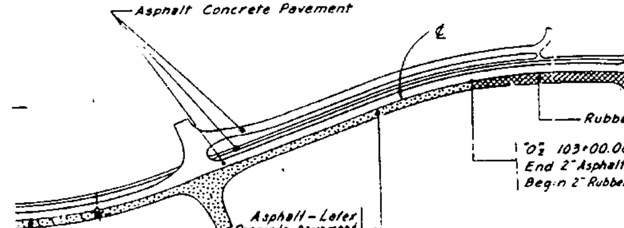


"O1" 0+60.00 P.O.C. ~ Right
End Asphalt Concrete Pavement
Begin 2" Asphalt-Rubber Concrete Pavement

"L" 14+50.00 P.O.T. - End 2" Asphalt Concrete Pavement, Left side of road. Begin Stress Absorbing Membrane (3/8" thick SAM) and 1 5/8" Asphalt Concrete Pavement, Left side of road.

"O" 26+00.00 P.O.C. ~ Right
End Stress Absorbing Membrane (3/8" thick SAM) and 1 5/8" Asphalt-Latex Concrete Pavement
Begin 2" Asphalt-Latex Concrete Pavement

"O2" 107+11.25 P.O.C. ~ Right
End 2" Rubberized Asphalt-Rubber Concrete Pavement



"O2" 103+00.00 P.O.C. ~ Right
End 2" Asphalt-Latex Concrete Pavement
Begin 2" Rubberized Asphalt-Rubber Concrete Pavement

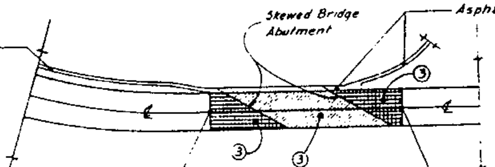
"23+00.00 P.O.C
d Stress Absorbing Membrane (3/8" thick SAM)
d 1 5/8" Asphalt Concrete Pavement, left side of road.
gin 2" Asphalt Concrete Pavement, left side of road.

"L" 17+90.00 P.O.T.
End 1 5/8" Asphalt-
Begin 1 5/8" Asphalt-
(SAM Continuous
ght
ber Concrete Pavement
tex Concrete Pavement
"L" 10+60.00 to "O" 26+00.00)

Note: ① The contractor is advised that there are ral commercial sources and manufacturers of asphalt products and granulated rubber that are similar to those required in the pavement sections. The following manufacturers are listed as an aid to the contractor in developing the pavement mix. There may be additional products available that satisfy the requirements stated in the contract assembly. The Department does not endorse any of the products, and it shall be the responsibility of the Contractor to conform to the specifications of the contract assembly.

1. Dow Chemical company
   Product: Downright Latexes
   Midland, MI 48640
   Contact: Larry Hudson, Product Manager
2. Tex-Crete Inc.
   Product: Latex for concrete and asphalt
   42289 Delany Road
   Zion, IL 60099
   Contact: Donald E. Scheck, President
3. Arizona Refining Company
   Product: A-R-Shield (asphalt-rubber blend)
   P. O. Box 1152
   Phoenix, AZ 85001
   Contact: Unknown
4. Polysar Latex
   3805 Amnicola Highway
   Chattanooga, TN 37406
5. Atlos Rubber
   1522 Fishburn Ave.
   Los Angeles, CA 90063
6. Rubber Granulators, Inc.
   12701 Mukilteo Speedway
   Everett, WA
7. Genstar Conservation Division
   3733 West Willis Road
   Chandler, AZ 85224
8. U.S. Rubber and Reclaiming Co., Inc.
   P. O. Box 54
   Vicksburg, MS 39180
9. Baker Rubber
   P. O. Box 2438
   South Bend, IN 46680
10. International Surfacing, Inc.
   3630 East Superior Avenue
   Phoenix, AZ 85040
   Contact: Mike Elias
   Product: Asphalt Rubber Blend

② To minimize possible problems with the test pavements resulting from plant operation difficulties, at least 50% of the asphalt concrete (Item 401(1)) shall be placed before mixing and placement of any of the pavements from Items 408(1), 408(2), 409(1), 410(1) and 411(1).



"L" 44+00.00 P.O.T.
Begin Rubberized Asphalt Concrete Pavement Surface Layer
End 3" Asphalt Concrete Pavement

"L" 49+00.00 P.O.T.
End Rubberized Asphalt Concrete Pavement. (Type E Surfacing)
Begin 3" Asphalt Concrete Pavement

③ Overlay Embankment with 2" of Asphalt Concrete (bottom layer) and 1" of Rubberized Asphalt Concrete pavement (top layer).
Overlay bridge deck with 1" of asphalt concrete (bottom layer) and 1" of Rubberized Asphalt Concrete pavement (top layer) - see Traffic Maintenance Plan for stage construction details.

- 408(1) ~ Asphalt - Rubber Concrete Pavement = Type A Surfacing
- 411 (1) ~ Stress Absorbing Membrane (SAM) = Type B Surfacing
- 410 (1) ~ Asphalt Latex Concrete Pavement = Type C Surfacing
- 408 (2) ~ Rubberized Asphalt - Rubber Concrete Pavement = Type D Surfacing
- 409 (1) ~ Rubberized Asphalt Concrete Pavement = Type E Surfacing

MODIFIED ASPHALT PAVEMENT SUMMARY

BEGIN		)	RUBBERIZED ASPHALT (TON)	ASPHALT-RUBBER (TON)	ASPHALT-LATEX (TON)	SAM SQ. YD.	RUBBERIZED ASPHALT-RUBBER	REMARKS
"L" 44+00.00	"L"	0.00	310	—	—	—	—	
"O" 0+60.00	"L"	0.00	—	528	—	—	—	2" Asphalt-Rubber Concrete.
"L" 10+60.00	"L"	.00	—	224	—	2443	—	1 5/8" Asphalt-Rubber Concrete overlaying a 3/8" thick SAM. Total = 2"
"L" 14+50.00	"O"	0.00	—	—	—	2854	—	1 5/8" Asphalt-Concrete overlaying a 3/8" thick SAM Total = 2"
"L" 17+90.00	"O"	0.00	—	—	208	2266	—	1 5/8" Asphalt-Latex Concrete overlaying a 3/8" thick SAM. Total = 2"
"O" 26+00.00	"O"	0.00	—	—	344	—	—	2" Asphalt-Latex Concrete
"O2" 103+00.00	"O"	1.25	—	—	—	—	152	2" Rubberized Asphalt-Rubber Concrete.
TOTAL			310	752	552	7563	152 TON	

MODIFIED PAVEMENT SECTION DETAIL

STATE OF ALASKA - NORTHERN REGION
DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES

BITUMINOUS MIX DESIGN
MARSHALL METHOD

PROJECT NAME:	GEIST EXT. COLLEGE- PEGER	DATE RECEIVED:	MAY 13 1988
PROJECT #:	30177542	DATE COMPLETED:	JUNE 1 1988
SUBMITTED BY:	EARTHMOVERS	LAB #:	88-052A
AGGREGATE SOURCE:	SEALAND PIT	FIELD #:	MD-1
ASPHALT SOURCE AND GRADE:	MAPCO AC-2.5	AGGREGATE QUALITY #:	87-615

TYPE II MIX
% ASPHALT CALCULATED
BY WEIGHT OF TOTAL MIX

CRITERIA

STABILITY: (EALS >1,000,000)	1500 MIN.
FLOW:	8-16
VOIDS FILLED:	70-95
VOIDS TOTAL MIX:	1-5
COMPACTING TEMP:	240-247 F
MIXING TEMP:	258-268 F
ANTI-STRIP:	1/4 OF 1%

SIEVE SIZE	GRADATION AS SUBMITTED	NARROW BAND RANGE
3/4"	100	100
3/8"	77	70 - 84
#4	51	45 - 58
#10	37	31 - 43
#40	25	21 - 28
#200	6	3 - 9

OPTIMUM DETERMINATION

% ASPHALT @ MAX UNIT WT:	5.2
% ASPHALT @ MAX STABILITY:	4.8
% ASPHALT @ 3% VOIDS:	4.8
% ASPHALT @ 80% VOIDS FILLED:	4.90
OPTIMUM ASPHALT CONTENT:	4.9+.4 =5.3
STABILITY @ OPTIMUM:	1950
UNIT WEIGHT @ OPTIMUM:	151.0
VOIDS TOTAL MIX @ OPTIMUM:	2
VOIDS FILLED @ OPTIMUM	88
FLOW @ OPTIMUM:	9

CALIBRATION POINTS FOR NUCLEAR CONTENT GAUGE

TARGET WEIGHT:	8176
% ASPHALT - LOW:	4.39
% ASPHALT - HIGH:	6.19
COLD/HOT FACTOR:	.984

REMARKS:
APPROVED % AC BY WT OF TOTAL MIX: 5.3

APPROVED: [signature]
PAUL W. MISTEREK, RME

Asphalt-Rubber Concrete - Type A Surfacing

STATE OF ALASKA - NORTHERN REGION
DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES

BITUMINOUS MIX DESIGN
MARSHALL METHOD

PROJECT NAME:	GEIST EXT. PEGER-COLLEGE	DATE RECEIVED:	8-17-88
PROJECT #:	RS-RRS-M-000S(52)	DATE COMPLETED:	8-24-88
	ITEM # 408(1)		
SUBMITTED BY:	PROJECT	LAB #:	88-330
AGGREGATE SOURCE:	SEALAND PIT	FIELD #:	MD 2
ASPHALT SOURCE AND GRADE:	CRAFCO INC: ATLOS 1515	AGGREGATE QUALITY #:	87-615

TYPE II MIX
% ASPHALT CALCULATED
BY WEIGHT OF TOTAL MIX

CRITERIA

STABILITY:	1500 MIN
FLOW:	8-16
VOIDS FILLED:	70-95
VOIDS TOTAL MIX:	1-5
COMPACTING TEMP:	NOT < 320 F
MIXING TEMP:	350 - 375 F
% ANTI-STRIP:	1/4 of 1%

SIEVE SIZE	GRADATION AS SUBMITTED	NARROW BAND RANGE
3/4"	100	100
3/8"	77	71 - 83
#4	51	45 - 57
#10	37	33 - 41
#40	25	21 - 28
#200	6	4 - 8

OPTIMUM DETERMINATION

% ASPHALT @ MAX UNIT WT:	6.5
% ASPHALT @ MAX STABILITY:	6.8
% ASPHALT @ 3% VOIDS:	6.0
% ASPHALT @ 80% VOIDS FILLED:	5.8
STABILITY @ OPTIMUM:	1540
UNIT WEIGHT @ OPTIMUM:	148.4
VOIDS TOTAL MIX @ OPTIMUM:	2.2
VOIDS FILLED @ OPTIMUM	86
FLOW @ OPTIMUM:	8.8

CALIBRATION POINTS FOR NUCLEAR CONTENT GAUGE

REMARKS:

APPROVED % AC BY WEIGHT OF TOTAL MIX: 6.4 +or- 0.4

APPROVED: [signature] for PAUL W. MISTEREK, RME

(Type D Surfacing)

STATE OF ALASKA - NORTHERN REGION
DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES

BITUMINOUS MIX DESIGN
MARSHALL METHOD

PROJECT NAME: GEIST EXTENSION, PEGER-COLLEGE
PROJECT #: RS-RRS-M-000S(52)
DATE RECEIVED: 8-17-88
DATE COMPLETED: 8-28-88

SUBMITTED BY: PROJECT
AGGREGATE SOURCE: SHANNON PIT
ASPHALT SOURCE AND GRADE: ATLOS 1515 , RUBBER NIBS
ITEM # 408(2)
LAB #: 88-328
FIELD #: MD-4
AGGREGATE QUALITY #: 85-088

TYPE II MIX
% ASPHALT CALCULATED
BY WEIGHT OF TOTAL MIX

CRITERIA

STABILITY:	
FLOW:	
VOIDS FILLED:	
VOIDS TOTAL MIX:	
COMPACTING TEMP	LAYDOWN NOT < 320 F
MIXING TEMP:	350 - 375 F
% ANTI-STRIP:	1/4 of 1%

SIEVE SIZE	GRADATION AS SUBMITTED	NARROW BAND RANGE
3/4"	100	100
3/8"	76	70 - 82
#4	49	45 - 55
#10	33	30 - 37
#40	21	17 - 25
#200	4	3 - 6

OPTIMUM DETERMINATION

% ASPHALT @ MAX UNIT WT:	6.65
% ASPHALT @ MAX STABILITY:	6.55
% ASPHALT @ 3% VOIDS:	7.2
% ASPHALT @ 80% VOIDS FILLED:	N/A
STABILITY @ OPTIMUM:	500
UNIT WEIGHT @ OPTIMUM:	141.1
VOIDS TOTAL MIX @ OPTIMUM:	3.7
VOIDS FILLED @ OPTIMUM	N/A
FLOW @ OPTIMUM:	12.7

CALIBRATION POINTS FOR NUCLEAR CONTENT GAUGE

REMARKS:

APPROVED % AC BY WEIGHT OF TOTAL MIX: 6.8 +or- 0.4

APPROVED: [signature]
PAUL W. MISTEREK, RME

(Type E Surfacing)

STATE OF ALASKA - NORTHERN REGION
DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES

BITUMINOUS MIX DESIGN
MARSHALL METHOD

PROJECT NAME:	GEIST EXT, PEGER-COLLEGE RD.	DATE RECEIVED:	8-18-88
PROJECT #:	RS-RRS-M-0005(52)	DATE COMPLETED:	10-13-88
	ITEM # 409(1)		
SUBMITTED BY:	PROJECT	LAB #:	88-329
AGGREGATE SOURCE:	SHANNON PIT	FIELD #:	MD-5
ASPHALT SOURCE AND GRADE:	AC-2.5/RUBBER NIBS(2.5%)	AGGREGATE QUALITY #:	85-088

TYPE II MIX
% ASPHALT CALCULATED
BY WEIGHT OF TOTAL MIX

CRITERIA

STABILITY:	
FLOW:	
VOIDS FILLED:	
VOIDS TOTAL MIX:	
COMPACTING TEMP:	
MIXING TEMP:	350 - 375 F
% ANTI-STRIP:	1/4 of 1%

SIEVE SIZE	GRADATION AS SUBMITTED	NARROW BAND RANGE
3/4"	100	100
3/8"	76	70 - 82
#4	49	45 - 55
#10	33	30 - 37
#40	21	17 - 25
#200	4	3 - 6

OPTIMUM DETERMINATION

% ASPHALT @ MAX UNIT WT:	6.0
% ASPHALT @ MAX STABILITY:	6.4
% ASPHALT @ 3% VOIDS:	5.8
% ASPHALT @ 80% VOIDS FILLED:	5.8
STABILITY @ OPTIMUM:	660
UNIT WEIGHT @ OPTIMUM:	145.1
VOIDS TOTAL MIX @ OPTIMUM:	3
VOIDS FILLED @ OPTIMUM	83
FLOW @ OPTIMUM:	9

CALIBRATION POINTS FOR NUCLEAR CONTENT GAUGE

REMARKS:

APPROVED % AC BY WEIGHT OF TOTAL MIX: 6.0 +or- 0.4

APPROVED: Paul W Misterek
PAUL W. MISTEREK, RME

GEIST EXTENSION EXPERIEMENTAL ASPHALT SECTIONS

Mix 362° F
Compact 320° F

2nd (Sealand Pit)

408(1) TYPE A SURFACING
STA. "01" 0+60 to 10+60 Rt.
STA. "01" 10+60 TO "L1" 17+90 Rt.

ASPHALT-RUBBER CONCRETE PAVEMENT 2" 411(1)
3/8" SAM AND ASPHALT-RUBBER CONCRETE PAVEMENT 1-5/8" 408(1)

MIX COMPOSITION:

AGGREGATES (Type II)	Sec. 703-2.15: 70% Fracture
ASPHALT-RUBBER BLEND: GROUND RUBBER (BUFFINGS) & AC-2.5 MODIFIED WITH EXTENDER OIL — Atlos 1515	Sec. 703-1.26 AC-2.5 (standard specs) with Asphalt Modifier (Extender Oil) Spec. 408-2.04

7-8% by wt of total Mix

6, 6.5, 7, 7.5, 8

Mix 362° F
Compact 320° F

4th (Shannon Pit)

408(2) TYPE D SURFACING
STA. "02" 103+00 TO 107+11.25 Rt.
Rt.

RUBBERIZED ASPHALT-RUBBER CONCRETE PAVEMENT 2"

MIX COMPOSITION:

AGGREGATES (Type II)	Sec. 703-2.13 QUALITY -- Coarse Aggregate inc. standard specs. AASHTO M62-74 and AASHTO 79-64 QUALITY -- Fine Aggregate ASTM D1073(AASHTO M29)
ASPHALT-RUBBER BLEND: GROUND RUBBER (BUFFINGS) & AC-2.5 MODIFIED WITH EXTENDER OIL	Sec. 703-1.26 AC-2.5 (standard specs) with Asphalt Modifier (Extender Oil) Spec. 408-2.04
AGGREGATE-SIZE RUBBER (TIRES)	Granulated aggregate rubber Sec. 703-2.14

2.5% Rubber Nibs by wt of total Mix

6, 6.5, 7, 7.5, 8

Mix 362° F
Compact 320° F

5th (Shannon Pit)

409(1) TYPE E SURFACING
"L" 44+00 TO 49+00 (BRIDGE)

RUBBERIZED ASPHALT CONCRETE PAVEMENT 1"

MIX COMPOSITION:

AGGREGATE	Sec. 703-2.13 (TYPE II)
AC-2.5	Sec. 702
GRANULATED AGGREGATE RUBBER (TIRES)	Sec. 703-2.14

2.5% Rubber NibS ~~6~~ 6.5, 7, 7.5, 8, 8.5

Same as Plus Ride on Airport Rd.

APPENDIX E

ASPHALT-RUBBER BINDER PROPERTIES

FOR

DANBY ROAD SITES

(FAIRBANKS)

CRAFCO INC.
6975 W. CRAFCO WAY • CHANDLER, AZ 85226 • 602/276-0406
WATTS 1 (800) 528-8242 • FAX (602) 961-0513

July 12, 1988

Asphalt Rubber ATLOS 408

RECEIVED JUL 1 8 1988

Mr. Bill Randall
EAGLE CREST CONSTRUCTION
P.O. Box 3039
Arlington, WA 98223

RE: Alaska Asphalt Rubber Project; Project No. RS-RRS-M-0005(52)/60494
Geist Road Extension, Peger Road to College Road Connc.

Dear Mr. Randall,

We have examined the specifications for the referenced project and performed testing to verify mix results for project specification conformance.

Materials Tested

Asphalt Cement - AC-2.5 from MAPCO Asphalt Petroleum, Inc., North Pole Alaska.

Coherex Base - extender oil from Witco.

Califlux GP - extender oil from Witco.

Atlos Rubber Blend - vulcanized, reclaimed tire rubber.

Tonson C112 - high natural rubber material.

Aggregate Chips - from Earthmover's Sealand Pit in Fairbanks, Alaska.

Asphalt Rubber Mixture Design

Project specifications contain requirements for the ground, reclaimed rubber (section 703-2.16), Asphalt Cement (section 411-2.01), and properties of the asphalt-rubber blend (section 411-2.02). Lab testing was performed to identify a materials formulation to meet these requirements.

Constituents of the formula which needed to be identified are:

Asphalt Percentage
Rubber Percentage
Extender Oil Percentage
Rubber Blend Constituents

GENERAL OFFICES: CHANDLER TECHNOLOGY CENTER, 7402 W. DETROIT STREET, SUITE 180
CHANDLER, AZ 85226

CRAFCO INC.

The first testing performed consisted of determining properties of the AC-2.5 asphalt sample submitted. Properties are as follows:

Penetration, 77°F	273
Softening Point, °F	96°F
Minimum Flexibility Temp.	24°F

Then, to determine the influence of the Coherex Base extender oil, 2, 4, and 6% oil were added to the asphalt and the minimum flexibility temperature determined. Results are as follows:

% Coherex Base	Minimum Flexibility Temperature
0	24°F
2	22°F
4	16°F
6	14°F

Rubber materials which were used included Tonson C112 and a blend of Atlos vulcanized tire rubber. The gradation of the rubbers are as follows:

Sieve Size	Tonson C112	Atlos Vulcanized	Specification Limits
No. 8	100.0	100.0	100%
No. 10	100.0	100.0	100%
No. 16	99.8	99.0	85-100
No. 30	57.3	53.5	40-80
No. 50	21.5	16.9	10-45
No. 100	8.2	5.9	0-10
No. 200	2.4	0.0	0-5

As can be seen from the above gradations, each rubber meets the specification limits and therefore, any blend of the two will meet specification limits.

The first asphalt rubber mixture tried contained 4% Coherex Base, 14% Atlos vulcanized rubber, 4% C112 and 78% asphalt. Reaction results are shown on Report EC-88-02. This data indicates acceptable viscosity and softening point results, however, the low temperature fracture results fail to meet the 10°F maximum requirement. Therefore, several different mixtures were made with varying amounts of Coherex Base, the rubber blend, and Califlux GP oil to attempt to formulate a mixture which meets all specification requirements. Test results for these mixtures are contained on reports EC-88-3, 4, 5, 6, and 7. Formulations for the mixtures are as follows:

CRAFCO INC

	FORMULATION PERCENTAGES				
	CB-2	CA-1	CA-2	CA-3	CA-4
AC-2.5 asphalt	75	78	78	78	78
Coherex Base	6	--	--	--	--
Califlux GP	--	4	4	4	4
Atlos vulcanized	14	14	16	12	15
Tonson C112	5	4	2	6	3

Findings based on these mixtures are as follows:

1. Mixture CB-2 with increased Coherex Base and 1% more C112 rubber th CB-1, met low temperature properties but had a higher viscosity.

2. Mixture CA-1 also had a somewhat high viscosity at 90 minutes reaction.

3. Use of a lower amount of C112 (mixture CA-2) resulted in low viscosities but also lower softening point (108°F at 90 minutes).

4. Use of a higher amount of C112 (mixture CA-3) resulted in high viscosities and softening point.

Therefore it was decided that the most appropriate mixture to use meeting specification requirements would be mixture CA-4. Results shown on report EC-88-07.

This mixture when reacted at 400 +/- 10°F provides material meeting specification requirements after 120 minutes of reaction.

The softening point exceeds the specification by 18°F, and the mater does not fracture until 6°F which exceeds the specification limits 10°F maximum. Additionally, the material meets specificat requirements after a 24 hour holdover period.

Atlos rubber is therefore manufacturing a blend of vulcanized rubber Tonson C112 at the proportions used in mixture CA-4 for supply to t project. The rubber designation is Atlos 1515 rubber. The rubber w be certified to specification requirements by Atlos.

If holdover loads are experienced, I would suggest adding additio rubber to increase viscosity to the 1200 cp range at 400°F.

Testing indicated that Califlux GP oil at 4% was required for appropri low temperature properties. To achieve the same low temperat properties, 6% Coherex Base would be required as an alternate.

Aggregate Testing

Aggregate gradation results are shown in report EC-88-01. The sample project specification requirements.

CRAFCO INC.

We then performed an adhesion evaluation with the chips and the asphalt-rubber material to be used for the project. Results are shown on report EC-88-08. Results indicate excellent aggregate retention both initially and after water immersion.

If there are any questions, please contact me.

Sincerely,

James G. Chehovits

Jim G. Chehovits
Chief Engineer, Sealants

JGC/lm

Enclosures

cc: Bob Winters, Atlos Rubber
    Carl Jacobson

CRAFCO INC.

Lab Report No. EC-88-01

Work Order No.

Report Date July 12, 1988

Material: Aggregate Chips

Identification: For asphalt rubber project, Fairbanks, Alaska

Source: Earthmovers Sealand Pit, Fairbanks, Alaska

Sampled By: Jim Mack/MAPPA Date 6/2/88 Tested By: Paul Petroff

Requested By: Bill Randall Date 6/1/88 Reviewed By: [signature]

Test Procedure: Gradation and Moisture Content

RESULTS

Sieve Size	% Passing	Project Specifications
1/2"	100.0	100
3/8"	94.8	85-100
No. 4	29.9	10-30
No. 8	3.2	0-10
No, 16	2.0	0-5
No. 200	1.1	0-2

As received moisture content = 0.02%

CRAFCO INC.

Lab Report No. EC-88-02

Work Order No.

Report Date July 12, 1988

Material Asphalt Rubber Mixture (CB-1)

Identification Alaska AC-2.5 (78.0%), Coherex Base (4%), Atlos (14%), Tonson (4%)

Source Various

Sampled By Date Tested By Paul Petroff

Requested By Date Reviewed By [signature]

Test Procedure Asphalt Rubber Reaction

RESULTS

	Reaction Period, Minutes				
	30	60	90	120	180
Temperature, F	412	400	406	406	412
Brookfield Viscosity, No. 3 at 20 RPM	---	1200 cp	---	1200 cp	1000 cp
Cone Penetration, 77°F	---	165	---	170	210
Resilience, 77°F	---	-5	---	-8	-20
Softening Point, F	118	116	116	118	116
Fracture Temperature 2 seconds, 90°, 1" dia.					
Lowest Passing	---	14	---	14	---
Fracture	---	12	---	12	---

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INTERIOR REGION
DOT/PF

CRAFCO INC.

Lab Report No. EC-88-03

Work Order No.

Report Date July 12, 1988

Material Asphalt Rubber (CA-1)

Identification Alaska AC-2.5 (78%), Califlux GP (4%), Atlos Blend (14%), Tonson C112 (4

Source Lab various

Sampled By ______ Date ______ Tested By Paul Petroff

Requested By ______ Date ______ Reviewed By [signature]

Test Procedure Asphalt Rubber Reaction

RESULTS

	Reaction Period, Minutes		
	30	60	90
Temperature, F	380	394	406
Brookfield Viscosity, No. 3 at 20 RPM, cp	2800	3000	1400
Cone Penetration, 77°F (ASTM D1191)	----	----	156
Resilience, 77°F, % (ASTM D3407)	----	----	-3%
Softening Point (ASTM D36)	----	----	118F
Flex Temperature 90°, 2 seconds, 1" dia.			
Passing Temp., °F	----	----	8
Fail Temp., °F	----	----	6

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MATERIALS ENGINEER
INTERIOR REGION
DOT/PF

CRAFCO INC.

Lab Report No. EC-88-04

Work Order No.

Report Date July 12, 1988

Material Asphalt Rubber (CB-2)

Identification Alaska AC-2.5 (75%), Coherex Base (6%), Atlos Blend (14%), Tonson C112 (5%)

Source

Sampled By Date Tested By Paul Petroff

Requested By Date Reviewed By [signature]

Test Procedure Asphalt Rubber Reaction

RESULTS

	Reaction Period, Minutes		
	30	60	90
Temperature, F	380	390	408
Brookfield, Viscosity No. 3 at 20 RPM, cp	4800	5100	1800
Cone Penetration, 77°F (ASTM D1191)	----	----	171
Resilience, 77°F (ASTM D3407)	----	----	-5
Softening Point (ASTM D36)	----	----	112
Flex Temperature, 90°, 2 seconds, 1" dia.			
Passing Temp., °F	----	----	8
Fail Temp., °F	----	----	6

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INTERIOR REGION
DOT/PF

CRAFCO INC.

Lab Report No. EC-88-05

Work Order No.

Report Date July 12, 1988

Material Asphalt Rubber (CA-2)

Identification Alaska AC-2.5 (78%), Califlux GP (4%), Atlos Blend (16%), Tonson C112 (2

Source

Sampled By Date Tested By Paul Petroff

Requested By Date Reviewed By [signature]

Test Procedure Asphalt Rubber Reaction

RESULTS

	Reaction Period, Minutes		
	30	60	90
Temperature, °F	402	398	410
Brookfield Viscosity No. 2, at 20 RPM, cp	1600	1680	960
Cone Penetration, 77°F (ASTM D1191)	----	----	191
Resilience, 77°F (ASTM D3407)	----	----	-26%
Softening Point (ASTM D36)	----	----	108
Flex Temperature, 90°, 2 seconds, 1" dia.			
Passing Temp., °F	----	----	8
Fail Temp., °F	----	----	6

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MATERIALS ENGINEER
INTERIOR REGION
DOT/PF

CRAFCO INC.

Lab Report No. EC-88-06

Work Order No.

Report Date July 12, 1988

Material Asphalt Rubber (CA-3)

Identification Alaska AC-2.5 (78%), Califlux GP (4%), Atlos Blend (12%), Tonson C112 (6%)

Source

Sampled By Date Tested By Paul Petroff

Requested By Date Reviewed By [signature]

Test Procedure Asphalt Rubber Reaction

RESULTS

	Reaction Period, Minutes		
	30	60	90
Temperature, °F	398	402	410
Brookfield Viscosity, No. 2 at 20 RPM, cp	1760	2240	2640
Cone Penetration, 77°F (ASTM D1191)	----	----	156
Resilience, 77°F (ASTM D3407)	----	----	-3
Softening Point (ASTM D36)	----	----	122
Flex Temperature, 90°, 2 seconds, 1" dia.			
Passing Temp., °F	----	----	8
Fail Temp., °F	----	----	6

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DOT/PF

CRAFCO INC.

Lab Report No. EC-88-07

Work Order No.

Report Date July 12, 1988

Material Asphalt Rubber (CA-4)

Identification Alaska AC 2.5 (78%), Califlux GP (4%), Atlos Blend (15%), Tonson C112 (

Source Various

Sampled By Date Tested By Paul Petroff

Requested By Date Reviewed By [signature]

Test Procedure Asphalt Rubber Reaction

RESULTS

	Reaction Period, Minutes								
	30	60	90	120	180	240	300	360*	24 h
Temperature, °F	392	396	400	410	410	410	410	410	410
Brookfield Viscosity, No. 2 at 20 RPM, cp	2080	2200	1600	1200	1120	1200	1040	920	800
Cone Penetration, 77°F (ASTM D1191)	----	145	----	164	----	----	----	202	20[illegible]
Resilience, 77°F, % (ASTM D3407)	----	-2	----	-7	----	----	----	-30	-30
Softening Point (ASTM D36)	120	120	118	118	110	110	108	102	102
Flex Temperature, 90°, 2 seconds, 1" dia.									
Passing Temp., °F	----	8	----	8	----	----	----	8	8
Fail Temp., °F	----	6	----	6	----	----	----	6	6

NOTE: * Holdover temperature is 300°F.

CRAFCO INC.

Lab Report No. EC-88-08

Work Order No.

Report Date July 12, 1988

Material Aggregate Chips

Identification

Source Earthmovers Sealand Pit, Fairbanks, Alaska

Sampled By Jim Mack/MAPPA Date 6/2/88 Tested By Paul Petroff

Requested By Bill Randall Date 6/1/88 Reviewed By [signature]

Test Procedure Aggregate Chip Retention

RESULTS

Single Layer Capacity (PSY)	Initial Retention (PSY)	Soaked Retention (PSY)	Initial Retention Ratio	Soaked Retention Ratio
16.6	16.75	16.5	101%	98.2%

NOTE: Asphalt Rubber binder is:

AC-2.5 asphalt	78%
Califlux GP oil	4%
Atlos vulcanized	15%
Tonson C112	3%

Binder application rate is 0.55 gsy.

CRAFCO INC.
6975 W. CRAFCO WAY • CHANDLER, AZ 85226 • 602/276-0406
WATTS 1 (800) 528-8242 • FAX (602) 961-0513

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July 13, 1988

RECEIVED

Mr. Mickey Randall
EAGLE CREST CONSTRUCTION
P.O. Box 3039
Arlington, WA 98223

RE: Mixture Formulation for Project No. RS-RRS-M-0005(52)/60494 Geist Road Extension, Peger Road to College Road Connc.

Dear Mr. Randall,

The mixture formulation for the referenced project is:

Asphalt Cement	MAPCO Asphalt Petroleum, Inc. AC-2.5	78%
Ground Rubber	Atlos 1515	18%
Asphalt Modifier	Califlux GP	4%

The attached lab report contains test results for this mixture.

Results on the attached report indicate that the asphalt rubber blend meets test requirements contained in section 411-2.02 of the project specifications.

If there are any questions, please contact me.

Sincerely,

James G. Chehovits

Jim G. Chehovits
Chief Engineer, Sealants

JGC/lm

Enclosure

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INTERIOR REGION
DOT/PF

GENERAL OFFICES: CHANDLER TECHNOLOGY CENTER, 7402 W. DETROIT STREET, SUITE 180
CHANDLER, AZ 85226

CRAFCO INC.

Lab Report No. EC-88-09

Work Order No.

Report Date July 13, 1988

Material Asphalt Rubber - Geist Rd. Estension, Fairbanks, Alaska

Identification AC-2.5 (MAPCO), 78%, Califlux GP 4%, Atlos 1515, 18%

Source Laboratory, Mixture

Sampled By Date Tested By Paul Petroff

Requested By Bill Randall Date 6/1/88 Reviewed By [signature]

Test Procedure Asphalt Rubber Testing

RESULTS

Property	Job Mix* Result	Project Specification Limits
Viscosity at 400°F, Brookfield, No. 2 at 20 RPM	1200 cps	1200 cps max.
Softening Point, °F (ASTM D36)	118°F	100°F min.
Flex Temperature (90° Bend Test)	8°F	10°F max.

NOTE: * Results are for material reacted for 120 minutes at 400° +/- 10°F.

APPENDIX F

CONDITION SURVEY DATA

(ANCHORAGE)

PAVEMENT CONDITION SURVEY

Road/Street Name	Minnesota Drive , Anchorage , AK
Date of Survey	June 16 , 1994
Direction	Southbound
Location	600 ft. past RR overpass
Sample Mark	M-4
Type of Surfacing	Rubberized asphalt concrete
Date of Mix Design	1986

Mix Design

Binder : Chevron-AC5 , 1/4% antistrip , 2.5% rubber by total mix
Opt. ac , % : 7.5 by total mix
Voids , % : 1.1
Flow : 29
Stability , lbs. : 870
Density , pcf : 145.9

Material Gradation of Mix

Aggregate			Rubber		
Sieve	%Passing	Specf.	Sieve	%Passing	Specf.
3/4 "	100	100	1/4 "	No	100
3/8 "	56	50-62	#4	Info.	76-100
1/4 "	38	30-44	#10	is	28-42
#10	26	20-30	#20	Available	16-24
#30	17	12-23			
#200	9	7-11			

Condition Survey

500 ft. of pavement surveyed ; 3 lanes ; at the exit of a gravel company

Pavement : 2 in. rubberized asphalt concrete (overlay)
2 in. conventional hot mix asphalt
3 in. asphalt treated base
6 in. subbase, Grading "B"
36 in. borrow, Type "A"

Transverse Cracking : Extends over the 3 lanes at the sampling spot; no cracking observed before and after sampling spot by 250 ft.

Rutting :

Right lane :	
Average left wheel path rut depth , in :	0.189
Average right wheel path rut depth , in:	0.368
Middle lane :	
Average left wheel path rut depth , in :	0.683
Average right wheel path rut depth , in:	0.599
Left lane :	
Average left wheel path rut depth , in :	0.285
Average right wheel path rut depth , in:	0.637

Flushing : Localized flushed binder spots

PAVEMENT CONDITION SURVEY

Road/Street Name	Minnesota Drive , Anchorage, AK
Date of Survey	June 16 , 1994
Direction	Southbound
Location	600 ft. before Lang drive
Sample Mark	M-III
Type of Surfacing	Conventional hot mix asphalt
Date of Mix Design	1986

Mix Design

Binder :	Chevron-AC5 , 0.25% antistrip
Opt. ac , % :	6.3 by weight of mix
Voids , % :	2.7
Flow :	11
Stability , lbs. :	1700
Density , pcf :	150.9

Material Gradation of Mix

Aggregate		
Sieve	%Passing	Specf.
3/4 "	100	100
1/2 "	92	86-99
3/8 "	82	75-89
#4	61	55-68
#10	47	41-53
#40	26	22-30
#80	14	10-18
#200	6	4-9

Condition Survey

400 ft. of pavement surveyed ; 2 lanes

Pavement :
- 2 in. conventional hot mix asphalt (overlay)
- 2 in. conventional hot mix asphalt
- 3 in. asphalt treated base
- 6 in. subbase, Grading "B"
- 36 in. borrow, Type "A"

Longitudinal Cracking : Construction joint at the separation of the 2 lanes

Transverse Cracking : None

Rutting : Right lane :

Average left wheel path rut depth , in : 0.348

Average right wheel path rut depth , in: 0.314

Polishing : Slight

PAVEMENT CONDITION SURVEY

Road/Street Name	Minnesota Drive , Anchorage , AK
Date of Survey	June 16, 1994
Direction	Southbound
Location	300 ft. south of Diamond Blvd.
Sample Mark	M-1
Type of Surfacing	Rubberized asphalt concrete
Date of Mix Design	1986

Mix Design

Binder : Chevron-AC5 , 1/4% antistrip , 2.5% rubber by total mix
Opt. ac , % : 7.5 by total mix
Voids , % : 1.1
Flow : 29
Stability , lbs. : 870
Density , pcf : 145.9

Material Gradation of Mix

Aggregate			Rubber		
Sieve	%Passing	Spect.	Sieve	%Passing	Specf.
3/4 "	100	100	1/4 "	No	100
3/8 "	56	50-62	#4	Info.	76-100
1/4 "	38	30-44	#10	is	28-42
#10	26	20-30	#20	Available	16-24
#30	17	12-23			
#200	9	7-11			

Condition Survey

400 ft. of pavement surveyed centered at the sampling spot (ie ~ 200 ft. before sampling spot and ~ 200 ft. after it) ; 2 lanes

Pavement : 2 in. rubberized asphalt concrete (overlay)
2 in. conventional hot mix asphalt
3 in. asphalt treated base

Longitudinal Cracking : Construction joint in the middle of the 2 lanes

Transverse Cracking : None

Rutting : Right lane :
Average left wheel path rut depth , in : 0.264
Average right wheel path rut depth , in: 0.085

Polishing : Coarse texture

PAVEMENT CONDITION SURVEY

Road/Street Name	Minnesota Drive , Anchorage , AK
Date of Survey	June 16 , 1994
Direction	Southbound
Location	1300 ft. before C Street
Sample Mark	M-II
Type of Surfacing	Conventional hot mix asphalt
Date of Mix design	1986

Mix Design

Binder : Chevron-AC5 , 0.25% antistrip
Opt. ac , % : 6.3 by weight of mix
Voids , % : 2.7
Flow : 11
Stability , lbs. : 1700
Density , pcf : 150.9

Material Gradation of Mix

	Aggregate	
Sieve	%Passing	Specf.
3/4 "	100	100
1/2 "	92	86-99
3/8 "	82	75-89
#4	61	55-68
#10	47	41-53
#40	26	22-30
#80	14	10-18
#200	6	4-9

Condition Survey

400 ft. of pavement surveyed ; 2 lanes
Pavement : 2 in. conventional hot mix asphalt (overlay)
2 in. conventional hot mix asphalt
3 in. asphalt treated base
6 in. subbase, Grading "B"
36 in. borrow, Type "A"

Longitudinal Cracking : None

Transverse Cracking : None

Rutting : Right lane :
Average left wheel path rut depth , in : 0.492
Average right wheel path rut depth , in: 0.631

Polishing : Slight

PAVEMENT CONDITION SURVEY

Road/Street Name	N. Seward Hwy. , Anchorage , AK
Date of Survey	June 16 , 1994
Direction	Northbound
Location	1000 ft. past 36th Street
Sample Mark	S-II & S-II-2
Type of Surfacing	Conventional hot mix asphalt
Date of Mix Design	1987

Mix Design

Binder : Chevron-AC10 , 1/4 % antistrip
Opt. ac , % : 5.8 by total mix
Voids , % : 2.4
Flow : 13
Stability , lbs. : 2660
Density , pcf : 151.8

Material Gradation of Mix

Aggregate		
Sieve	%Passing	Specf.
1/2 "	100	100
3/8 "	86	79-93
#4	62	55-69
#10	46	40-52
#40	22	18-26
#200	6	3-9

Condition Survey

400 ft. of pavement surveyed ; 3 lanes
Pavement : 1.5 in. conventional hot mix asphalt , Type II , (overlay)
3 in. conventional hot mix asphalt
6 in. crushed aggregate base , Grading "D-1"
6 in. subbase , Grading "B"
selected material (variable depth)

Longitudinal Cracking : In the middle of right lane and at the separation of lanes

Transverse Cracking : Extends over the 3 lanes ; average spacing = 15 ft. ; 1/4 in. cracks

Rutting :

Right lane :
Average left wheel path rut depth , in : 0.27
Average right wheel path rut depth , in: 0.139

PAVEMENT CONDITION SURVEY

Road/Street Name	N. Seward Hwy. , Anchorage , AK
Date of Survey	June 16 , 1994
Direction	Northbound
Location	600 ft. past on-ramp from Tudor Road
Sample Mark	S-1
Type of Surfacing	Rubberized asphalt concrete
Date of Mix Design	1985

Mix Design

Binder : Chevron-AC5 , 0.25% antistrip , 2.5% rubber by total mix
Opt. ac , % : 7.7 by total mix
Voids , % : 1.8
Flow : 25
Stability , lbs. : 800
Density , pcf : 145.3

Material Gradation of Mix

Aggregate			Rubber		
Sieve	%Passing	Specf.	Sieve	%Passing	Specf.
3/4 "	100	100	1/4 "	100	100
3/8 "	56	50-62	#4	98	76-100
1/4 "	40	34-44	#10	30	28-42
#10	25	21-29	#20	16	16-24
#30	20	16-23			
#200	9	7-11			

Condition Survey

400 ft. of pavement surveyed ; 3 lanes ;
Pavement : 1.75 in. rubberized asphalt concrete (overlay)
2 in. conventional hot mix asphalt

Transverse Cracking : Extends over the 3 lanes ; average spacing = 75 ft.

Rutting :

Right lane :

Average left wheel path rut depth , in :	0.064
Average right wheel path rut depth , in:	0.19

Left lane :

Average left wheel path rut depth , in :	1.019
Average right wheel path rut depth , in:	0.638

PAVEMENT CONDITION SURVEY

Road/Street Name	A Street , Anchorage , AK
Date of Survey	June 16 , 1994
Direction	Northbound
Location	500 ft. past Northern Lights Blvd.
Sample Mark	A-1
Type of Surfacing	Conventional hot mix asphalt
Date of Mix Design	1986

Mix Design

Binder : Chevron-AC5 , 0.25% antistrip
Opt. ac , % : 6.4 by weight of dry aggregate
Voids , % : 2
Flow : 14
Stability , lbs. : 1800
Density , pcf : 152.6

Material Gradation of Mix

	Aggregate	
Sieve	%Passing	Specf.
3/4 "	100	100
3/8 "	78	72-85
#4	57	50-64
#10	43	37-49
#40	22	18-26
#200	6	3-9

Condition Survey

400 ft. of pavement surveyed ; 3 lanes
Pavement : 2 in. conventional hot mix asphalt
3 in. asphalt treated base
6 in. subbase , Grading "C"
36 in. borrow , Type "A"

Transverse Cracking : Extends over the 3 lanes ; average spacing = 100 ft. ; 1/2 in. cracks

Rutting :

Right lane :

Average left wheel path rut depth , in :	0.196
Average right wheel path rut depth , in:	0.113

PAVEMENT CONDITION SURVEY

Road/Street Name	A Street , Anchorage , AK
Date of Survey	June 16 , 1994
Direction	Northbound
Location	200 ft. south of Chester Creek
Sample Mark	A-2
Type of Surfacing	Rubberized asphalt concrete
Date of Mix Design	1985

Mix Design

Binder : Chevron-AC5 , 0.25% antistrip , 2.5% rubber by total mix
Opt. ac , % : 7.5 by weight of mix
Voids , % : 1.4
Flow : 25
Stability , lbs. : 870
Density , pcf : 145.9

Material Gradation of Mix

Aggregate			Rubber		
Sieve	%Passing	Specf.	Sieve	%Passing	Specf.
3/4 "	100	100	1/4"	No	100
3/8 "	56	50-62	#4	Info.	76-100
1/4 "	37	30-44	#10	is	28-42
#10	26	20-32	#20	Available	16-24
#30	19	12-23			
#200	8	7-11			

Condition Survey

400 ft. of pavement surveyed ; 3 lanes
Pavement : 2 in. rubberized asphalt concrete
3 in. asphalt treated base
6 in. subbase , Grading "C"
36 in. borrow Type "A" + borrow Type "B"

Transverse Cracking : Extends over the 3 lanes ; average spacing = 60 ft. ; 1/4 in. cracks

Rutting :

Right lane :
Average left wheel path rut depth , in : 0.398
Average right wheel path rut depth , in: 0.358

PAVEMENT CONDITION SURVEY

Road/Street Name	C Street , Anchorage , AK
Date of Survey	June 16 , 1994
Direction	Southbound
Location	1500 ft. south of 36 th. street
Sample Mark	C-2
Type of Surfacing	Conventional hot mix asphalt
Date of Mix Design	1986

Mix Design

Binder : Chevron-AC5 , 0.25% antistrip
Opt. ac , % : 6.4 by weight of dry aggregate
Voids , % : 2
Flow : 14
Stability , lbs. : 1800
Density , pcf : 152.6

Material Gradation of Mix

Aggregate		
Sieve	%Passing	Specf.
3/4 "	100	100
3/8 "	78	72-85
#4	57	50-64
#10	43	37-49
#40	22	18-26
#200	6	3-9

Condition Survey

400 ft. of pavement surveyed ; 4 lanes
Pavement : 2 in. conventional hot mix asphalt
3 in. asphalt treated base
6 in. subbase , Grading "C"
36 in. borrow Type "A"

Longitudinal Cracking : Construction joint in the wheel path of the right lane

Transverse Cracking : Extends over the 4 lanes ; average spacing = 150 ft. ; 1/2 in. cracks

Rutting : Right lane :
Average left wheel path rut depth , in : 0.44
Average right wheel path rut depth , in: 0.413

PAVEMENT CONDITION SURVEY

Road/Street Name	C Street , Anchorage , AK
Date of Survey	June 16 , 1994
Direction	Southbound
Location	500 ft. north of Fireweed Lane
Sample Mark	C-1
Type of Surfacing	Rubberized asphalt concrete
Date of Mix Design	1985

Mix Design

Binder : Chevron-AC5 , 1/4% antistrip , 2.5% rubber by total mix
Opt. ac , % : 7.5 by weight of mix
Voids , % : 1.4
Flow : 25
Stability , lbs. : 870
Density , pcf : 145.9

Material Gradation of Mix

Aggregate			Rubber		
Sieve	%Passing	Specf.	Sieve	%Passing	Specf.
3/4 "	100	100	1/4"	No	100
3/8 "	56	50-62	#4	Info.	76-100
1/4 "	37	30-44	#10	is	28-42
#10	26	20-32	#20	Available	16-24
#30	19	12-23			
#200	8	7-11			

Condition Survey

400 ft. of pavement surveyed ; 4 lanes

Pavement : 2 in. rubberized asphalt concrete
3 in. asphalt treated base
6 in. subbase , Grading "C"
36 in. borrow Type "A"

Transverse Cracking : Extends over the 4 lanes ; average spacing = 120 ft. ; 1/4 in. cracks

Rutting : Right lane :
Average left wheel path rut depth , in : 0.147
Average right wheel path rut depth , in: 0.07

APPENDIX G

CONDITION SURVEY DATA

(FAIRBANKS)

PAVEMENT CONDITION SURVEY

Road/Street Name	Danby Street , Fairbanks , AK
Date of Survey	Sept. 25 , 1994
Direction	Southbound
Location	Intersection of Wembley and Danby
Sample Mark	5, 6, 7 & 8
Type of Surfacing	Conventional hot mix asphalt
Date of Mix Design	1988

Mix Design

Binder : Mapco AC2.5
Opt. ac , % : 5.3
Voids , % : 2
Flow : 9
Stability , lbs. : 1950
Density , pcf : 151

Material Gradation of Mix

Aggregate		
Sieve	%Passing	Specf.
3/4"	100	100
3/8"	77	70-84
#4	51	45-58
#10	37	31-43
#40	25	21-28
#200	6	3-9

Condition Survey

300 ft. of pavement surveyed (the whole length of test section) ; 1 lane
Pavement : 2 in. conventional hot mix asphalt
6 in. crushed aggregate base
36 in. borrow containing less than 7% fines

Longitudinal Cracking : None

Transverse Cracking : Extends over the whole lane ; average spacing = 20 ft.

Rutting : None

PAVEMENT CONDITION SURVEY

Road/Street Name	Danby Street , Fairbanks , AK
Date of Survey	Sept. 25 , 1994
Direction	Northbound
Location	Intersection of Wembley and Danby
Sample Mark	1, 2, 3 & 4
Type of Surfacing	Asphalt-rubber concrete
Date of Mix Design	1988

Mix Design

Binder : Crafco Inc. , Atlos 1515 ; an asphalt rubber blend consisting of ground rubber (buffings) and AC2.5 modified with extender oil
Opt. ac , % : 6.4 by weight of total mix
Voids , % : 2.2
Flow : 8.8
Stability , lbs. : 1540
Density , pcf : 148.4

Material Gradation of Mix

Aggregate (Type II - Sealand Pit)			Rubber		
Sieve	%Passing	Specf.	Sieve	%Passing	Specf.
3/4"	100	100	#8	No	100
3/8"	77	71-83	#10	Info.	100
#4	51	45-57	#16	Available	85-100
#10	37	33-41	#30		40-80
#40	25	21-28	#50		10-45
#200	6	4-8	#100		0-10
			#200		0-5

Condition Survey

300 ft. of pavement surveyed (the whole length of test section) ; 1 lane
Pavement : 2 in. asphalt-rubber concrete
6 in. crushed aggregate base
36 in. borrow containing less than 7% fines

Longitudinal Cracking : None

Transverse Cracking : Extends over the whole lane ; spacing = 120 ft.
Extends also over the southbound conventional hot mix asphalt lane

Rutting : None

PAVEMENT CONDITION SURVEY

Road/Street Name	Danby Street , Fairbanks , AK
Date of Survey	Sept. 25 , 1994
Direction	Northbound
Location	Intersection of Danby and College Road
Sample Mark	9, 10, 11 & 12
Type of Surfacing	Rubberized asphalt-rubber concrete
Date of Mix Design	1988

Mix Design

Mix : Atlos 1515 , rubber nibs ; an asphalt rubber blend consisting of ground rubber (buffings) and AC2.5 modified with extender oil , plus granulated aggregate rubber (2.5% rubber nibs)

Opt. ac , % : 6.8 by weight of total mix
Voids , % : 3.7
Flow : 12.7
Stability , lbs. : 500
Density , pcf : 141.1

Material Gradation of Mix

Aggregate (Type II - Shannon Pit)			Rubber for asphalt-rubber		Rubber mixed with aggregate	
Sieve	%Passing	Specf.	Sieve	Specf.	Sieve	Specf.
3/4"	100	100	#8	100	1/4"	100
3/8"	76	70-82	#10	100	#4	82-100
#4	49	45-55	#16	85-100	#10	42-56
#10	33	30-37	#30	40-80	#20	33-41
#40	21	17-25	#50	10-45		
#200	4	3-6	#100	0-10		
			#200	0-5		

Condition Survey

300 ft. of pavement surveyed ; 1 lane

Pavement : 2 in. rubberized asphalt-rubber concrete
6 in. crushed aggregate base
36 in. borrow containing less than 7% fines

Longitudinal Cracking : None

Transverse Cracking : Only 2 cracks in this test section (20 ft. apart) ; they extend to the southbound conventional hot mix asphalt lane where the average crack spacing is 16 ft.

Rutting : None

PAVEMENT CONDITION SURVEY

Road/Street Name	University/Airport frontage road , Fairbanks , AK
Date of Survey	Sept. 25 , 1994
Direction	Eastbound
Location	Frontage road at the intersection of University Ave. and Airport way
Sample Mark	13 & 14
Type of Surfacing	Rubber modified asphalt concrete (PlusRide)
Date	1979

Mix Design

Binder : AC5 (7-8 % by dry weight of aggregate) , 3 - 3.5 % rubber
Opt. ac , % : 7.5
Voids , % : 3.0
Flow : -
Stability , lbs. : 320
Density , pcf : -

Material Gradation of Mix

Aggregate			Rubber		
Sieve	%Passing	Specf.	Sieve	%Passing	Specf.
3/4"	No	100	1/4"	No	-
3/8"	Info.	60-77	#4	Info.	100
#4	Available	45-59	#10	Available	15-35
#10		29-41	#20		-
#40		12-20	#40		0-6
#200		4-10	#200		0-2

Condition Survey

100 ft. of pavement surveyed
Pavement : 2.25 in. rubber modified asphalt concrete (overlay)
2 in. conventional hot mix asphalt

Longitudinal Cracking : At the separation of the PlusRide lane and the westbound conventional hot mix asphalt lane and at about 8 ft. from the edge of the pavement

Transverse Cracking : Extends across the whole lane ; average spacing = 24 ft.
Crack width : varies from < 1/4 in. to 1 in.

Rutting : None

Ravelling : Severe

PAVEMENT CONDITION SURVEY

Road/Street Name	University/Airport frontage road , Fairbanks , AK
Date of Survey	Oct. 2, 1994
Direction	Westbound
Location	Frontage road at the intersection of University Ave. and Airport way
Sample Mark	16 & 17
Type of Surfacing	Conventional hot mix asphalt
Date of Mix Design	Not available

Mix Design

Binder :
Opt. ac , % :
Voids , % :
Flow :
Stability , lbs. :
Density , pcf :

No mix information is available

Material Gradation of Mix

Aggregate		
Sieve	%Passing	Specf.

Condition Survey

100 ft. of pavement surveyed

Pavement : 2 in. conventional hot mix asphalt (overlay)
2 in. conventional hot mix asphalt

Longitudinal Cracking : At the separation of the conventional hot mix asphalt lane and the eastbound PlusRide lane and at about 8 ft. from the edge of the pavement

Transverse Cracking : Extends across the whole lane ; average spacing = 10 ft.
Crack width : varies from < 1/4 in. to 1 in.

Rutting : None

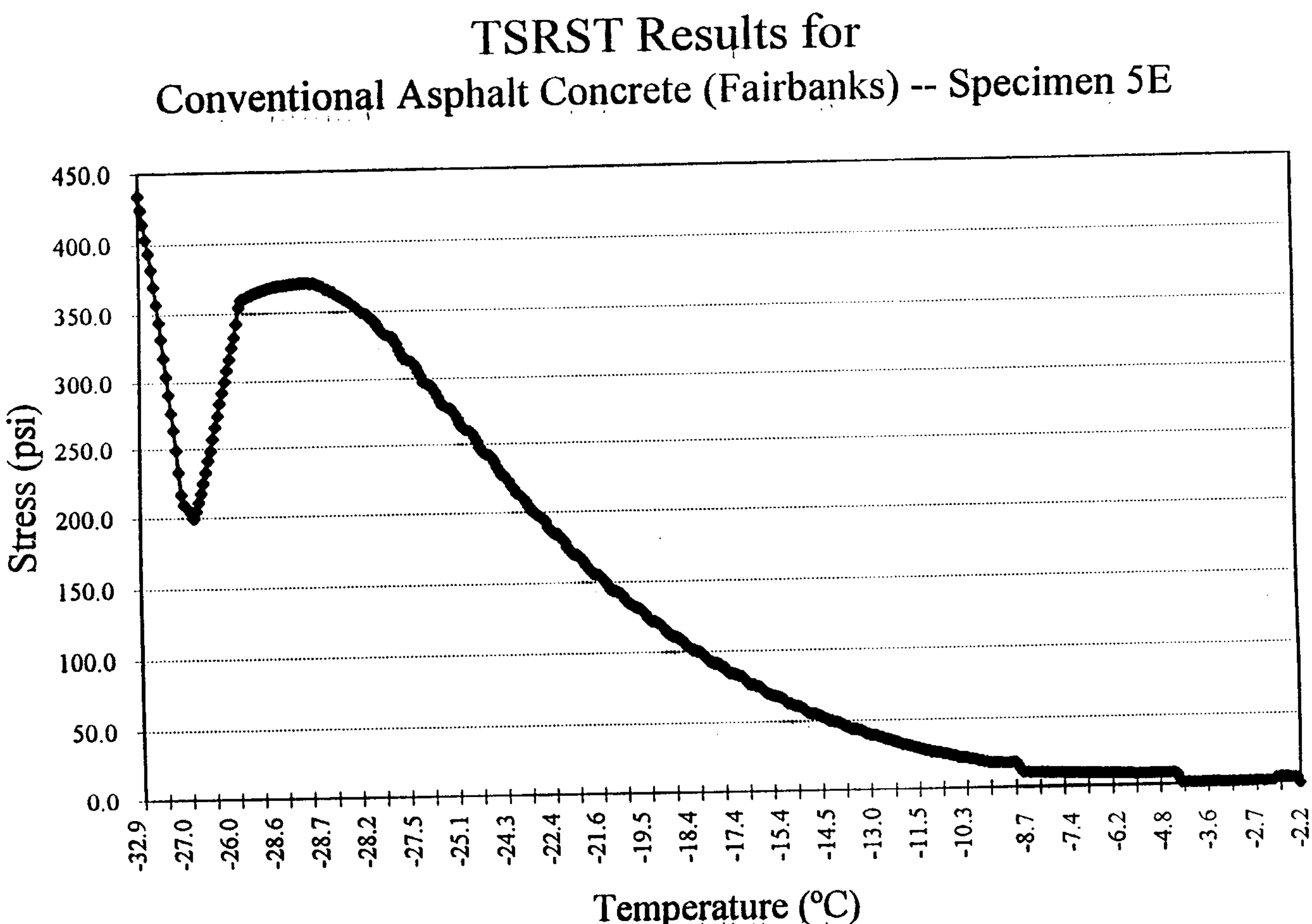
APPENDIX H

THERMAL STRESS RESTRAINED SPECIMEN TEST (TSRST)

DATA

TSRST Report --

Filename	5E
Test date	
Cross section area (sq. in.)	3.47
No. of observations	479
Cooling rate (deg C/hr)	-7.50
Regression coeff. for cooling rate	0.968
Fracture strength (psi)	435
Fracture temperature (deg C)	-32.8
First slope (psi/deg C)	-1.62
Regression coeff. for 1st slope	0.760
Second slope (psi/deg C)	-35.39
Regression coeff. for 2nd slope	0.875
Tangent transition temperature (deg C)	-19.3
Bisector transition temperature (deg C)	-23.4
Specimen shape	

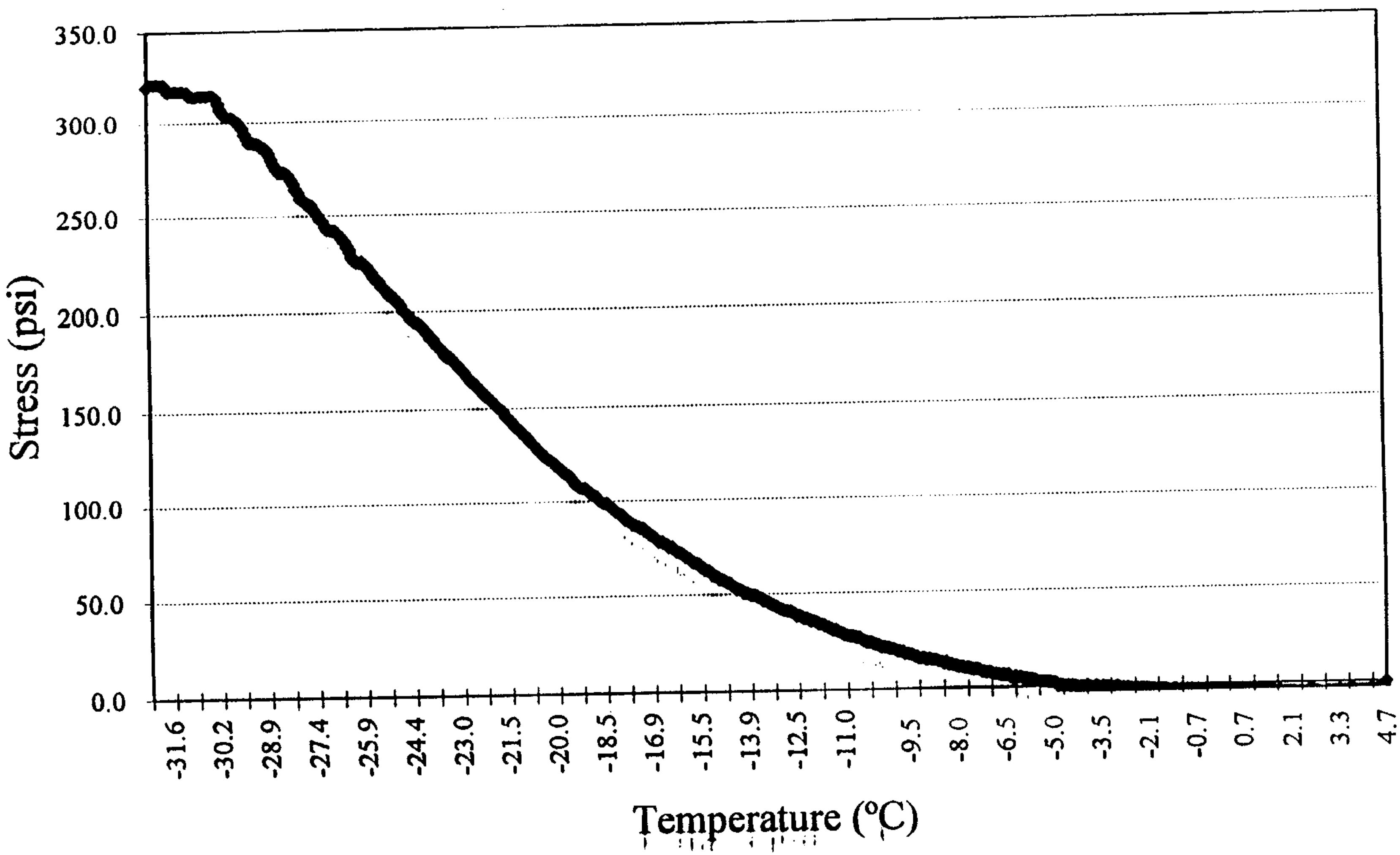

TSRST Results for
Conventional Asphalt Concrete (Fairbanks) -- Specimen 5E
Stress (psi)
450.0
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
-32.9
-27.0
-26.0
-28.6
-28.7
-28.2
-27.5
-25.1
-24.3
-22.4
-21.6
-19.5
-18.4
-17.4
-15.4
-14.5
-13.0
-11.5
-10.3
-8.7
-7.4
-6.2
-4.8
-3.6
-2.7
-2.2
Temperature (°C)

TSRST Report --

Filename	5F
Test date	
Cross section area (sq. in.)	3.53
No. of observations	517
Cooling rate (deg C/hr)	-9.01
Regression coeff. for cooling rate	1.000
Fracture strength (psi)	322
Fracture temperature (deg C)	-32.7
First slope (psi/deg C)	-0.45
Regression coeff. for 1st slope	0.613
Second slope (psi/deg C)	-18.73
Regression coeff. for 2nd slope	0.995
Tangent transition temperature (deg C)	-14.6
Bisector transition temperature (deg C)	-19.8
Specimen shape	

TSRST Results for

Conventional Asphalt Concrete (Fairbanks) -- Specimen 5F

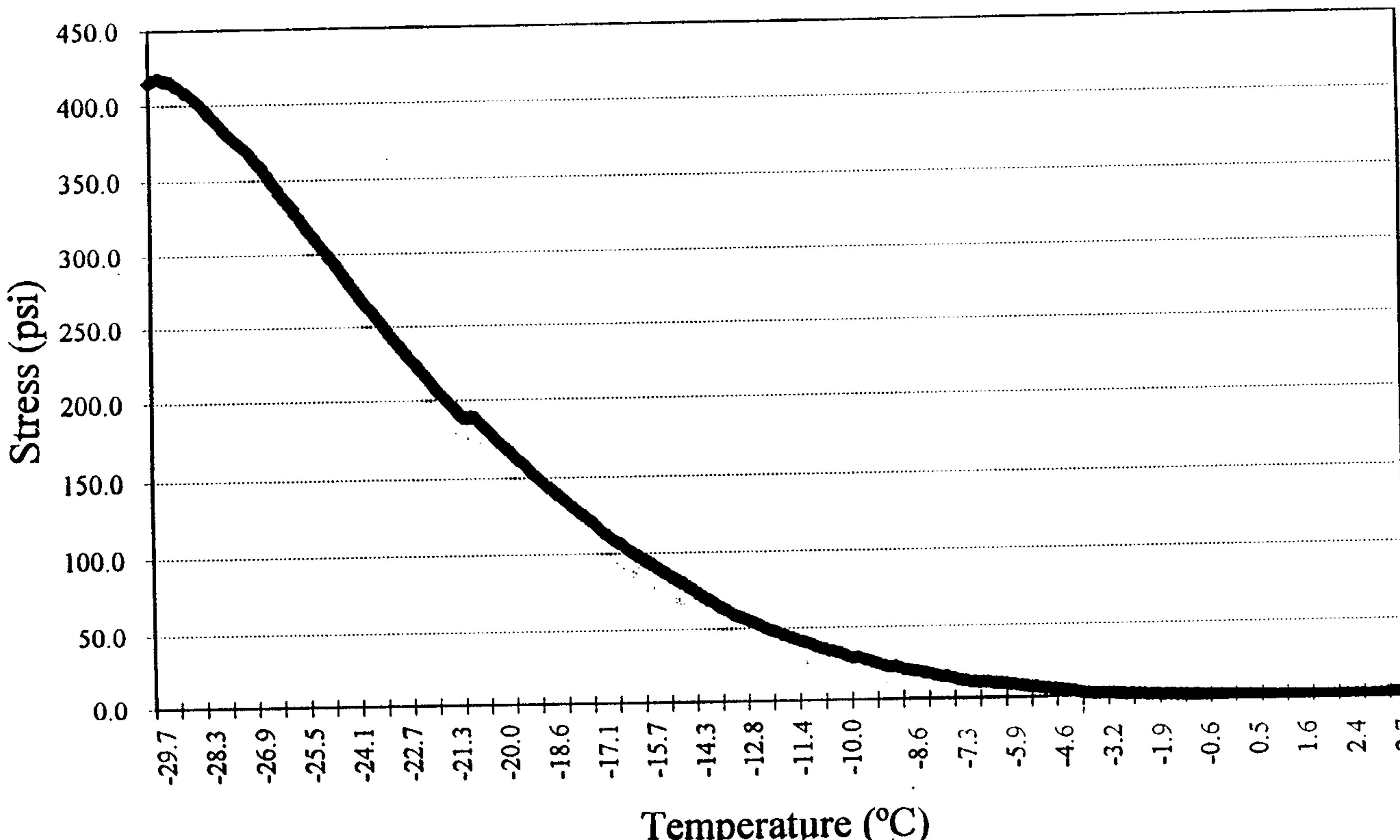


TSRST Report --

Filename	5G
Test date	
Cross section area (sq. in.)	3.5
No. of observations	487
Cooling rate (deg C/hr)	-8.73
Regression coeff. for cooling rate	0.999
Fracture strength (psi)	417
Fracture temperature (deg C)	-30.2
First slope (psi/deg C)	-0.45
Regression coeff. for 1st slope	0.718
Second slope (psi/deg C)	-29.50
Regression coeff. for 2nd slope	0.996
Tangent transition temperature (deg C)	-15.6
Bisector transition temperature (deg C)	-21.4
Specimen shape	

TSRST Results for

Conventional Asphalt Concrete (Fairbanks) -- Specimen 5G

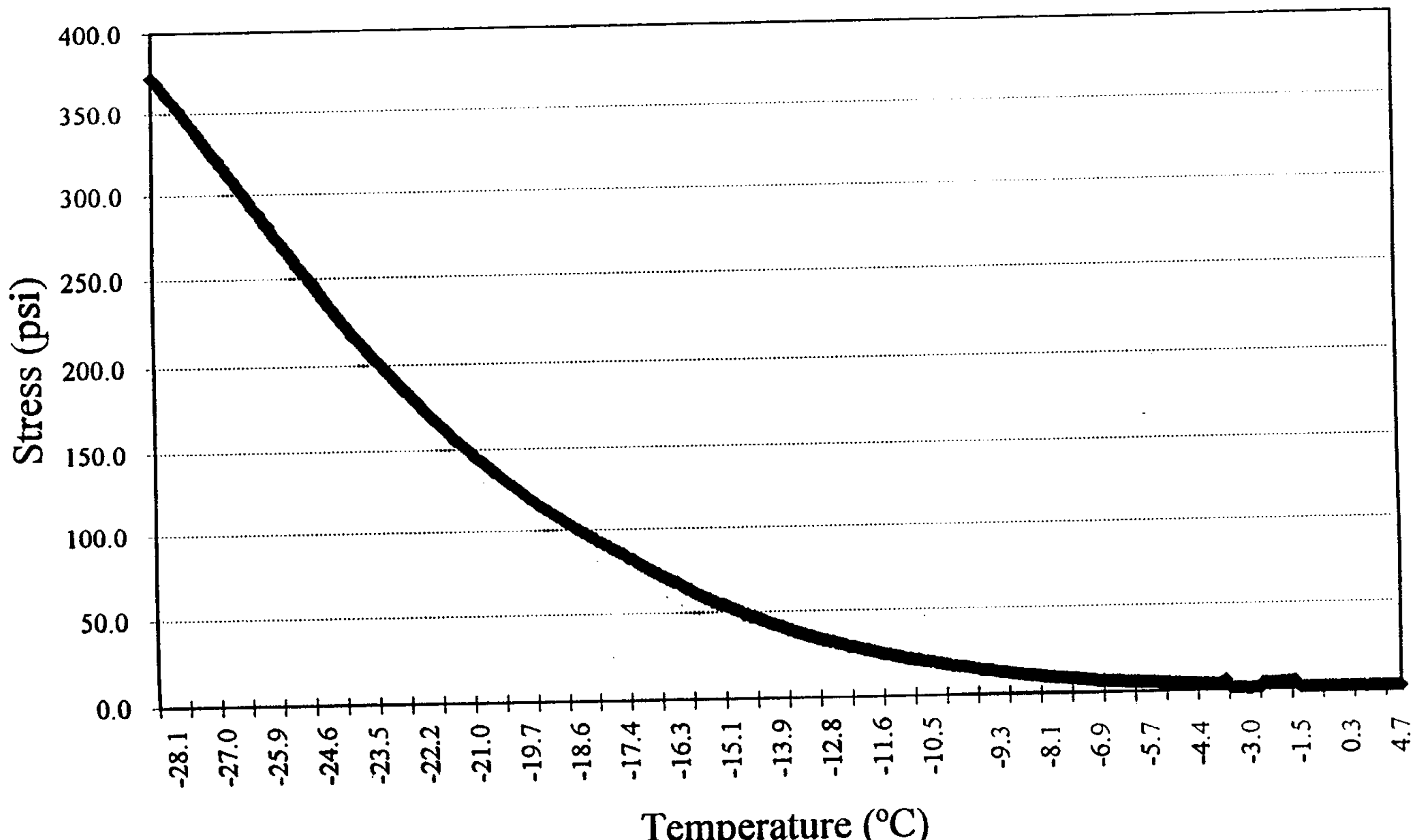


TSRST Report --

Filename	**5H**
Test date	
Cross section area (sq. in.)	3.45
No. of observations	396
Cooling rate (deg C/hr)	-9.11
Regression coeff. for cooling rate	0.996
Fracture strength (psi)	372
Fracture temperature (deg C)	-28.9
First slope (psi/deg C)	-0.66
Regression coeff. for 1st slope	0.726
Second slope (psi/deg C)	-26.59
Regression coeff. for 2nd slope	0.992
Tangent transition temperature (deg C)	-16.5
Bisector transition temperature (deg C)	-20.7
Specimen shape	

TSRST Results for

Conventional Asphalt Concrete (Fairbanks) -- Specimen 5H

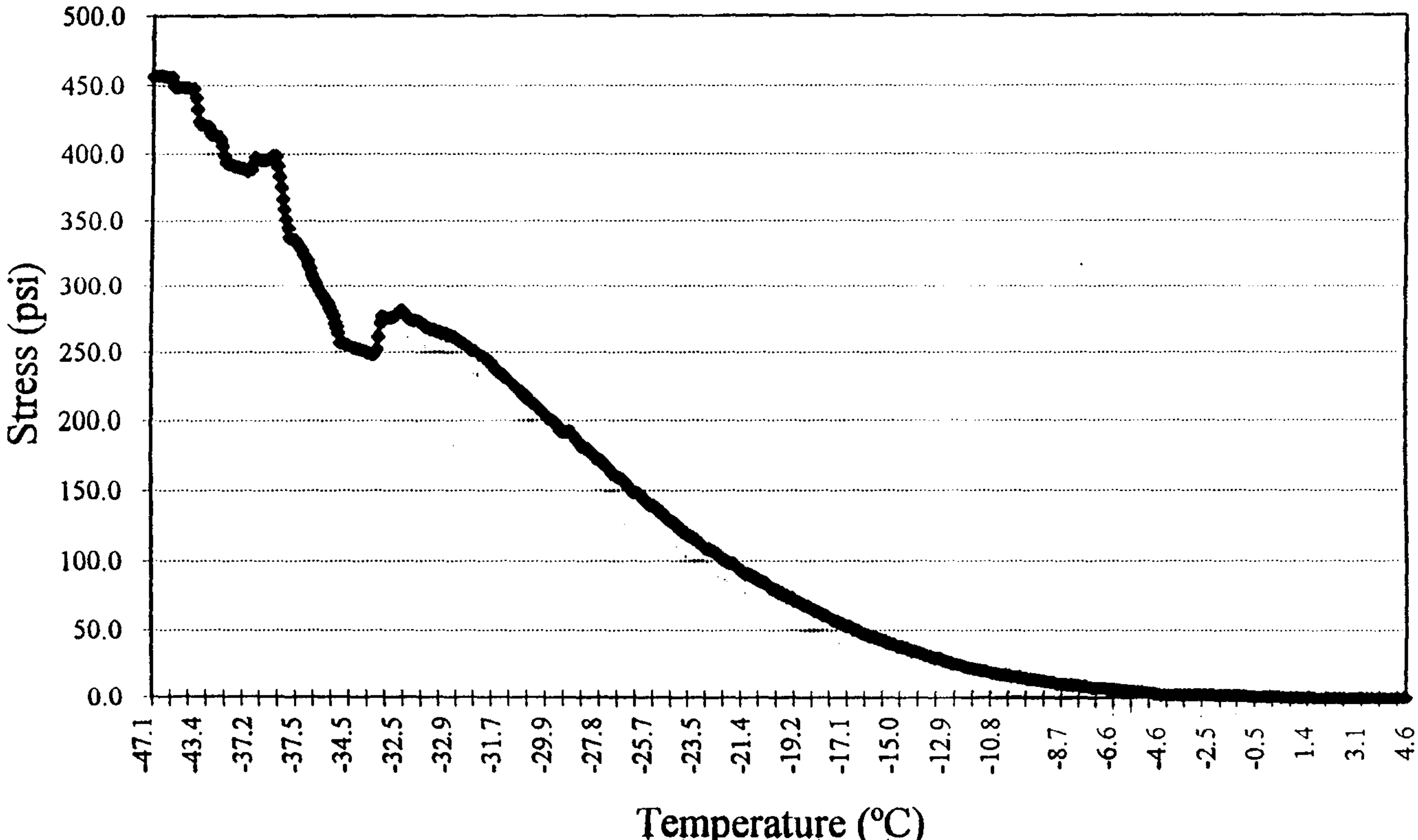


TSRST Report --

Filename	4G
Test date	
Cross section area (sq. in.)	3.41
No. of observations	706
Cooling rate (deg C/hr)	-8.61
Regression coeff. for cooling rate	0.993
Fracture strength (psi)	457
Fracture temperature (deg C)	-47.1
First slope (psi/deg C)	-0.42
Regression coeff. for 1st slope	0.845
Second slope (psi/deg C)	5.64
Regression coeff. for 2nd slope	0.458
Tangent transition temperature (deg C)	-74.3
Bisector transition temperature (deg C)	-32.6
Specimen shape	

TSRST Results for

ARC (Fairbanks) -- Specimen 4G

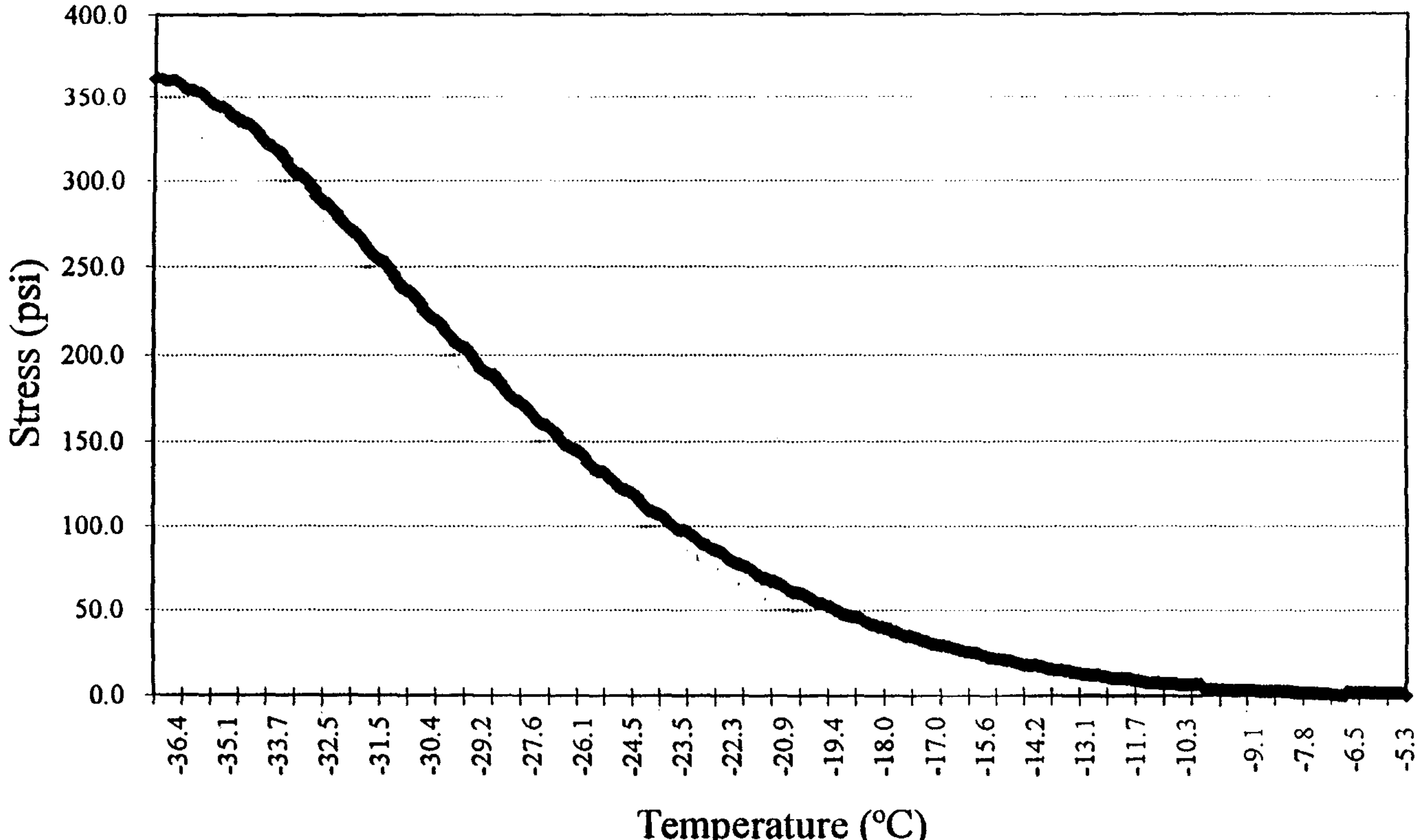


TSRST Report --

Filename	**4H**
Test date	
Cross section area (sq. in.)	3.56
No. of observations	448
Cooling rate (deg C/hr)	-9.01
Regression coeff. for cooling rate	0.999
Fracture strength (psi)	362
Fracture temperature (deg C)	-38.3
First slope (psi/deg C)	-1.29
Regression coeff. for 1st slope	0.851
Second slope (psi/deg C)	-21.90
Regression coeff. for 2nd slope	0.944
Tangent transition temperature (deg C)	-21.3
Bisector transition temperature (deg C)	-25.3
Specimen shape	

TSRST Results for

ARC (Fairbanks) -- Specimen 4H

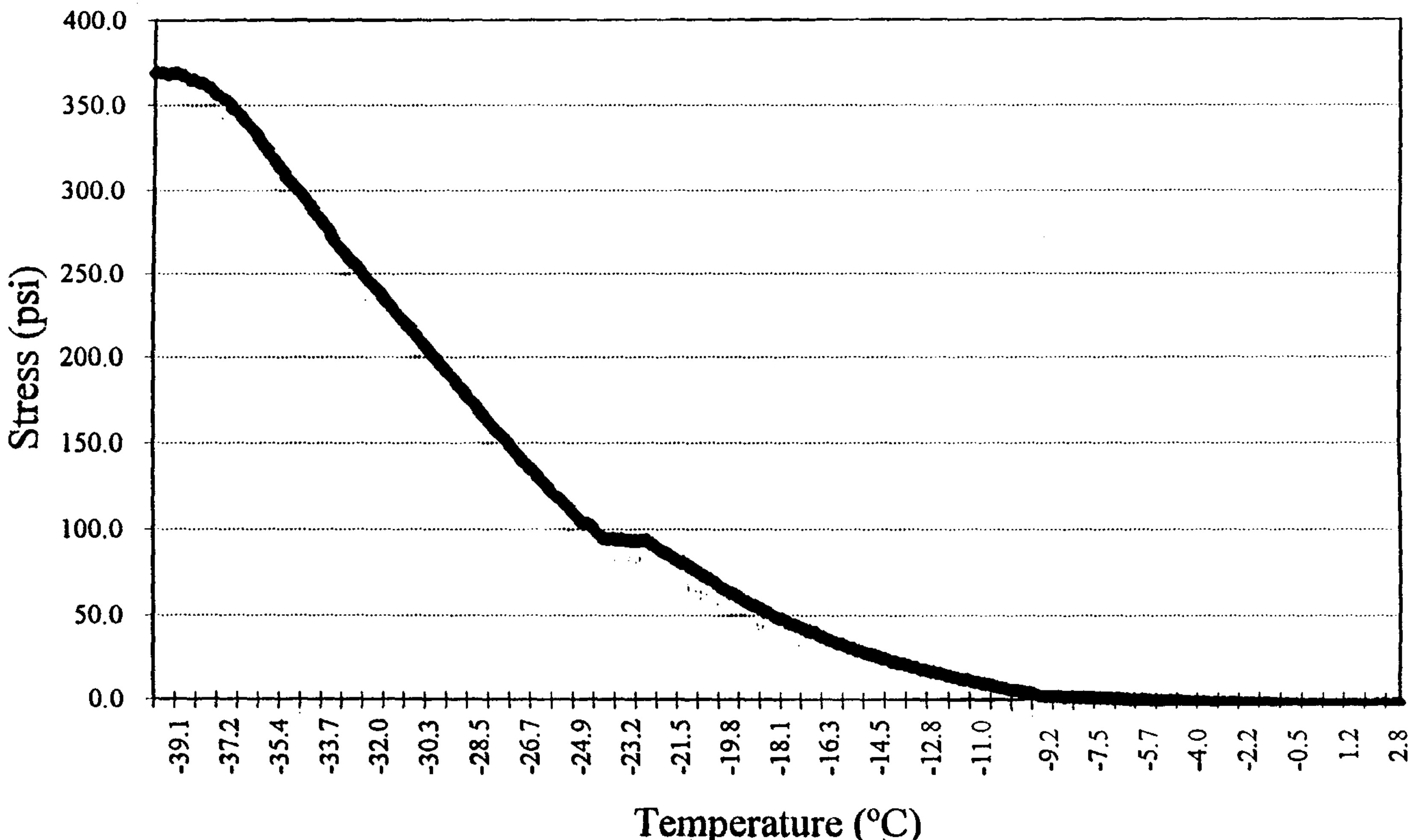


TSRST Report --

Filename	4J
Test date	
Cross section area (sq. in.)	3.51
No. of observations	598
Cooling rate (deg C/hr)	-8.38
Regression coeff. for cooling rate	1.000
Fracture strength (psi)	369
Fracture temperature (deg C)	-41.4
First slope (psi/deg C)	-0.24
Regression coeff. for 1st slope	0.631
Second slope (psi/deg C)	-20.05
Regression coeff. for 2nd slope	0.999
Tangent transition temperature (deg C)	-20.9
Bisector transition temperature (deg C)	-25.6
Specimen shape	

TSRST Results for

ARC (Fairbanks) -- Specimen 4J

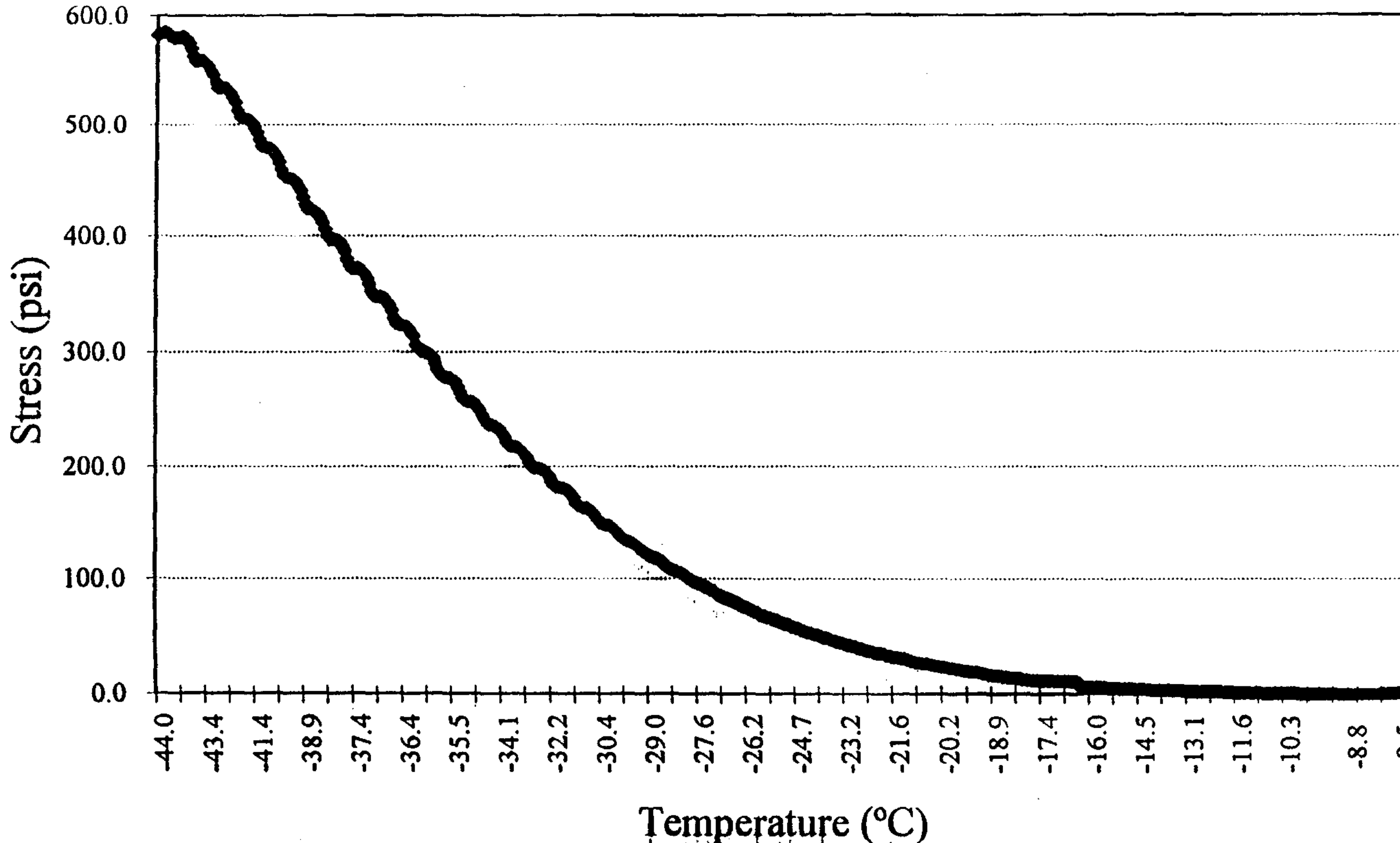


TSRST Report --

Filename	9B2
Test date	
Cross section area (sq. in.)	2.7
No. of observations	512
Cooling rate (deg C/hr)	-9.01
Regression coeff. for cooling rate	0.998
Fracture strength (psi)	585
Fracture temperature (deg C)	-45.0
First slope (psi/deg C)	-0.57
Regression coeff. for 1st slope	0.755
Second slope (psi/deg C)	-27.75
Regression coeff. for 2nd slope	0.835
Tangent transition temperature (deg C)	-26.1
Bisector transition temperature (deg C)	-29.7
Specimen shape	

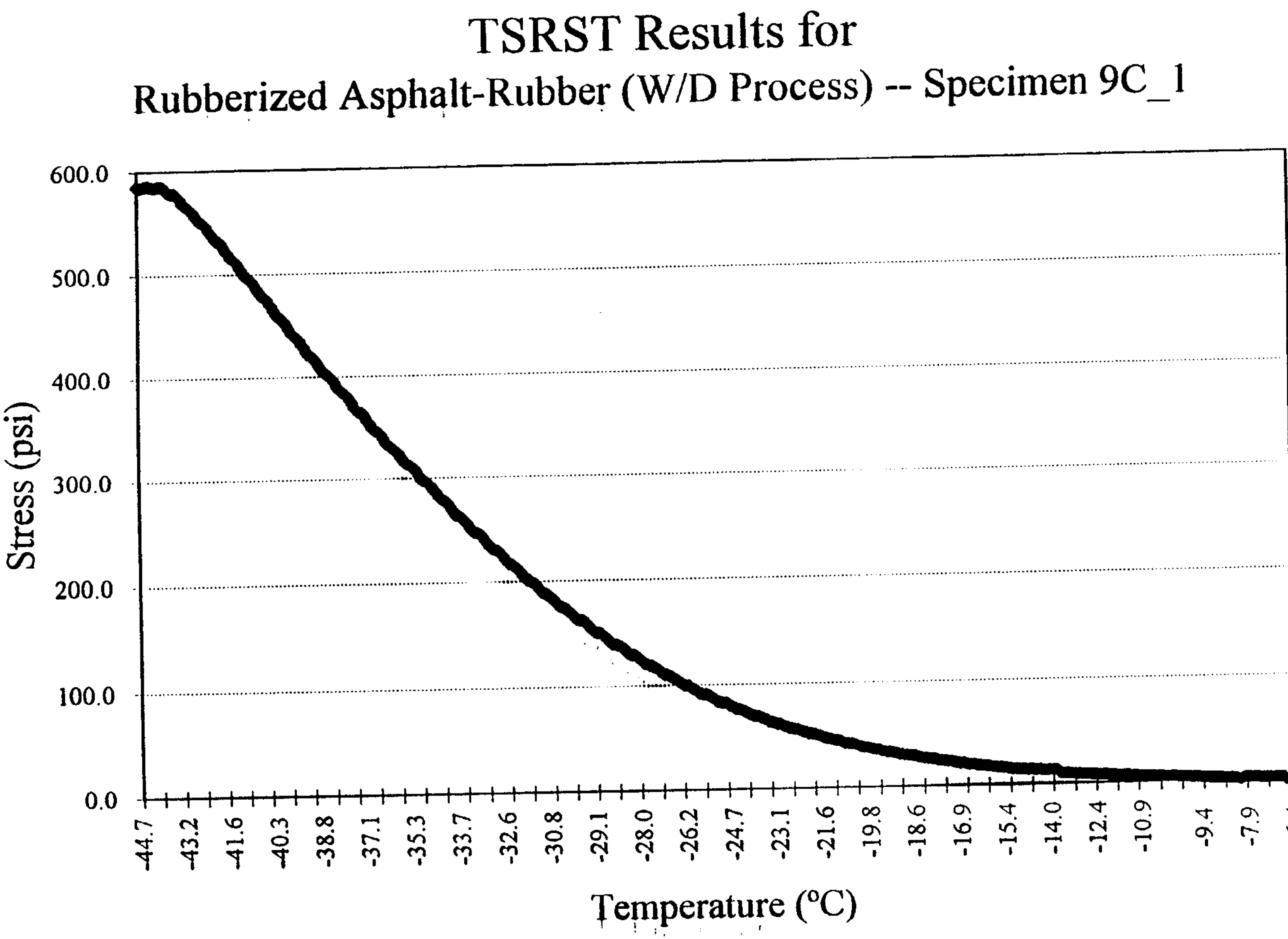
TSRST Results for

Rubberized Asphalt-Rubber (W/D Process) -- Specimen 9B2



TSRST Report --

Filename	9C 1
Test date	
Cross section area (sq. in.)	2.64
No. of observations	533
Cooling rate (deg C/hr)	-8.80
Regression coeff. for cooling rate	1.000
Fracture strength (psi)	586
Fracture temperature (deg C)	-45.1
First slope (psi/deg C)	-1.16
Regression coeff. for 1st slope	0.945
Second slope (psi/deg C)	-31.28
Regression coeff. for 2nd slope	0.962
Tangent transition temperature (deg C)	-26.8
Bisector transition temperature (deg C)	-31.5
Specimen shape	



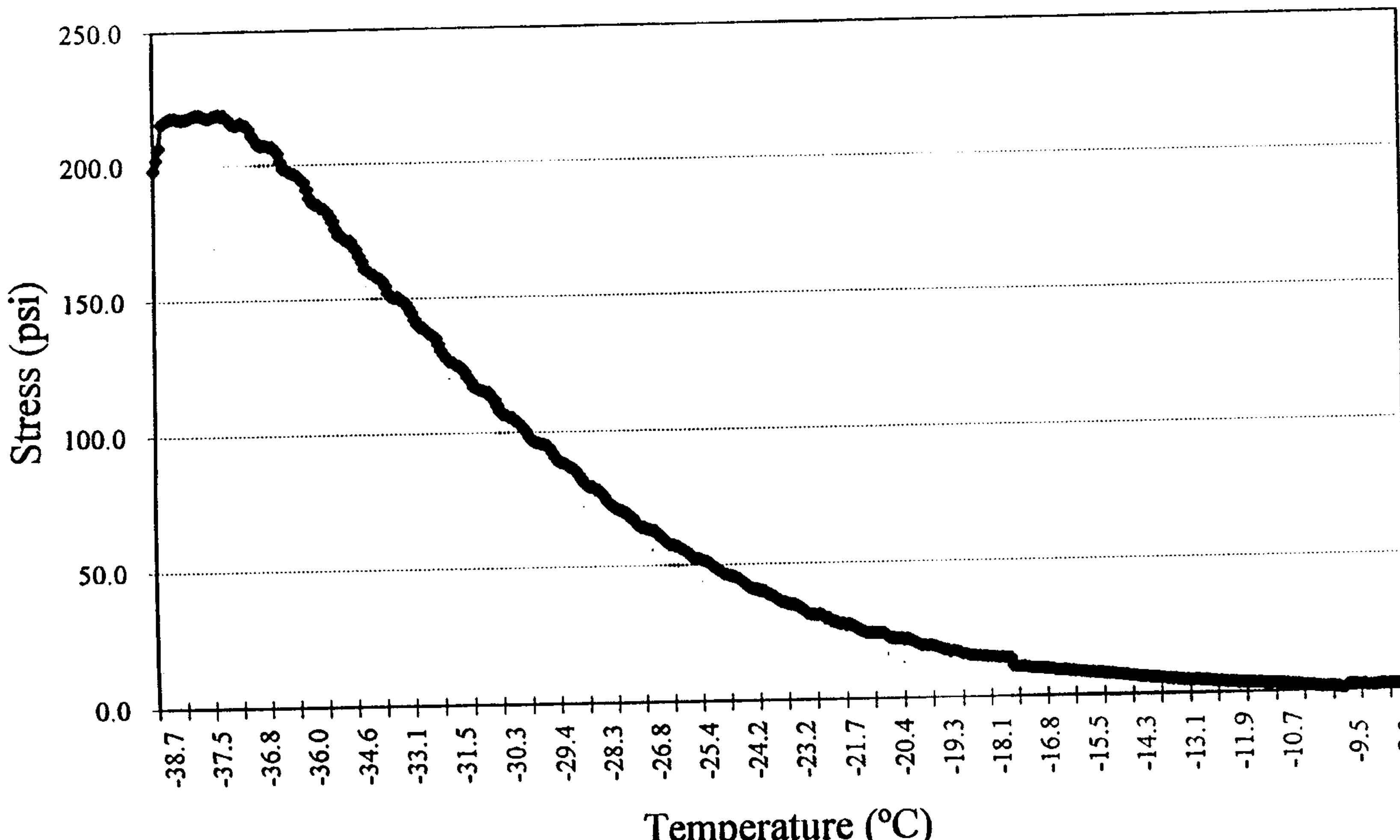
TSRST Results for
Rubberized Asphalt-Rubber (W/D Process) -- Specimen 9C_1
Stress (psi)
600.0
500.0
400.0
300.0
200.0
100.0
0.0
-44.7
-43.2
-41.6
-40.3
-38.8
-37.1
-35.3
-33.7
-32.6
-30.8
-29.1
-28.0
-26.2
-24.7
-23.1
-21.6
-19.8
-18.6
-16.9
-15.4
-14.0
-12.4
-10.9
-9.4
-7.9
-6.4
Temperature (°C)

TSRST Report --

Filename	9G
Test date	
Cross section area (sq. in.)	2.7
No. of observations	437
Cooling rate (deg C/hr)	-8.94
Regression coeff. for cooling rate	0.999
Fracture strength (psi)	219
Fracture temperature (deg C)	-38.6
First slope (psi/deg C)	-0.84
Regression coeff. for 1st slope	0.907
Second slope (psi/deg C)	-16.17
Regression coeff. for 2nd slope	0.953
Tangent transition temperature (deg C)	-25.5
Bisector transition temperature (deg C)	-29.0
Specimen shape	

TSRST Results for

Rubberized Asphalt-Rubber (W/D Process) -- Specimen 9G

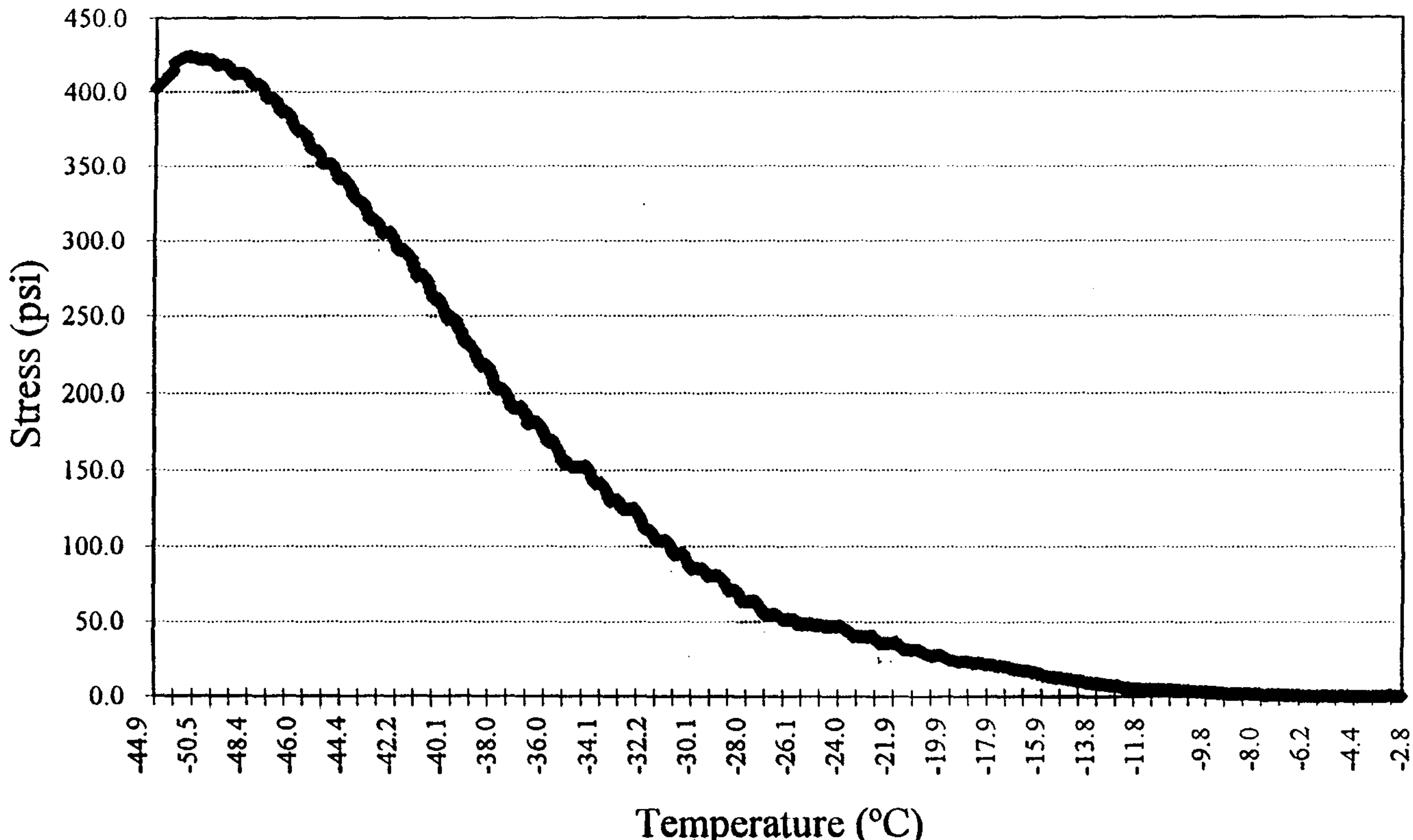


TSRST Report --

Filename	9H
Test date	
Cross section area (sq. in.)	2.7
No. of observations	677
Cooling rate (deg C/hr)	-9.05
Regression coeff. for cooling rate	0.996
Fracture strength (psi)	424
Fracture temperature (deg C)	-52.3
First slope (psi/deg C)	-0.39
Regression coeff. for 1st slope	0.779
Second slope (psi/deg C)	-21.74
Regression coeff. for 2nd slope	0.954
Tangent transition temperature (deg C)	-29.4
Bisector transition temperature (deg C)	-35.5
Specimen shape	

TSRST Results for

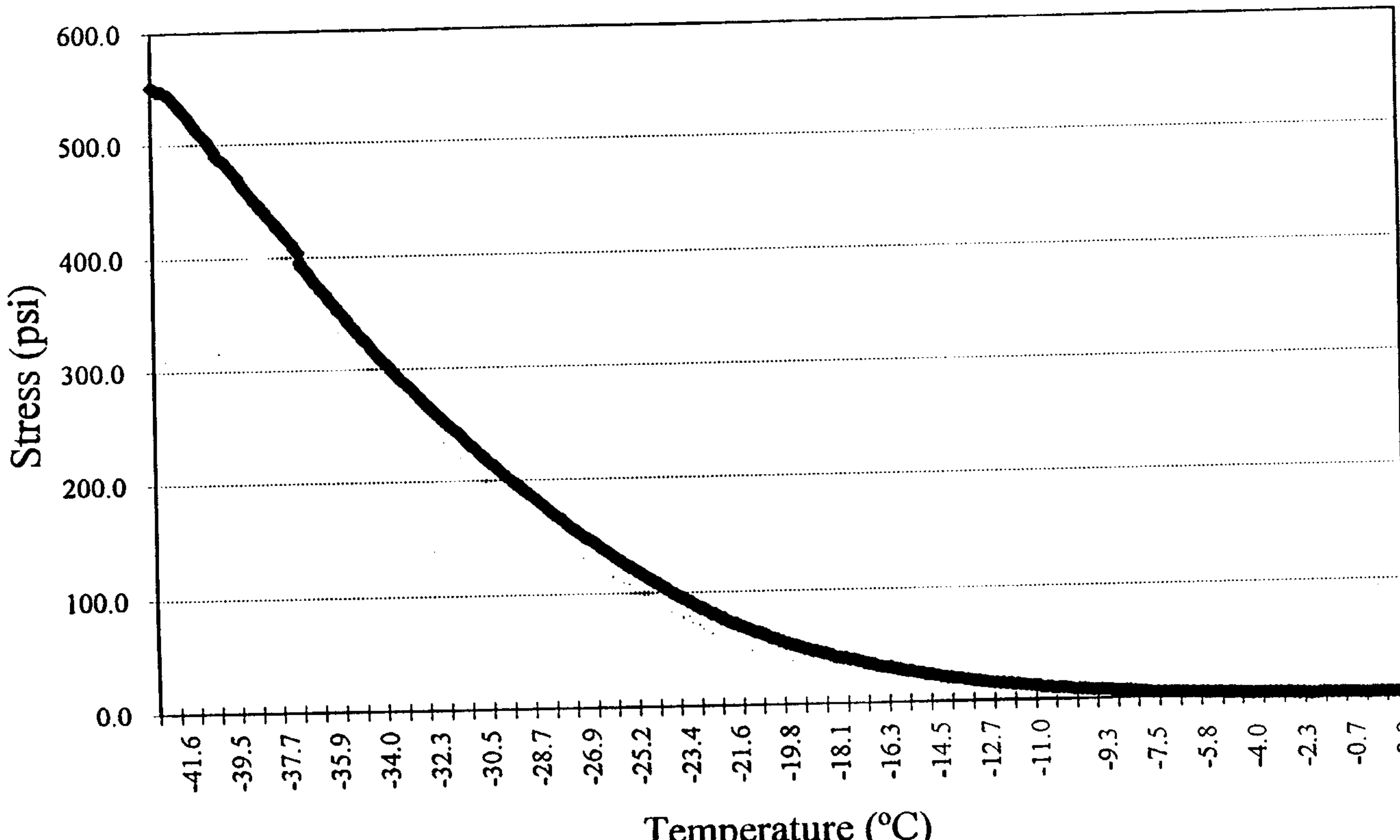
Rubberized Asphalt-Rubber (W/D Process) -- Specimen 9H



TSRST Report --

Filename	9K_1
Test date	
Cross section area (sq. in.)	2.86
No. of observations	600
Cooling rate (deg C/hr)	-8.53
Regression coeff. for cooling rate	1.000
Fracture strength (psi)	551
Fracture temperature (deg C)	-43.7
First slope (psi/deg C)	-0.48
Regression coeff. for 1st slope	0.912
Second slope (psi/deg C)	-25.79
Regression coeff. for 2nd slope	0.999
Tangent transition temperature (deg C)	-23.2
Bisector transition temperature (deg C)	-29.4
Specimen shape	

TSRST Results for
Rubberized Asphalt-Rubber (W/D Process) -- Specimen 9K_1

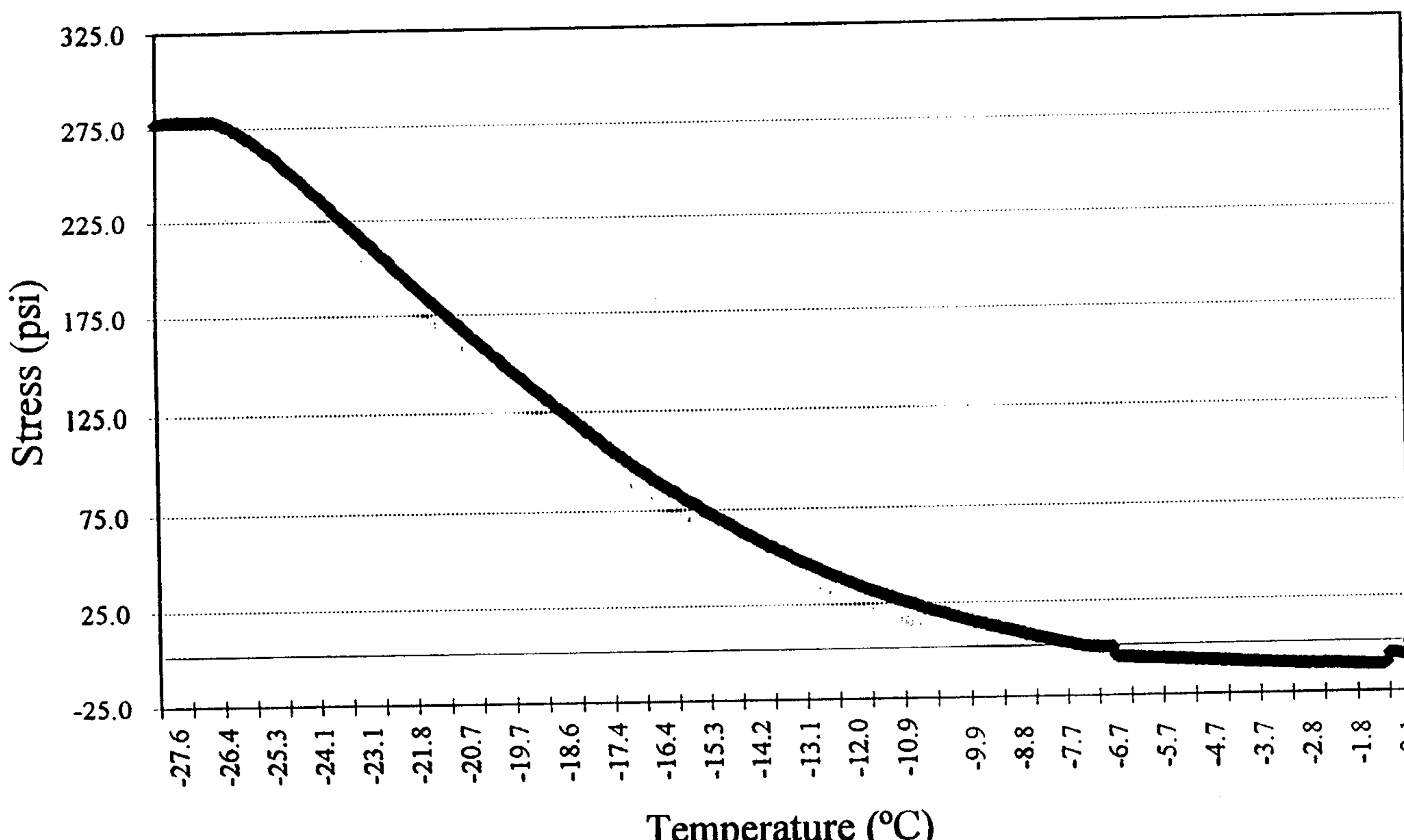


TSRST Report --

Filename	C-2-1
Test date	
Cross section area (sq. in.)	3.86
No. of observations	387
Cooling rate (deg C/hr)	-8.56
Regression coeff. for cooling rate	0.999
Fracture strength (psi)	279
Fracture temperature (deg C)	-27.9
First slope (psi/deg C)	-1.55
Regression coeff. for 1st slope	0.599
Second slope (psi/deg C)	-20.50
Regression coeff. for 2nd slope	0.998
Tangent transition temperature (deg C)	-13.4
Bisector transition temperature (deg C)	-17.6
Specimen shape	

TSRST Results for

Conventional Asphalt Concrete (Anchorage) -- Specimen C-2-1



TSRST Report --

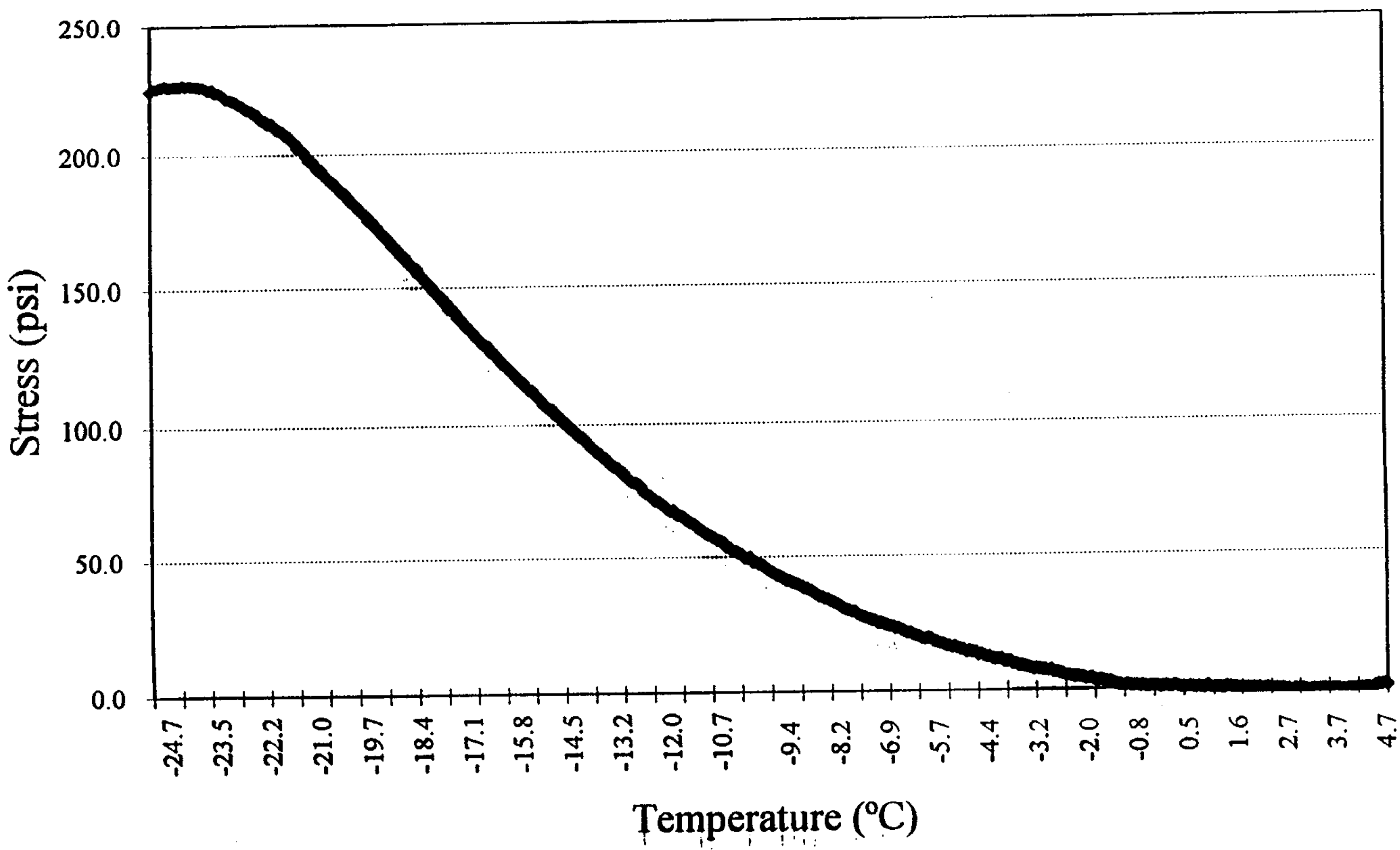
Filename	C-2-2
Test date	
Cross section area (sq. in.)	3.9
No. of observations	430
Cooling rate (deg C/hr)	-8.34
Regression coeff. for cooling rate	1.000
Fracture strength (psi)	333
Fracture temperature (deg C)	-26.0
First slope (psi/deg C)	-1.29
Regression coeff. for 1st slope	0.841
Second slope (psi/deg C)	-22.07
Regression coeff. for 2nd slope	0.999
Tangent transition temperature (deg C)	-10.7
Bisector transition temperature (deg C)	-15.0
Specimen shape	

TSRST Report --

Filename	C-2-3
Test date	
Cross section area (sq. in.)	4.01
No. of observations	421
Cooling rate (deg C/hr)	-8.30
Regression coeff. for cooling rate	1.000
Fracture strength (psi)	227
Fracture temperature (deg C)	-24.8
First slope (psi/deg C)	-0.69
Regression coeff. for 1st slope	0.734
Second slope (psi/deg C)	-15.53
Regression coeff. for 2nd slope	0.999
Tangent transition temperature (deg C)	-9.4
Bisector transition temperature (deg C)	-14.2
Specimen shape	

TSRST Results for

Conventional Asphalt Concrete (Anchorage) -- Specimen C-2-3

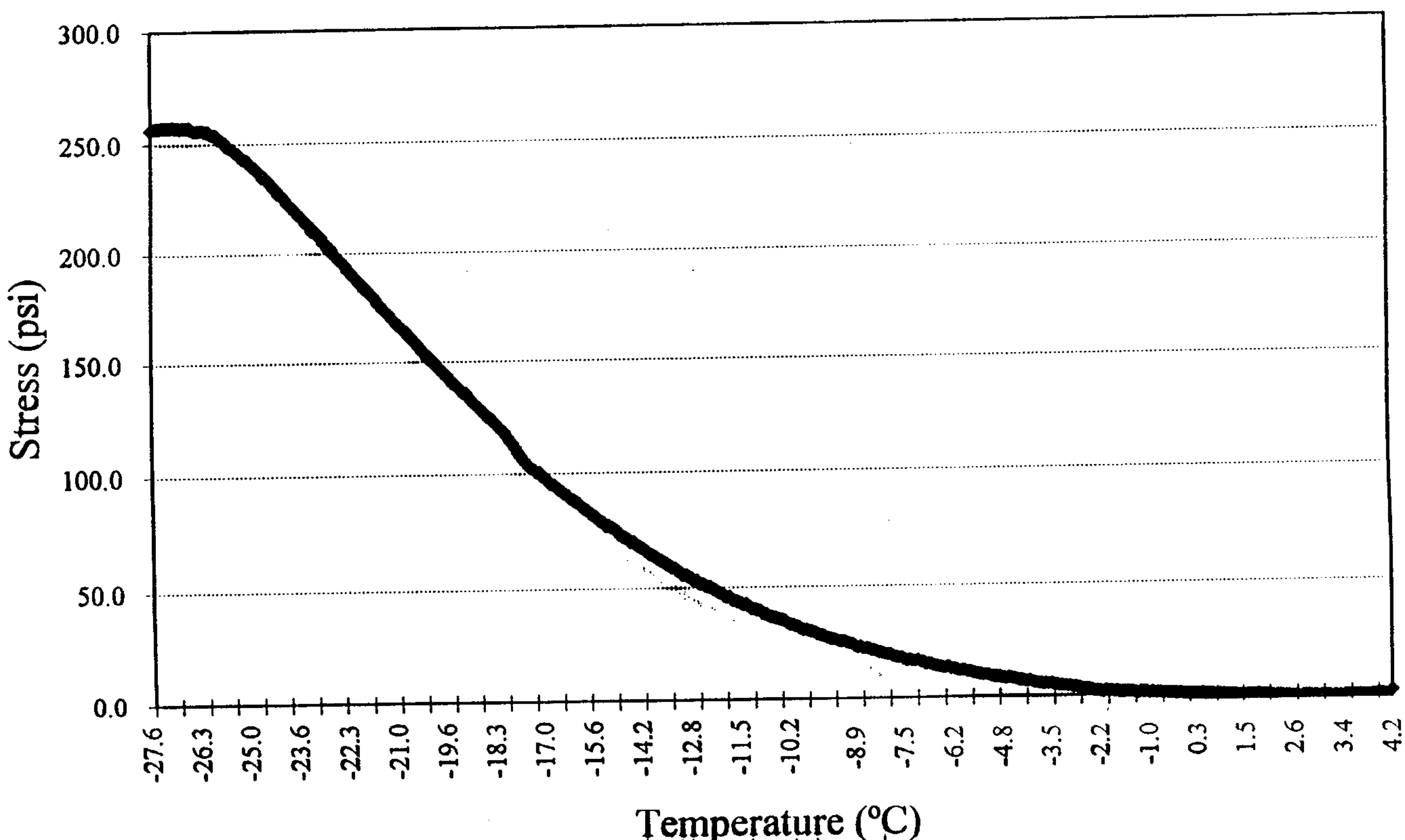


TSRST Report --

Filename	S-1-1
Test date	
Cross section area (sq. in.)	3.65
No. of observations	456
Cooling rate (deg C/hr)	-8.74
Regression coeff. for cooling rate	0.999
Fracture strength (psi)	258
Fracture temperature (deg C)	-27.4
First slope (psi/deg C)	-0.56
Regression coeff. for 1st slope	0.876
Second slope (psi/deg C)	-18.40
Regression coeff. for 2nd slope	0.999
Tangent transition temperature (deg C)	-12.6
Bisector transition temperature (deg C)	-17.0
Specimen shape	

TSRST Results for

PlusRide (Anchorage) -- Specimen S-1-1

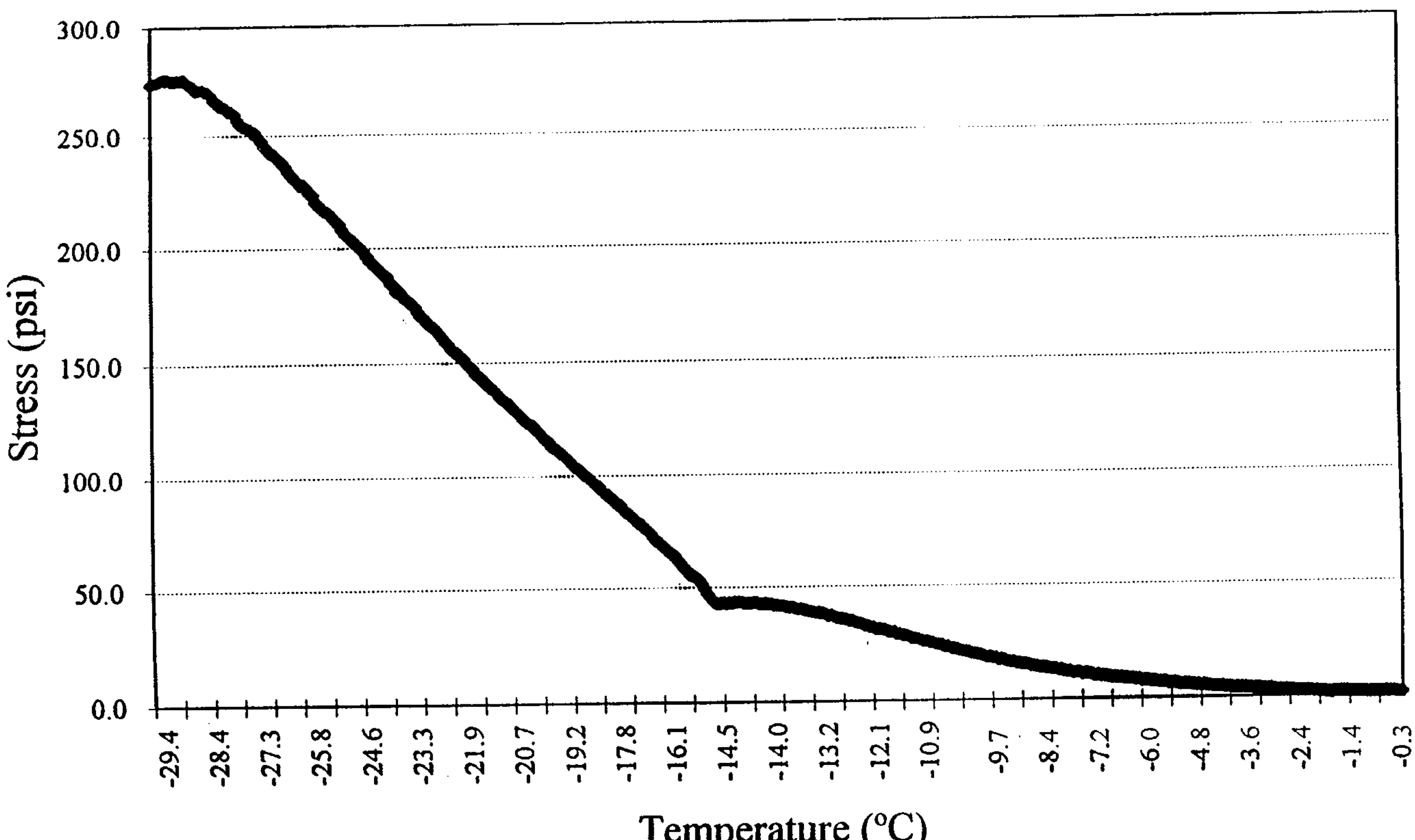


TSRST Report --

Filename	S-1-3
Test date	
Cross section area (sq. in.)	3.35
No. of observations	419
Cooling rate (deg C/hr)	-8.67
Regression coeff. for cooling rate	0.998
Fracture strength (psi)	276
Fracture temperature (deg C)	-29.5
First slope (psi/deg C)	-1.31
Regression coeff. for 1st slope	0.959
Second slope (psi/deg C)	-18.96
Regression coeff. for 2nd slope	0.994
Tangent transition temperature (deg C)	-15.7
Bisector transition temperature (deg C)	-20.3
Specimen shape	

TSRST Results for

PlusRide (Anchorage) -- Specimen S-1-3

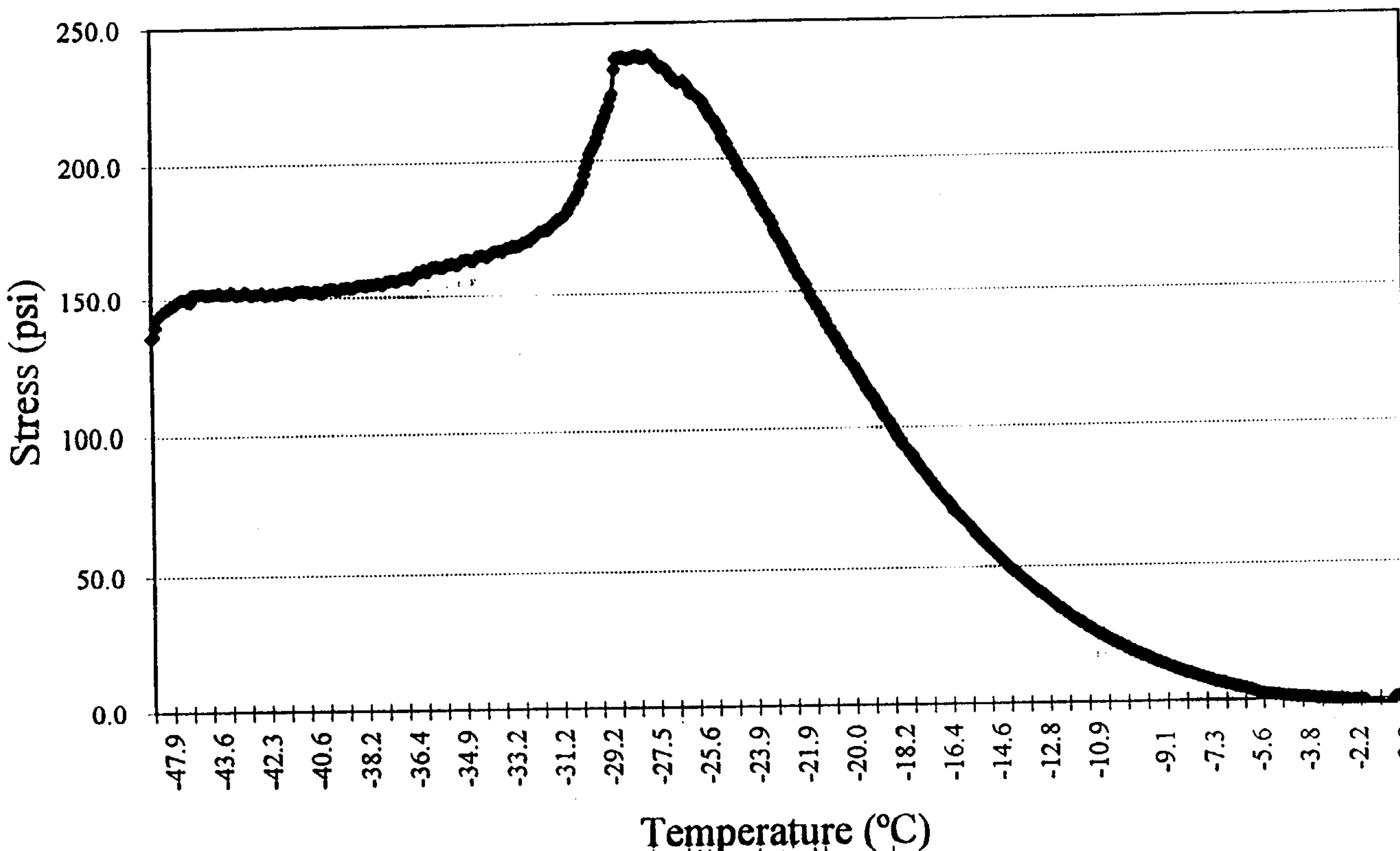


TSRST Report --

Filename	S-1-4
Test date	
Cross section area (sq. in.)	3.57
No. of observations	645
Cooling rate (deg C/hr)	-8.92
Regression coeff. for cooling rate	0.999
Fracture strength (psi)	238
Fracture temperature (deg C)	-28.4
First slope (psi/deg C)	-1.43
Regression coeff. for 1st slope	0.853
Second slope (psi/deg C)	2.45
Regression coeff. for 2nd slope	0.928
Tangent transition temperature (deg C)	-65.5
Bisector transition temperature (deg C)	-23.9
Specimen shape	

TSRST Results for

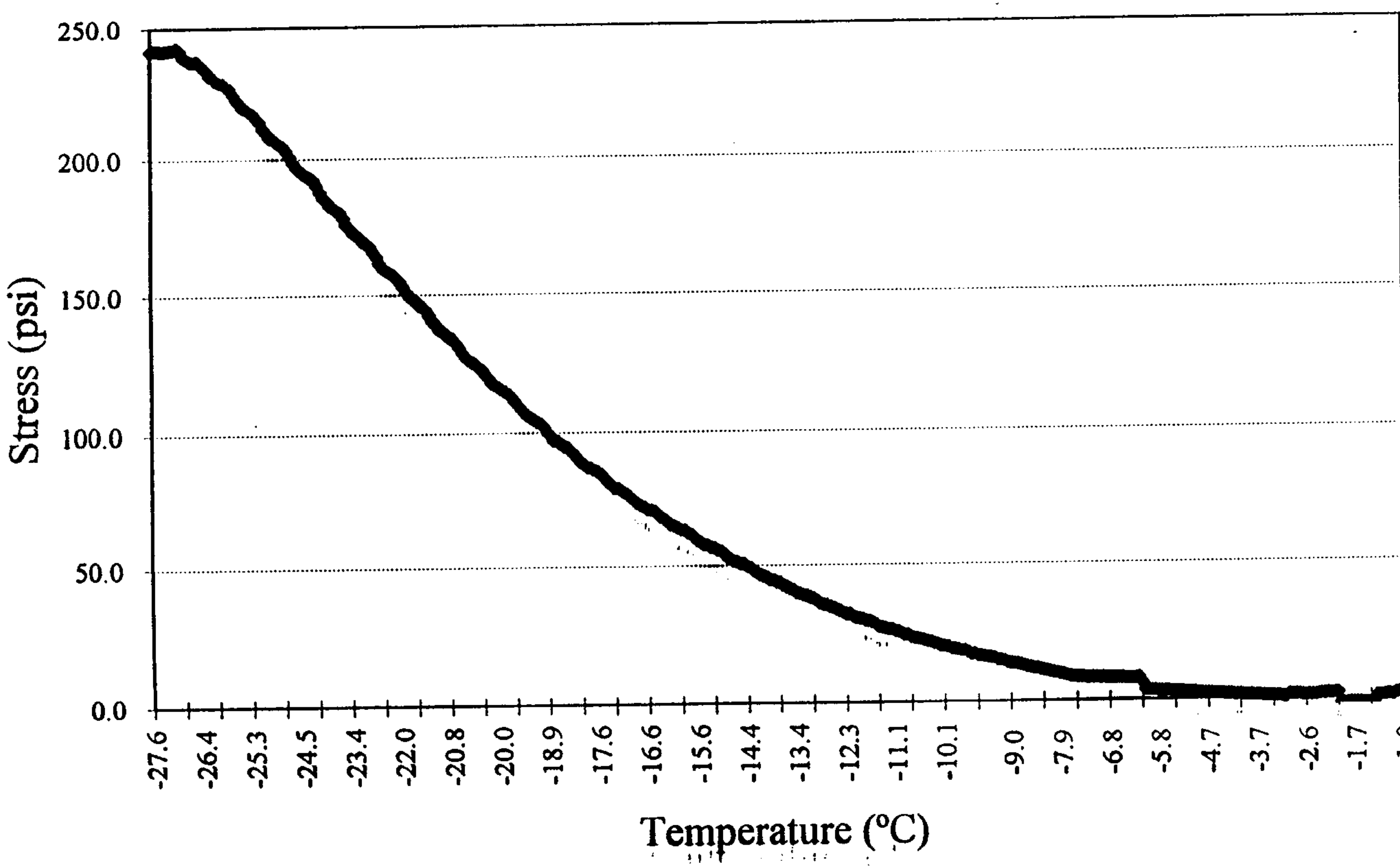
PlusRide (Anchorage) -- Specimen S-1-4



TSRST Report --

Filename	S-1-5
Test date	
Cross section area (sq. in.)	3.57
No. of observations	382
Cooling rate (deg C/hr)	-8.81
Regression coeff. for cooling rate	0.999
Fracture strength (psi)	242
Fracture temperature (deg C)	-27.8
First slope (psi/deg C)	-1.44
Regression coeff. for 1st slope	0.810
Second slope (psi/deg C)	-17.89
Regression coeff. for 2nd slope	0.988
Tangent transition temperature (deg C)	-14.9
Bisector transition temperature (deg C)	-18.6
Specimen shape	

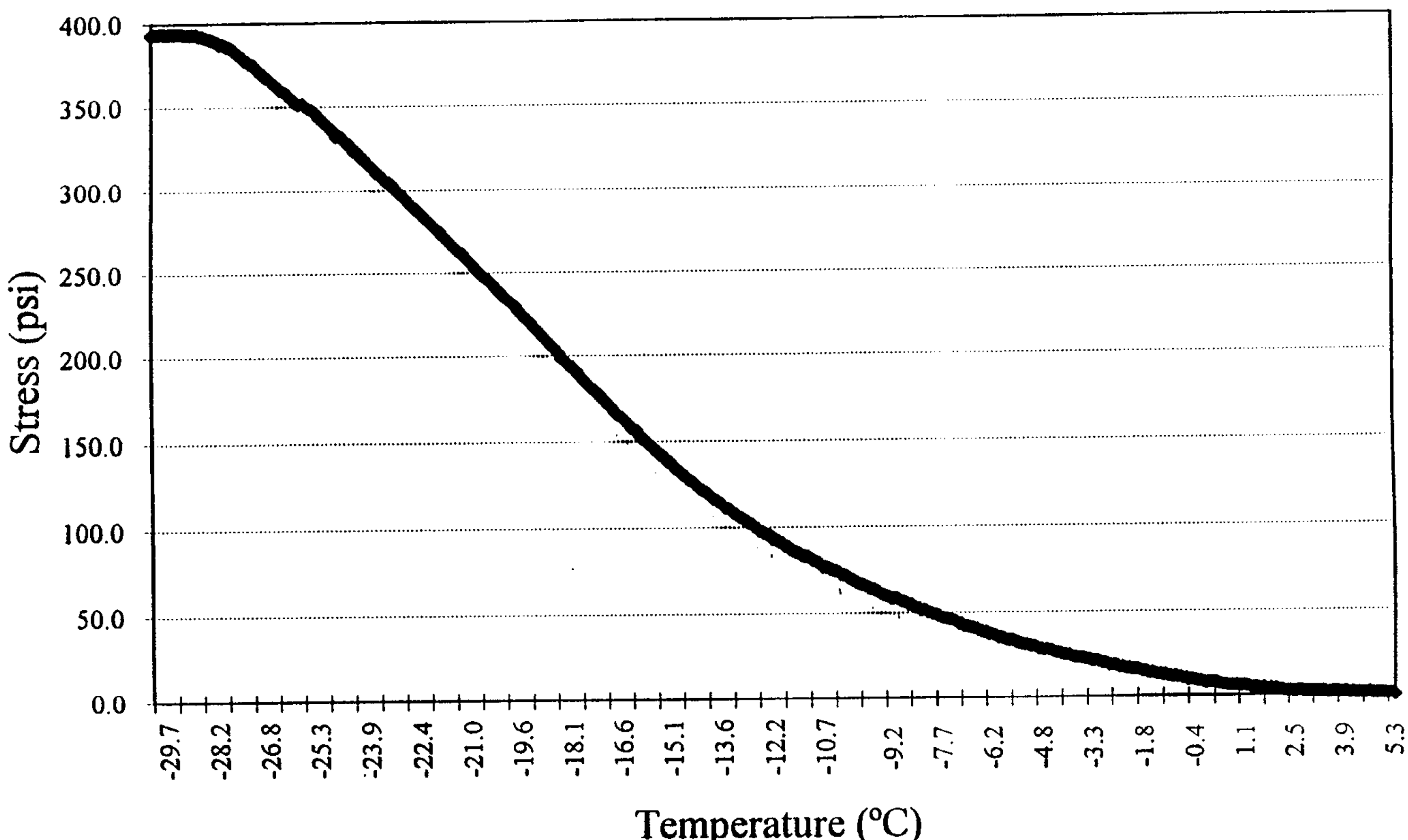
TSRST Results for
PlusRide (Anchorage) -- Specimen S-1-5



TSRST Report --

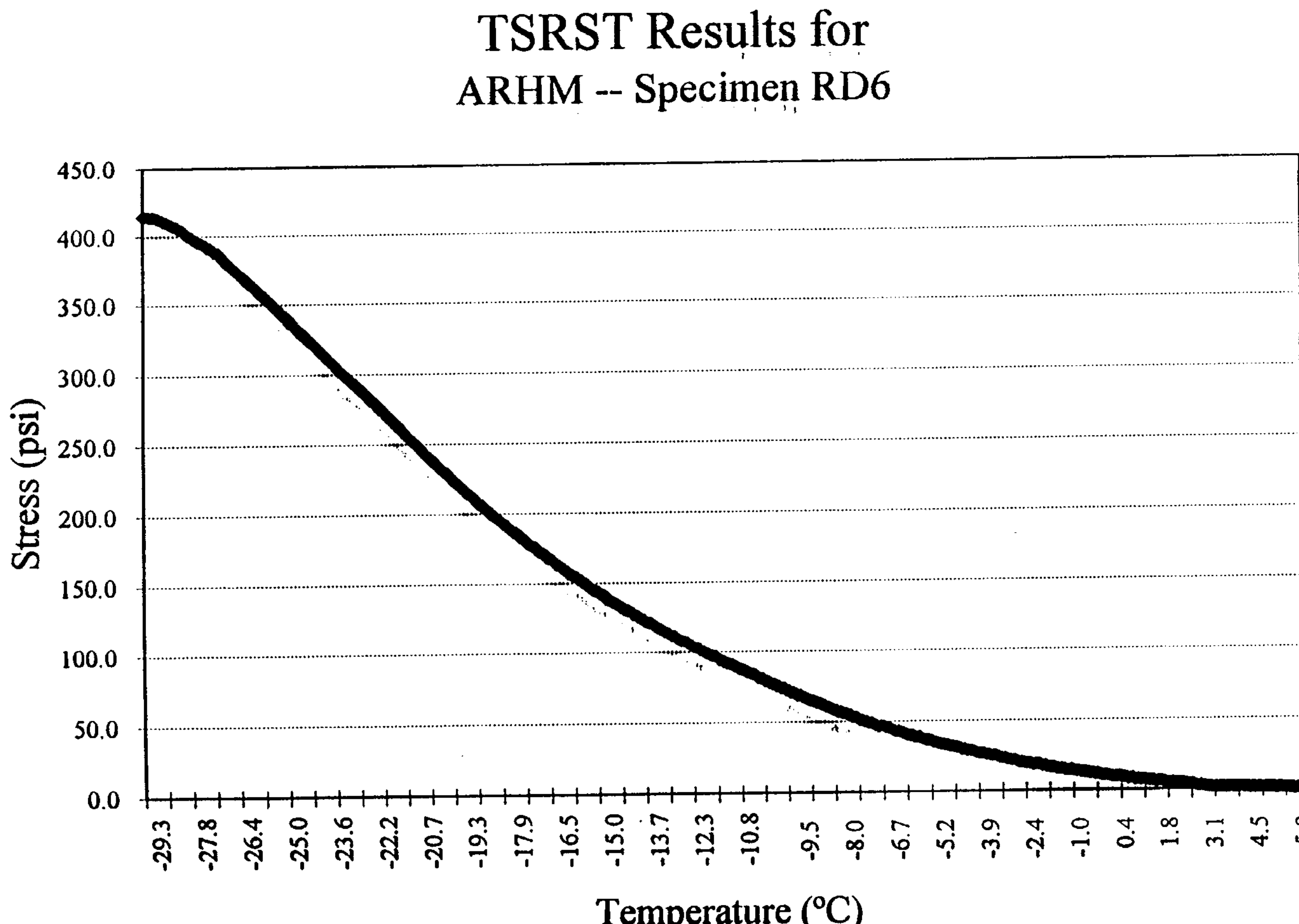
Filename	RD5
Test date	
Cross section area (sq. in.)	3.41
No. of observations	494
Cooling rate (deg C/hr)	-8.79
Regression coeff. for cooling rate	1.000
Fracture strength (psi)	394
Fracture temperature (deg C)	-30.3
First slope (psi/deg C)	-2.09
Regression coeff. for 1st slope	0.917
Second slope (psi/deg C)	-20.79
Regression coeff. for 2nd slope	0.999
Tangent transition temperature (deg C)	-10.7
Bisector transition temperature (deg C)	-14.4
Specimen shape	

TSRST Results for
ARHM -- Specimen RD5



TSRST Report --

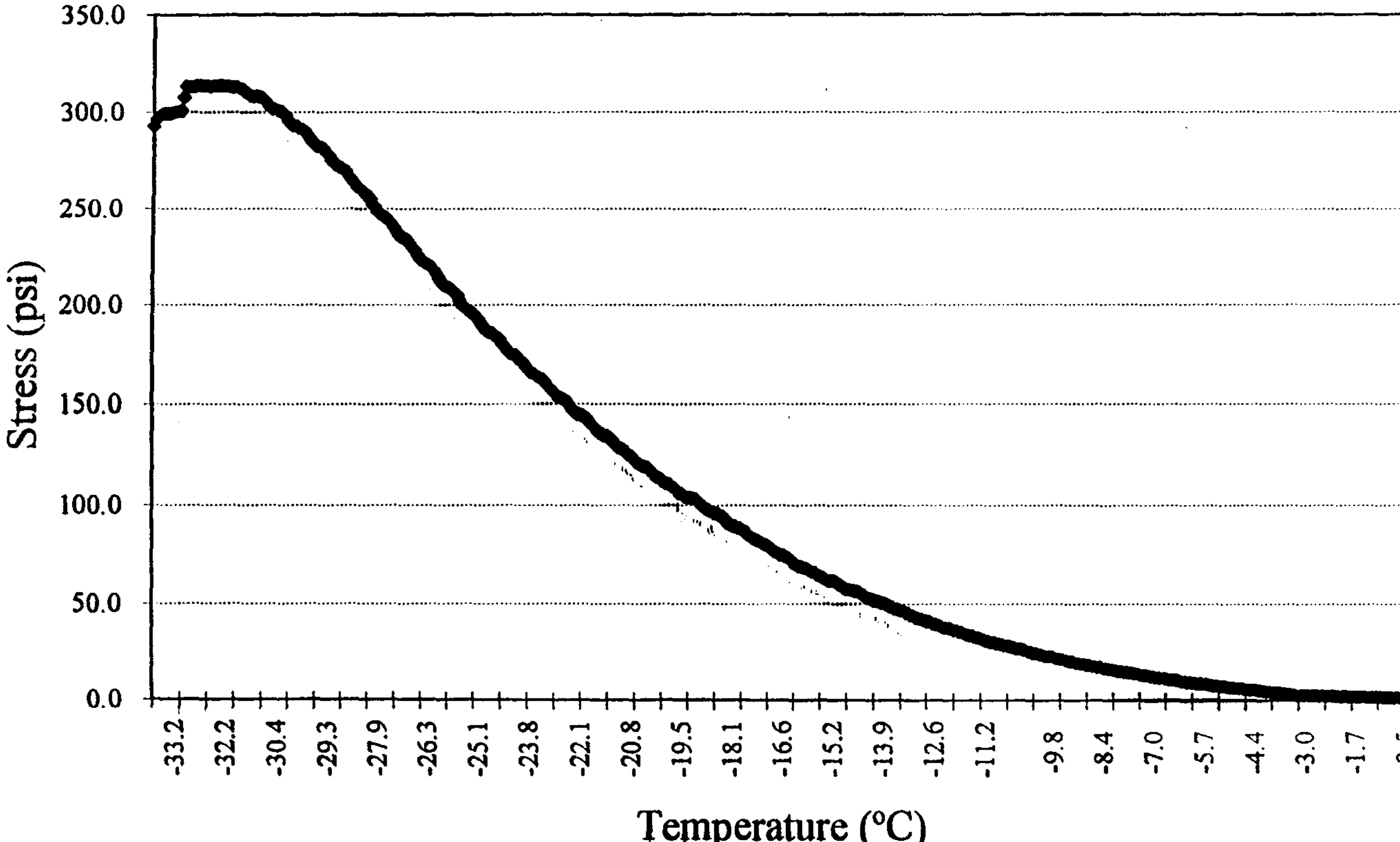
Filename	RD6
Test date	
Cross section area (sq. in.)	3.47
No. of observations	489
Cooling rate (deg C/hr)	-8.74
Regression coeff. for cooling rate	1.000
Fracture strength (psi)	414
Fracture temperature (deg C)	-30.1
First slope (psi/deg C)	-2.14
Regression coeff. for 1st slope	0.936
Second slope (psi/deg C)	-22.41
Regression coeff. for 2nd slope	0.999
Tangent transition temperature (deg C)	-12.2
Bisector transition temperature (deg C)	-17.6
Specimen shape	


TSRST Results for
ARHM -- Specimen RD6
Stress (psi)
450.0
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
-29.3
-27.8
-26.4
-25.0
-23.6
-22.2
-20.7
-19.3
-17.9
-16.5
-15.0
-13.7
-12.3
-10.8
-9.5
-8.0
-6.7
-5.2
-3.9
-2.4
-1.0
0.4
1.8
3.1
4.5
5.8
Temperature (°C)

TSRST Report --

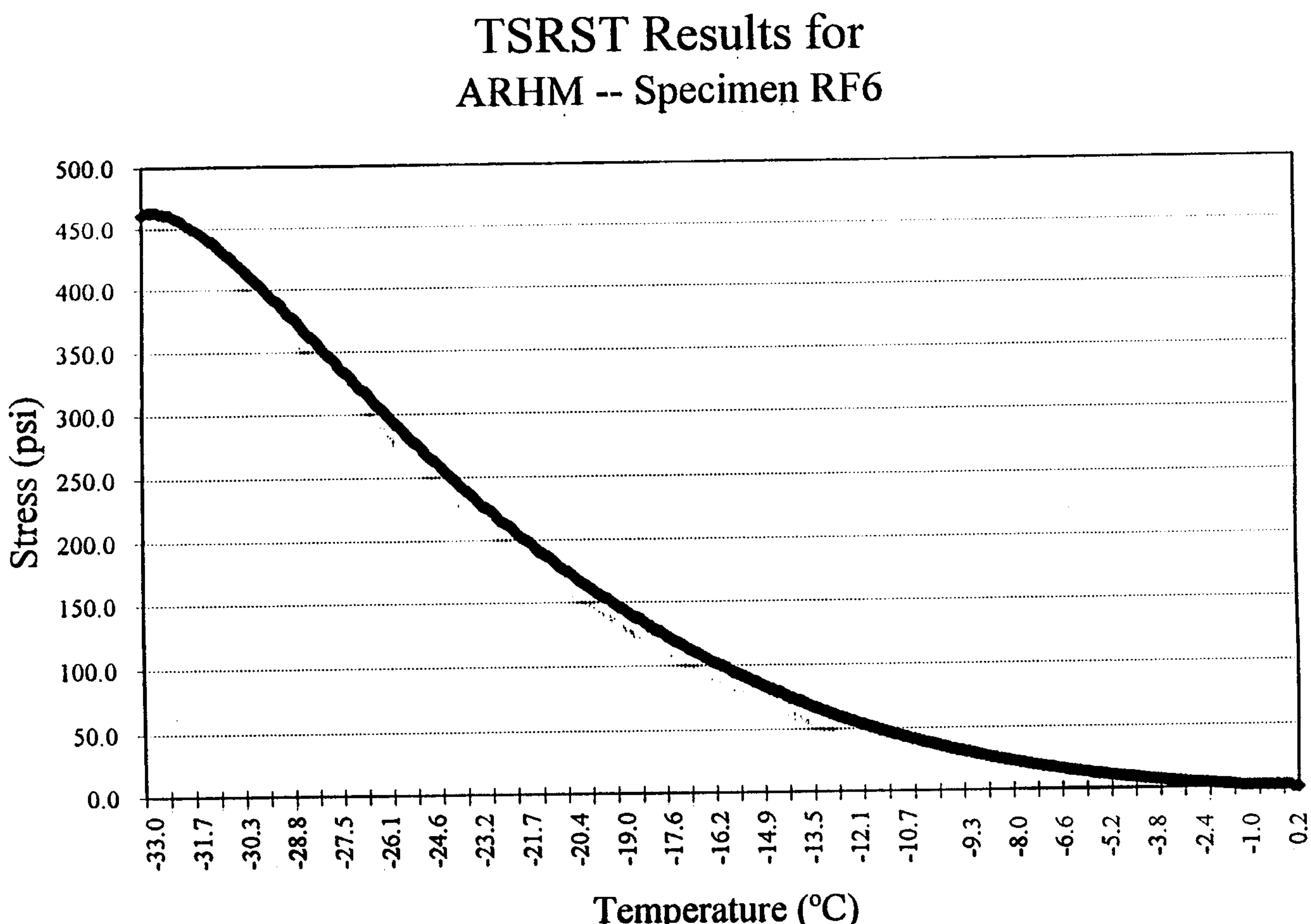
Filename	RF5
Test date	
Cross section area (sq. in.)	3.44
No. of observations	472
Cooling rate (deg C/hr)	-9.29
Regression coeff. for cooling rate	1.000
Fracture strength (psi)	314
Fracture temperature (deg C)	-33.4
First slope (psi/deg C)	-1.90
Regression coeff. for 1st slope	0.938
Second slope (psi/deg C)	-21.05
Regression coeff. for 2nd slope	0.989
Tangent transition temperature (deg C)	-18.1
Bisector transition temperature (deg C)	-23.1
Specimen shape	

TSRST Results for
ARHM -- Specimen RF5



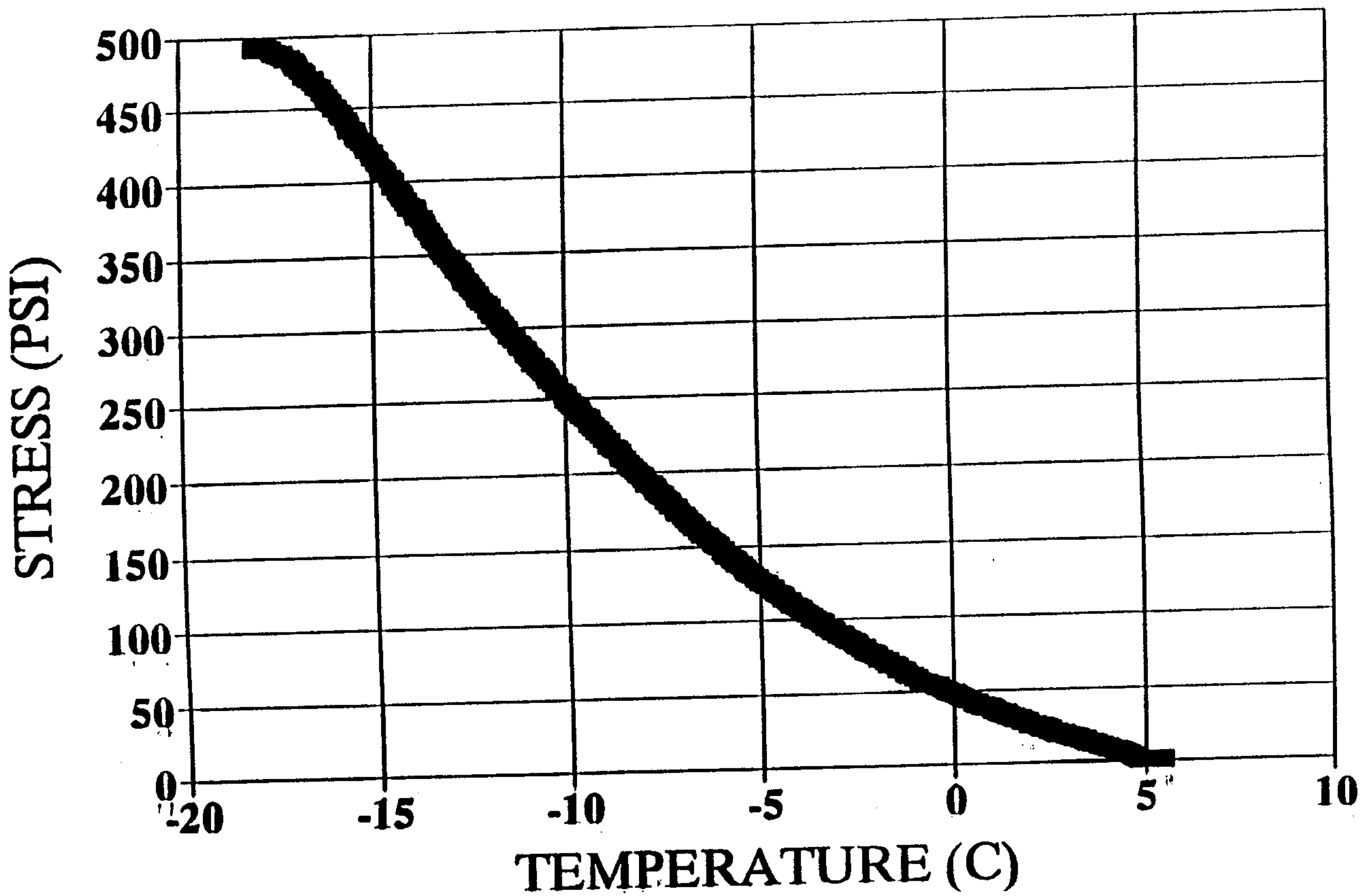
TSRST Report --

Filename	RF6
Test date	
Cross section area (sq. in.)	3.44
No. of observations	467
Cooling rate (deg C/hr)	-8.62
Regression coeff. for cooling rate	1.000
Fracture strength (psi)	463
Fracture temperature (deg C)	-33.5
First slope (psi/deg C)	-2.53
Regression coeff. for 1st slope	0.956
Second slope (psi/deg C)	-27.06
Regression coeff. for 2nd slope	0.998
Tangent transition temperature (deg C)	-17.0
Bisector transition temperature (deg C)	-22.3
Specimen shape	

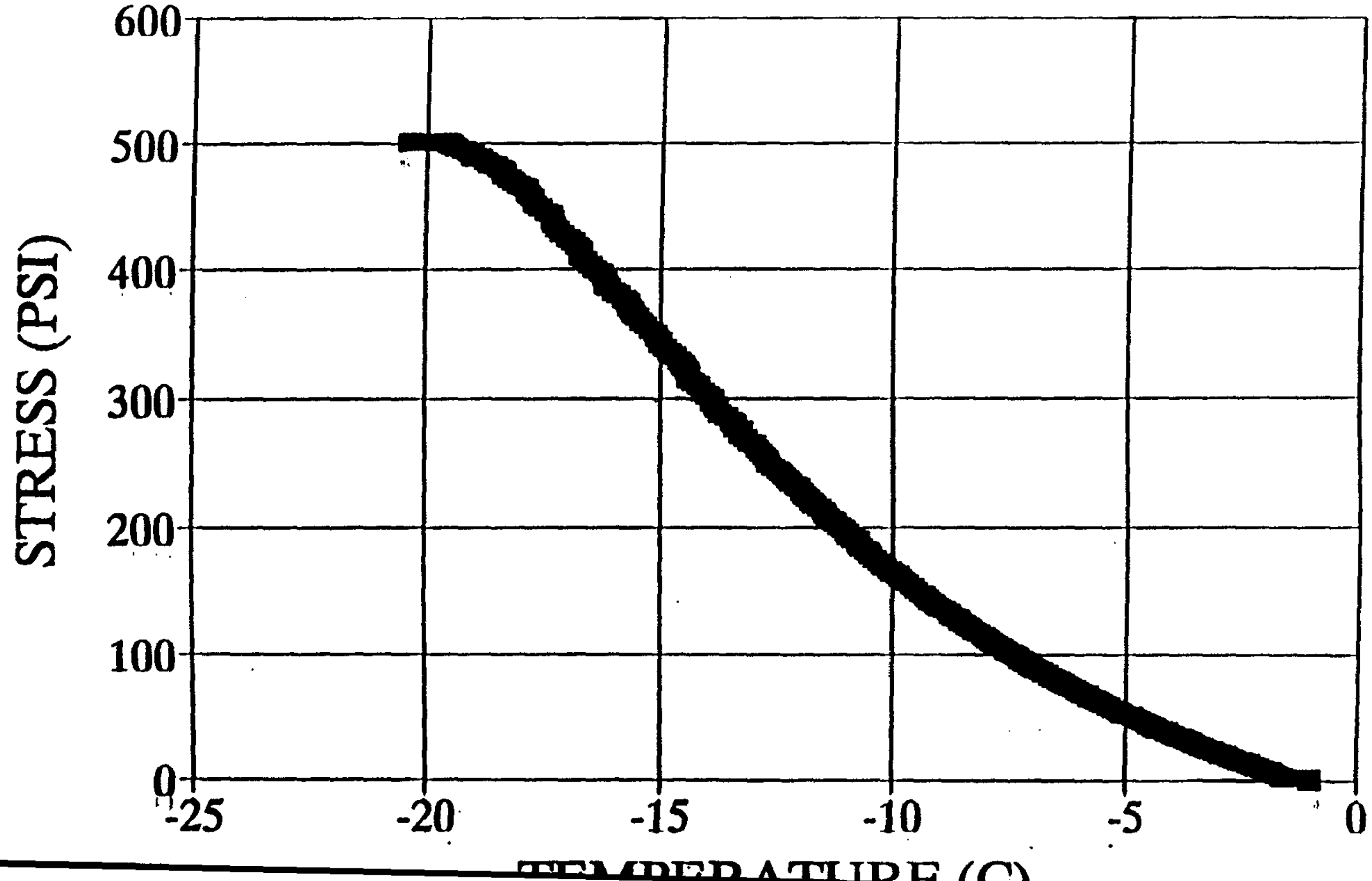


TSRST Results for
ARHM -- Specimen RF6
Stress (psi)
500.0
450.0
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
-33.0
-31.7
-30.3
-28.8
-27.5
-26.1
-24.6
-23.2
-21.7
-20.4
-19.0
-17.6
-16.2
-14.9
-13.5
-12.1
-10.7
-9.3
-8.0
-6.6
-5.2
-3.8
-2.4
-1.0
0.2
Temperature (°C)

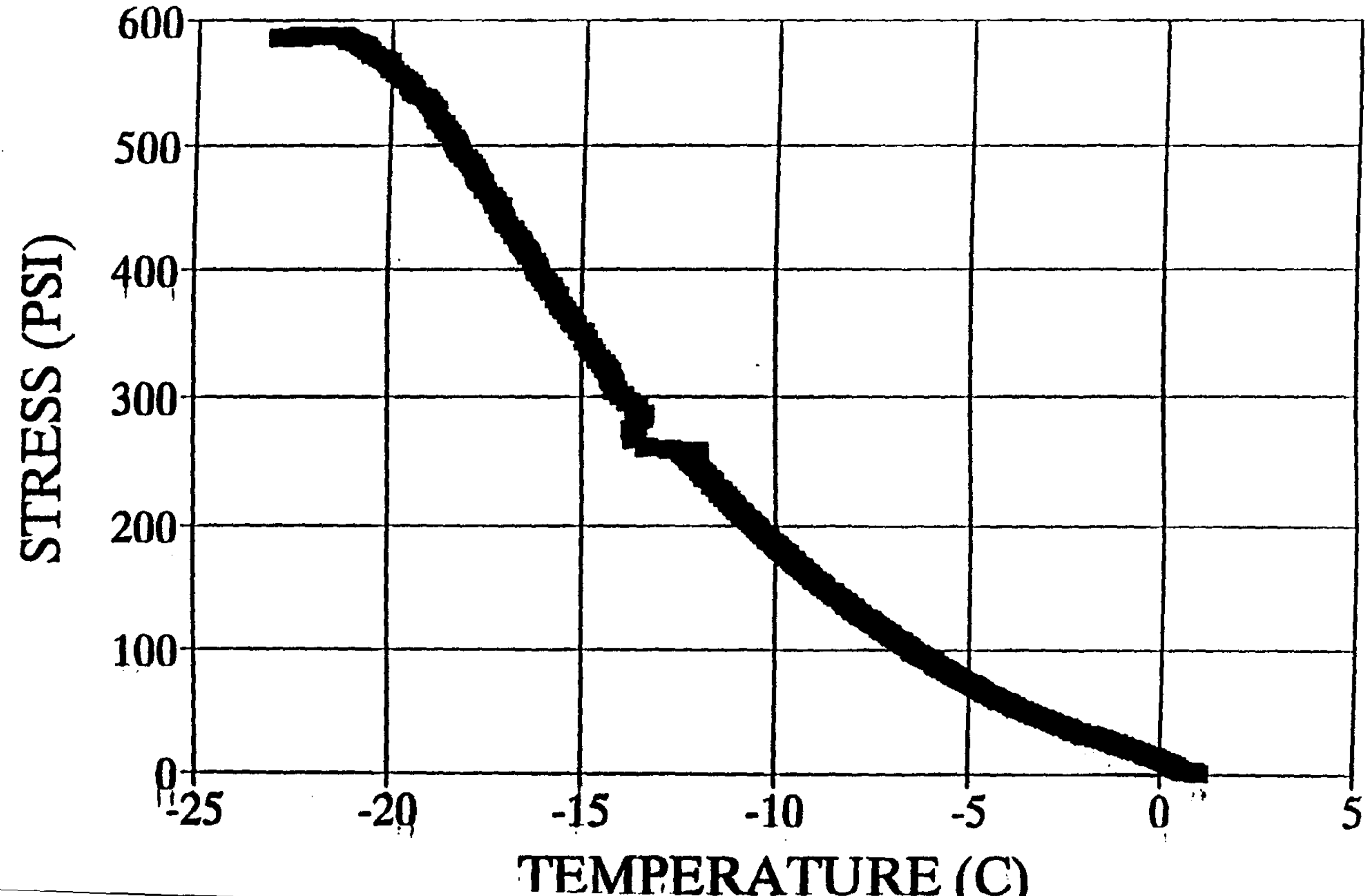
MANHOLE CAC-DG (CD5)
TSRS TEST , Cooling = 8.74 C/hr

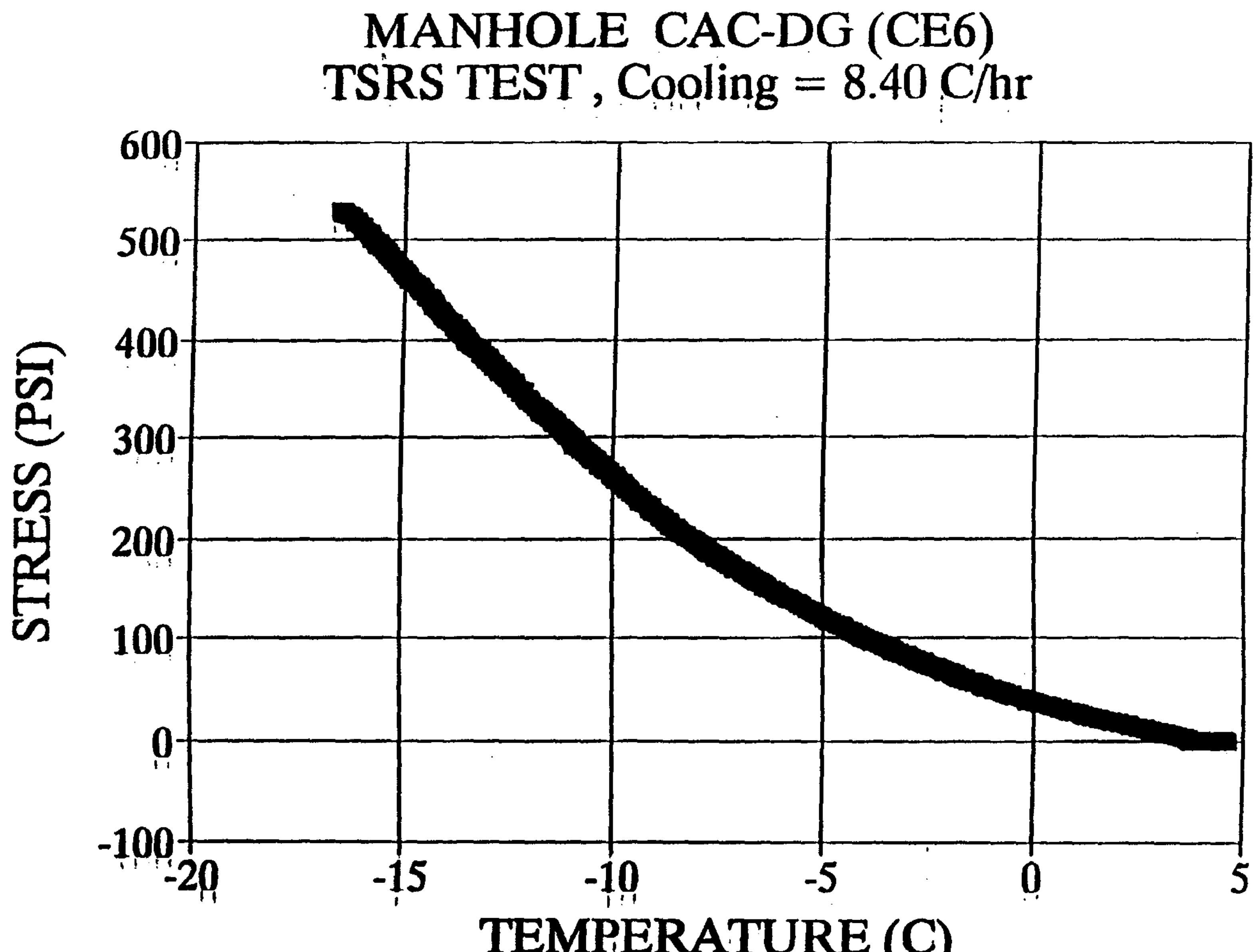


MANHOLE CAC-DG (CD6)
TSRS TEST , Cooling = 8.57 C/hr



MANHOLE CAC-DG (CE5)
TSRS TEST , Cooling = 8.88 C/hr




MANHOLE CAC-DG (CE6)
TSRS TEST , Cooling = 8.40 C/hr
STRESS (PSI)
600
500
400
300
200
100
0
-100
-20
-15
-10
-5
0
5
TEMPERATURE (C)