South Dakota

DOT

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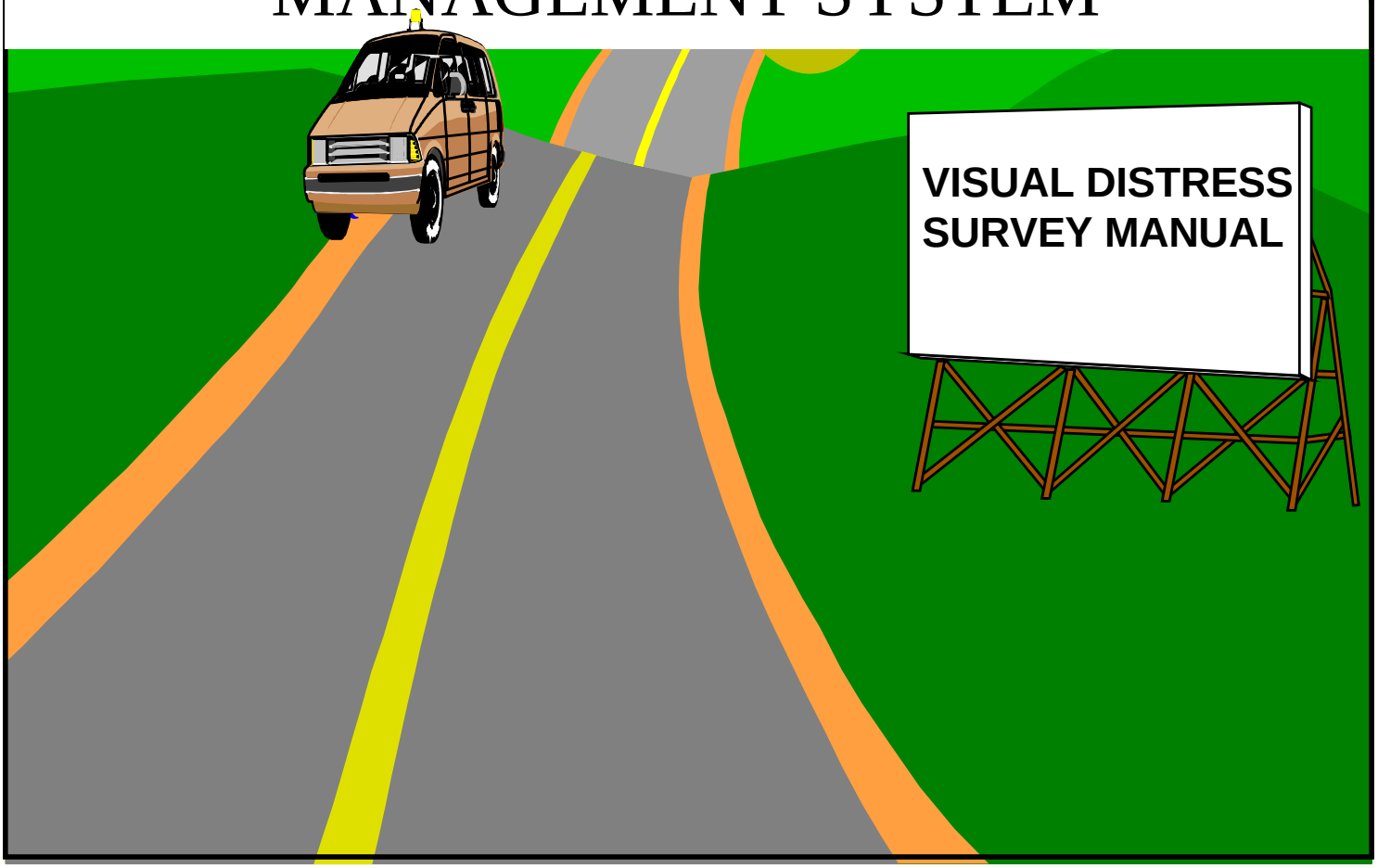
# SDDOT'S ENHANCED PAVEMENT MANAGEMENT SYSTEM



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# INTRODUCTION

In 1993, the South Dakota Department of Transportation initiated the Research Project SD93-14, Enhancement of South Dakota's Pavement Management System. As the Research Project progressed, it was determined that to better evaluate the condition of the pavement, a more detail distress survey needed to be performed by SDDOT. The Research Technical Panel identified the failure mechanisms for pavements that were prevalent and would trigger a rehabilitation or reconstruction project in South Dakota. These distresses are listed in Table 1.

| Flexible Pavements | Rigid Pavements |
|---|---|
| Transverse Cracking | D Cracking and ASR |
| Fatigue Cracking | Joint Spalling |
| Patching/Patch deterioration | Corner Cracking |
| Block Cracking | Faulting |
| Rutting | Joint Seal Damage |
| Roughness | Roughness |
| | Punchouts |

**Table 1: Failure mechanism deficiencies for flexible and rigid pavements in South Dakota.**

The Technical Panel and Deighton Associates staff then decided on categories of severity and extent for each distress. The extents and severity levels were based upon those given in the Strategic Highway Research Program's (SHRP) *Distress Identification Manual for the Long-Term Pavement Performance Project* 1993 Edition. A few modifications were made to better reflect conditions seen in South Dakota. The consultant then developed a process to collect data on the condition of the pavement based upon individual distresses.

At present, faulting, roughness and rut depth are collected by Office of Data Inventory staff with the SDDOT type road profiler. All other distresses are currently collected by a visual distress survey performed by seasonal staff of the Office of Planning & Programs. All distresses are collected by sections, the majority of which have a length of 0.250 mile. 1995 was the first year that the visual distress data had been collected on a statewide basis.

A project has been initiated that will hopefully lead to collecting pavement images with a specialized van travelling at highway speed. The visual pavement distress rating would then be performed in the office using these images. Some changes in the rating procedure may result by the change in data collection methods.

# DISTRESS DEFINITIONS

## FLEXIBLE PAVEMENT DISTRESSES

| | |
|---|---|
| **Transverse Cracking:** | Appears as cracks perpendicular to pavement centerline. |
| **Fatigue Cracking:** | Appears initially as a single longitudinal crack in the wheel path. Later appears as a series of interconnected cracks resembling alligator skin or chicken wire. |
| **Patching & Patch Deterioration:** | Appears as an area where the pavement surface has been removed and replaced, or as a localized overlay covering up another distress. A major concern with patching is whether you have a patch or an overlay, and the effect the patch has on the distress indices that the patch is covering up. To help with the determination of whether to rate a patch as a patch or an overlay, refer to page 26. |
| **Block Cracking:** | Appears as cracks which divide the surface into approximately rectangular pieces. |
| **Rut Depth*:** | Appears as a surface depression in the wheel paths. |
| **Roughness*:** | The rideability of the road section. |

*** Note: Rut Depth and Roughness are not collected during the visual distress survey.**

## RIGID PAVEMENT DISTRESSES

| | |
|---|---|
| **D-Cracking:** | Appears as a series of closely spaced crescent-shaped hairline surface cracks. The crack often causes dark coloring of the surface in the surrounding area. |
| **Alkali Silica Reactivity:** | Appears as a series of interconnected cracks. Frequently, larger cracks are oriented in the longitudinal direction of the pavement and interconnected by finer transverse or random cracks. |
| **Joint Spalling:** | Appears as the cracking, breaking, chipping, or fraying of slab edges within 2 feet (0.6 meters) of a joint or crack. |
| **Corner Cracking:** | Appears as a crack extending vertically through the entire slab depth which intersects the joints at a distance less than 6 feet from the corner of the slab. |
| **Faulting*:** | Appears as the difference in elevation across a joint or crack. |
| **Joint Seal Damage:** | Appears as any condition which enables incompressible materials and/or significant amount of water to infiltrate the joint from the surface. |
| **Punchouts:** | The area enclosed by two closely spaced (usually less than 2 feet) transverse cracks, a short longitudinal crack, and the edge of the pavement or a longitudinal joint. Will normally occur on CRCP Only. |
| **Roughness*:** | The rideability of the road section. |

*** Note: Faulting and Roughness are not collected during the visual distress survey.**

# DISTRESS SEVERITY AND EXTENT

| DEFICIENCY | LOW | MEDIUM | HIGH |
|---|---|---|---|
| Transverse Cracking | Crack <1/4 inch width or Routed & sealed crack < 1/2 inch | Crack > 1/4 inch width and/or <1/4 inch depressions | Crack > 1 inch or (Crack > 1/4 inch width & >1/4 inch depressions) |
| Fatigue Cracking | Fine parallel cracks in the wheel path(s) | Alligator pattern clearly developed | Alligator pattern clearly developed with spalling and distortion |
| Patching and Patch Deterioration | Patch shows no visual distress of any type and with a smooth ride | Patch shows low or medium severity distress of any type and/ or notable roughness | Patch shows a high severity distress of any type and/ or distinct roughness |
| Block Cracking | Random longitudinal cracks between the wheel paths, **Or** interconnected transverse and longitudinal cracks that form blocks greater than 6 ft per side | Interconnected transverse and longitudinal cracks that form blocks 3 feet to 6 feet per side | Interconnected transverse and longitudinal cracks that form blocks less than 3 feet per side |
| D Cracking & ASR | Cracks are light, with no loose or missing pieces. | Cracks are well defined and some small pieces are loose or missing. | Cracks are well developed pattern with a significant amount of loose or missing material. |
| Joint Spalling | Spalls < 3 inches wide with no significant loss of material or Joint & Spall repair patch with cracking. | Spalls 3 to 6 inches with loss of material. | Spalls > 6 inches with significant loss of material. |
| Corner Cracking | Crack not spalled with no faulting & piece not broken. | Crack spalled slightly, or faulting < 1/2 inch, or piece broken. | Crack spalled, or faulting > 1/2 inch, or piece broken. |
| Punchout | NO SEVERITY LEVELS | | |
| Joint Seal Damage | damage to < 10% of joint. | Damage to 10% - 50% of joint. | Damage to > 50% of joint. |

**Table 2: Severity levels used to describe the cracking failure mechanism deficiencies.**

| DEFICIENCY | LOW | MODERATE | HIGH | EXTREME |
|---|---|---|---|---|
| Faulting | 0.1 to 0.2” | 0.2” to 0.3” | > 0.3” | |
| Rutting | < 1/8 inch | 1/8 - 1/4 inch | 1/4 -1/2 inch | 1/2 - 3/4 inch |
| Roughness | < 170 | 170 - 195 | 195 - 225 | > 225 |

**Table 3: Severity levels used to describe the faulting, rutting and roughness failure mechanisms.**

| DEFICIENCY | LOW | MODERATE | HIGH | EXTREME |
|---|---|---|---|---|
| Transverse Cracking | > 50 ft. spacing. | >25 ft. & < 50 ft. spacing | < 25 ft. spacing. | N/A |
| Fatigue Cracking | 1% to 9% of wheel path | 10% to 24% of wheel path | 25% to 49% of wheel path | > 49 % of wheel path |
| Patching and Patch Deterioration | 1% to 9% of section | 10% to 24% of section | 25% to 49% of section | > 49 % of section |
| Block Cracking | 1% to 9% of section | 10% to 49% of section | >49% of section | N/A |
| D Cracking & ASR | 1% to 9% of slabs | 10% to 24% of slabs | 25% to 49% of slabs | > 49 % of slabs |
| Joint Spalling | 1% to 9% of joints | 10% to 24% of joints | 25% to 49% of joints | > 49 % of joints |
| Corner Cracking | 1% to 9% of slabs | 10% to 24% of slabs | 25% to 49% of slabs | > 49 % of slabs |
| Punchout | <10 per mile | 10 to 25 per mile | >25 per mile | N/A |
| Joint Seal Damage | 1% to 9% of joints | 10% to 24% of joints | 25% to 49% of joints | > 49 % of joints |

**Table 4: Extent levels used to describe the cracking failure mechanism deficiencies.**

# DISTRESS SURVEY PROCEDURE

## OVERVIEW

The distress survey processes must be able to identify and document the type, extent and all levels of severity of pavement distress, particularly the first stages of severity.

The continuous survey is conducted by driving the shoulder of the road at 8 to 15 mph. The survey is conducted from a van or minivan to provide the best (highest) perspective of the pavement deficiencies. The survey uses a two person team, a driver and a rater. The driver is responsible for running the Distance Measurement Instrument (DMI) and ensuring the correct location of the section being rated. The rater determines and rates the pavement deficiencies. On roadways with limited or no shoulder, the driver aids the rater by identifying and rating the pavement distresses that are being driven over by the van. The rater is responsible for recording the distress ratings (after discussions with the driver) on the laptop computer or on paper. The laptop computers add the obvious advantage of eliminating later keypunch time and costs.

All types of required visual pavement distresses are recorded during the survey. Severity levels and extents for each distress are shown in Tables 2 and 4. For most distresses, an extent is determined for each severity level. For transverse cracking when there is more than one level of severity of a single deficiency the "predominate" severity is recorded, with the extent being the total extent of all severities. This is further explained below in Table 5.

| DISTRESS | SEVERITY RATING RECORDING METHOD | EXTENT LEVEL RECORDING METHOD |
|---|---|---|
| **Transverse Cracking** | PREDOMINATE | TOTAL |
| **Fatigue Cracking** | INDIVIDUAL | INDIVIDUAL |
| **Patching and Patch Deterioration** | INDIVIDUAL | INDIVIDUAL |
| **Block Cracking** | INDIVIDUAL | INDIVIDUAL |
| **D Cracking & ASR** | INDIVIDUAL | INDIVIDUAL |
| **Joint Spalling** | INDIVIDUAL | INDIVIDUAL |
| **Corner Cracking** | INDIVIDUAL | INDIVIDUAL |
| **Punchout** | N/A | TOTAL |
| **Joint Seal Damage** | INDIVIDUAL | INDIVIDUAL |

**Table 5: Rating methods for individual distresses**

In conducting the continuous survey from a van, the crew must pay attention to the weather and the direction of the sun. Inclement weather has an effect on the crews ability to see pavement distress. Any weather event which covers the pavement surface (snow, rain puddles, etc.) should cause the crew to stop rating until conditions improve. Rating should also cease when weather conditions limit the crew's ability to be seen by passing traffic (fog, heavy rain, snow, etc.) in order to ensure the crew's safety. When driving into the sun, the most distresses can be seen. When driving away from the sun, the raters may not see all or even any of the pavement distresses. The driver and rater must constantly check behind them for pavement distresses so as not to miss any.

## LAPTOP OPERATION (WINDOWS 95/NT Version)

The Windows 95/NT version of the distress data collection software was written specifically for use with a pen-based touch pad laptop. The program can be used by a normal keyboard input laptop as well.

Before beginning the program, check to ensure the date on the computer is correct, since it will be inputted into the file. The distress survey program used to record the data is started by double clicking on the Distress Survey Icon on the desktop. When the program first begins, a window will pop up and ask "Please specify your crew name" (See Figure 1). Write the initials of the crewmembers with the touch pen as follows:

RI,DI

Where RI is the Raters Initials and DI is the Drivers Initials.

**Figure 1 Crew Name Window**

If the crew initials need to be changed at anytime, point to the Crew Icon on the top toolbar of the main program.

This will start the program and place the teams initials into the proper space. The program will open a window called "Edit Pavement Distresses" (See Figure 2). Notice that the drop box for Highway is highlighted. Use the touch pen to scroll down the drop box to the highway to be rated and click on the highway number (See Figure 3).

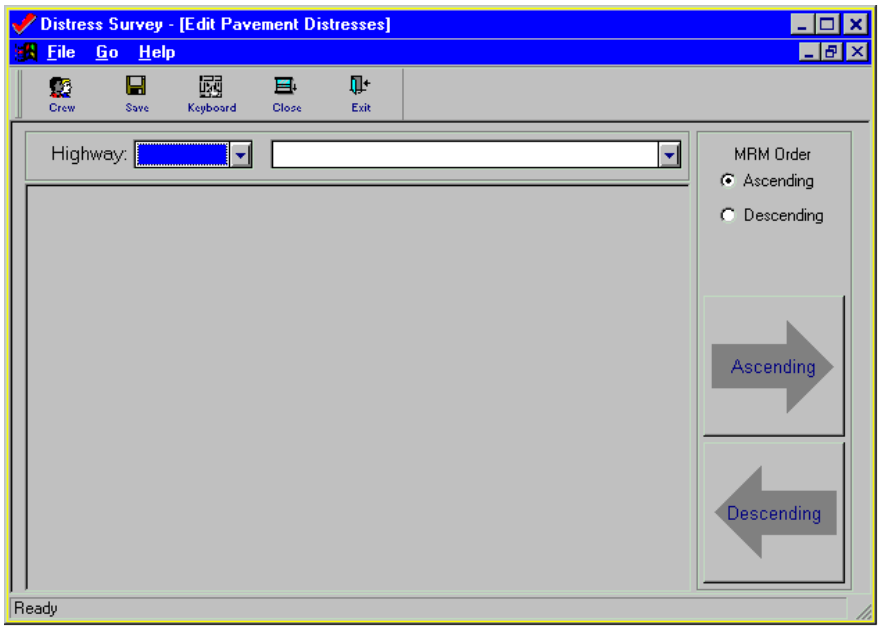


**Figure 2 Start-up Window**

The program will then jump to the first section of that highway. To the right of the Highway drop down box is the section drop down box. To the right of the section drop down box are two bullets under the title "MRM Order". The computer needs to know whether the survey is being done in the direction of Ascending (increasing) or Descending (decreasing) MRM's. MRM's generally increase from West to East and from South to North. Point to the bullet corresponding to the direction you will be surveying the highway.

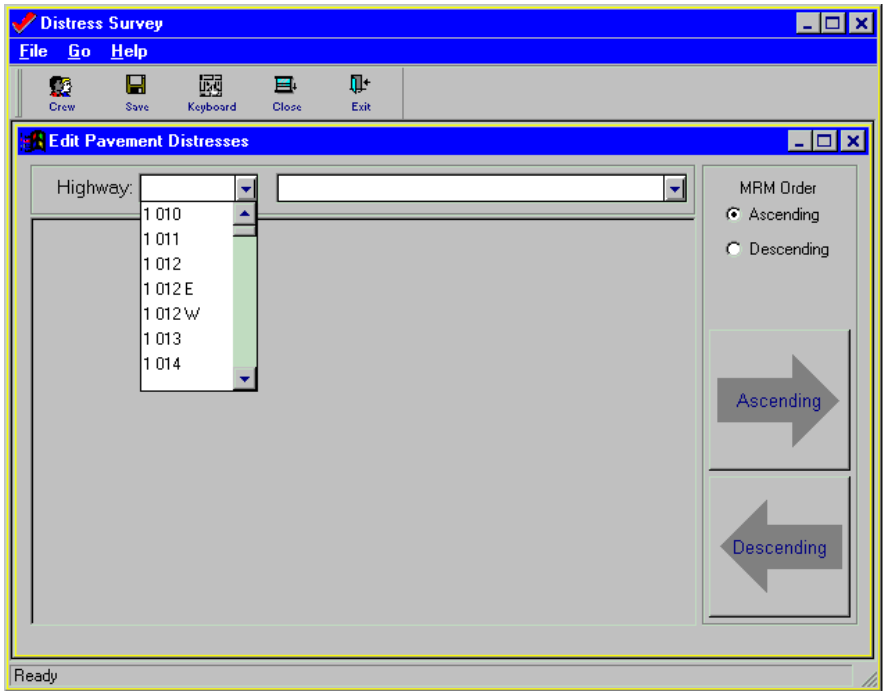


**Figure 3 Highway Drop Down Box**

Return to the section drop down box. Point to the down arrow. A list of sections will appear in either ascending or descending order, depending on which bullet is chosen (See Figure 4). Scroll down the drop box until you reach the section you are to begin with. (Note, when working in descending order, the From Description MRM is the section's beginning MRM in ascending order, choose the section below to begin with the correct section.) Before you begin rating, confirm with the driver the mileage on the DMI with the Address (starting when going ascending, ending when travelling in descending order.)

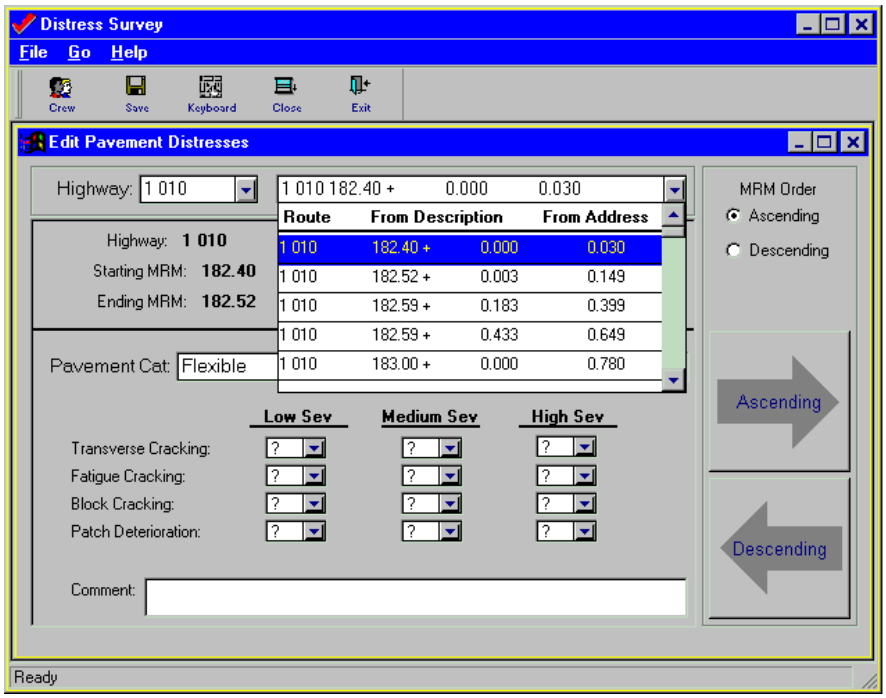


**Figure 4 Section Drop Down Box**

The program will then bring up a window with the section identification data and places for data entry. The date from the computer should be already entered into the Date field, and the Teams initials should be already entered into the Crew field. The first data field that needs to be entered is for the Pavement Cat(egory) field. The computer will display the last entered type for this section. The allowable types are : Flexible, Rigid and Gravel. Point to the drop box and choose the corresponding entry for the correct pavement type. Figures 5, 6, and 7 show the Edit Pavement Distress Window for each pavement type. Verify that the Date and Crew fields are correct.

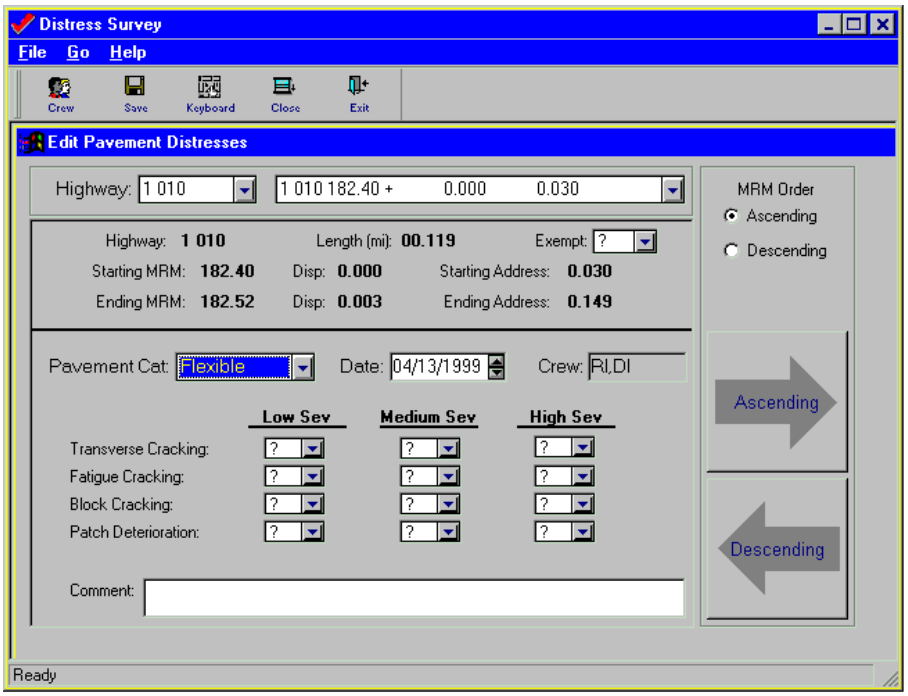


**Figure 5 Flexible Pavement Window**

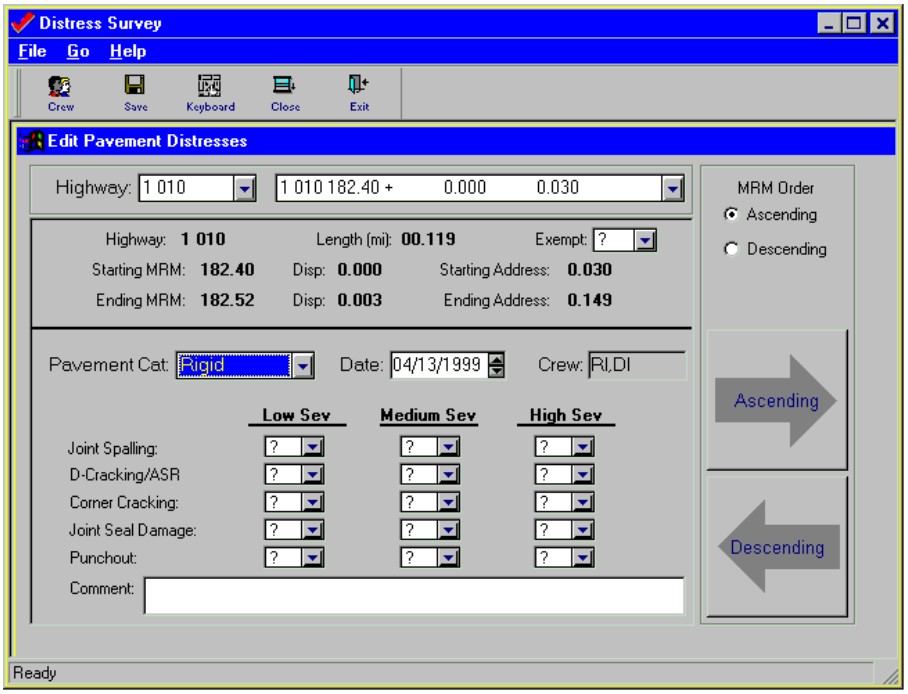


**Figure 6 Rigid Pavement Window**

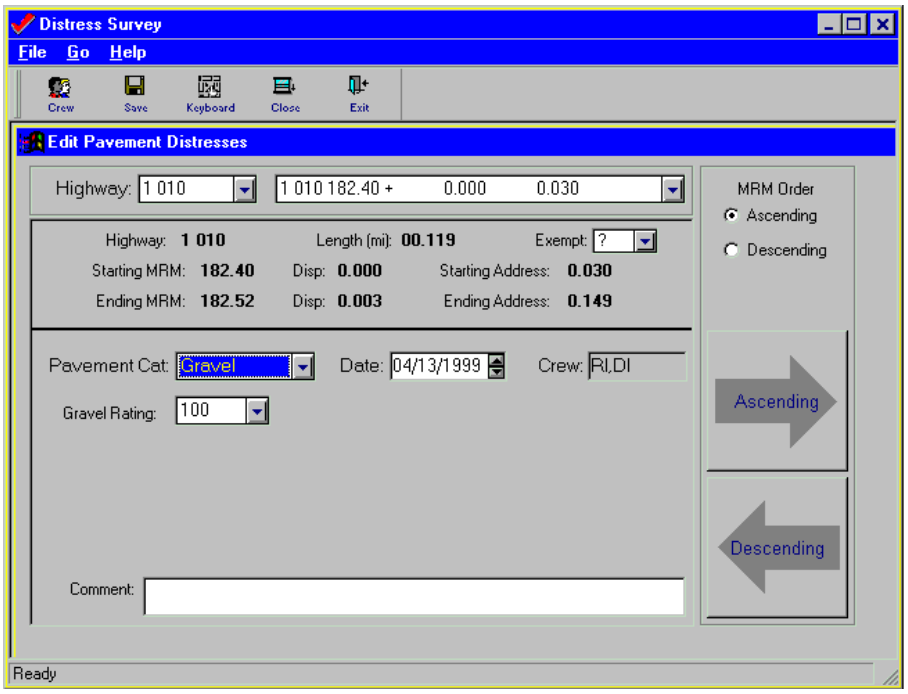


**Figure 7 Gravel Surfaced Window**

The program is now ready to rate the section of highway within the Starting and Ending Addresses. If for some reason the section cannot be rated, use the Exempt drop box to show the reason why you could not rate that section of highway. The default value of '?" is to be used if the section can be rated.

The other possible Codes to enter in this field are:

1. Bridge
2. Gravel
3. Construction
4. Other

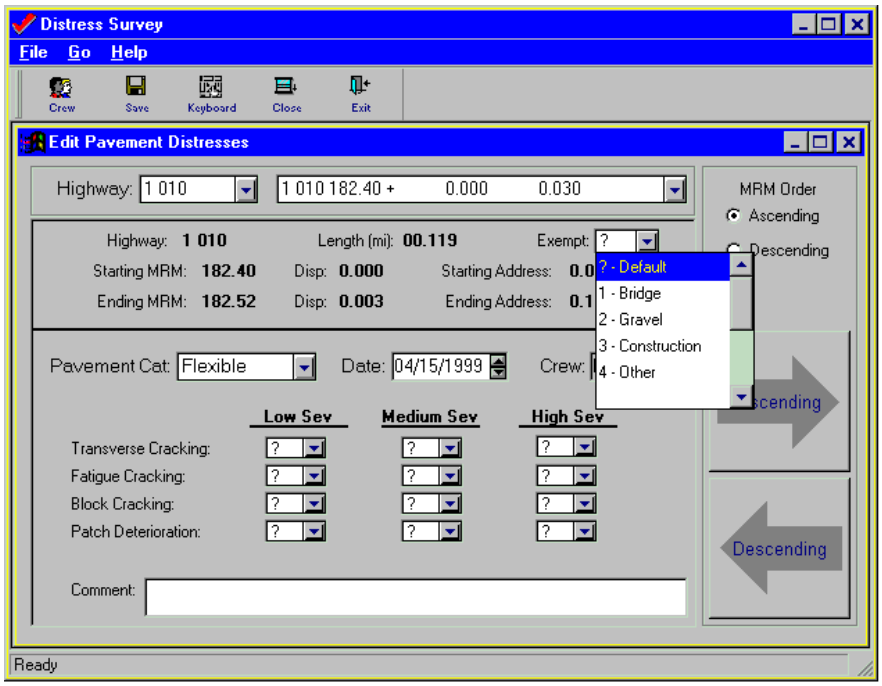


**Figure 8 Exempt Code Drop Down Box**

After entering the proper value, you can begin to rate the section of highway you are on. The individual distress fields below the identifier section of the window correspond to the chosen Pavement Cat(egory). When working on Flexible or Rigid pavement, for each individual distress, there is a drop box for the three severity levels (Low, Medium, and High). Use the drop down boxes to enter the value corresponding to the proper extent as follows:

? – Default (N)
L - Low Extent
M - Moderate Extent
H- High Extent
E- Extreme Extent (If applicable)
N - Not Found

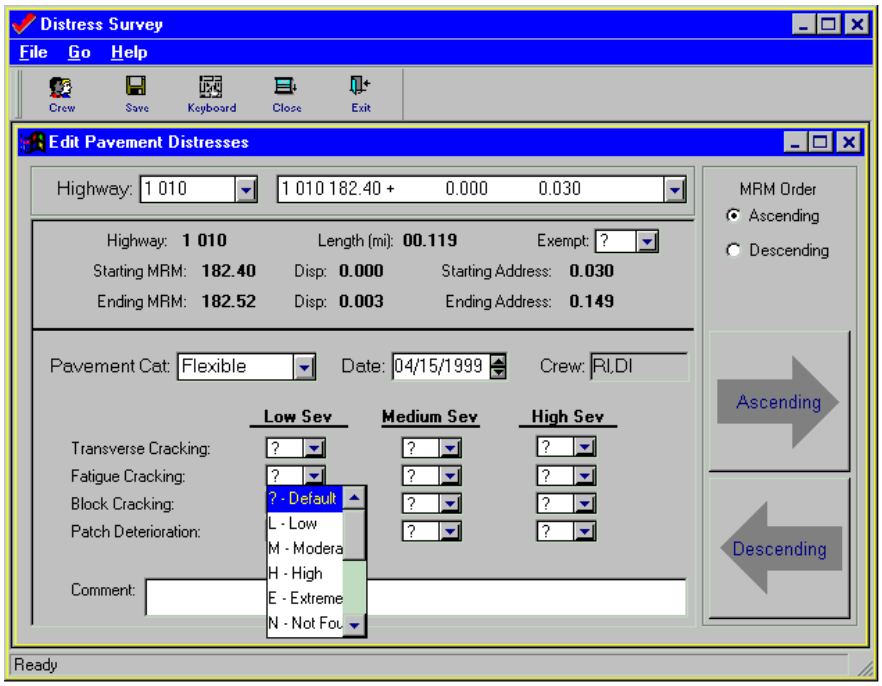


**Figure 9 Individual Distress Drop Down Box**

For Gravel Surfaced highways, only the Gravel Rating drop box appears (See figure 7). Point to the down arrow will bring up a scroll box with each number from 1 to 100 corresponding to the gravel rating (Note, if 100 is showing, you need to scroll up.).

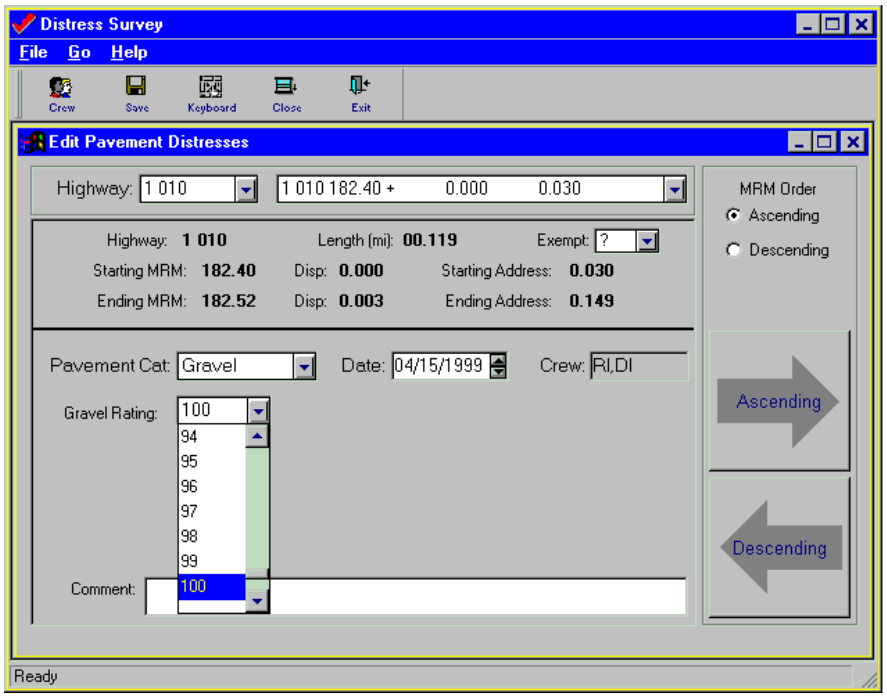


**Figure 10 Gravel Rating Drop Down Box**

When done inputting data for the section, point to the Arrow pointing to the right (It should be labeled to correspond with your ascending or descending direction) to go to the next section. When completed with the highway segment, point to the next highway in the Highway drop box if continuing to rate on a different highway. If you are planning on shutting down the laptop for a period of time, Press the Exit icon on the main toolbar. A message window will appear asking you to "Save pending changes?" Point to the corresponding Yes/No answer, and you should return to the Windows desktop.

When done for the day, you should back up the database file. Before exiting the program for the day, close the Edit Pavement Distress Window (Point to the Close icon on the main toolbar). A Tools menu should appear above the main toolbar. Under the Tools menu is the option Compress Database. Pointing to this item will create the file SURVEY.ZIP and place it in the in the Apps\Survey directory.

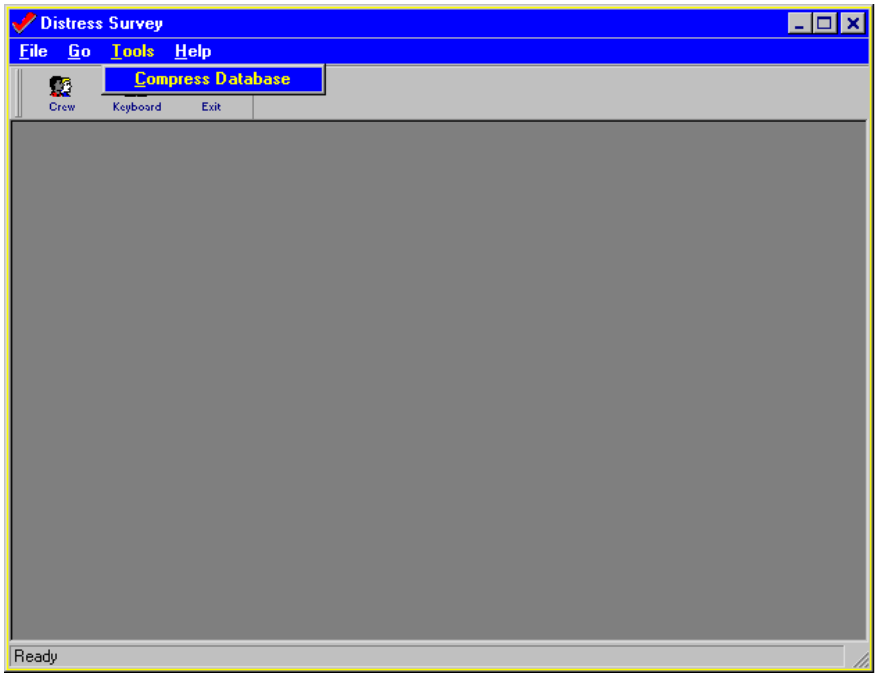


**Figure 11 Tools Menu**

## PAPER ENTRY OPERATION

In the event that the laptop is unavailable, data recording is to be done on paper. Before beginning the survey, the sections should be recorded on the paper forms. Different forms are available for use on asphalt, gravel or concrete surfaces. Copies of these forms follow. To determine which form to use, locate the highway segment to be rated in the Highway Needs Analysis Book and use the sheet for the predominant pavement type. Data is to be recorded in a similar method as on the laptop, with number corresponding to the proper extent entered under the proper severity column within the observed distress column.

# ASPHALT DISTRESS SURVEY FORM

DATE:________________________ RATERS:____________________________

| HIGHWAY | TRANSVERSE CRACKING | | | FATIGUE CRACKING | | | PATCHING AND PATCH DETERIORATION | | | BLOCK CRACKING | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SEGMENT | L | M | H | L | M | H | L | M | H | L | M | H |
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INSERT DISTRESS EXTENT RATING UNDER THE PROPER SEVERITY COLUMN FOR EACH DISTRESS

| DISTRESS TYPE | EXTENT RATING | | | |
|---|---|---|---|---|
| | **1** | **2** | **3** | **4** |
| **Transverse Cracking** | >50 ft spacing | 25 ft to 50 ft | < 25 ft | |
| **Fatigue Cracking** | 1 to 9% of wheel path | 10 to 24% of wheel path | 25 to 49% of wheel path | > 49% of wheel path |
| **Patching and Patch Deterioration** | 1 to 9% of section | 10 to 24% of section | 25 to 49% of section | > 49% of section |
| **Block Cracking** | 1 to 9% of section | 10 to 49% of section | > 50% of section | |

| DISTRESS SEVERITY LEVELS | | | |
|---|---|---|---|
| **DISTRESS TYPE** | **LOW** | **MEDIUM** | **HIGH** |
| **Transverse Cracking** | < ¼ inch wide or Routed & sealed < ½ inch wide | > ¼ and < 1 inch crack width and/or < ¼ inch depressions | > 1 inch wide or (> ¼ inch width & > ¼ inch depressions |
| **Fatigue Cracking** | Fine parallel hairline cracks in the wheel path(s) | Alligator pattern clearly developed | Alligator pattern clearly developed with spalling and distortion |
| **Patching and Patch Deterioration** | Patch shows no visual distress of any type and with a smooth ride | Patch shows low or medium severity distress of any type and/ or notable roughness | Patch shows a high severity distress of any type and/ or distinct roughness |
| **Block Cracking** | Random longitudinal cracks between the wheel paths, **Or** interconnected transverse and longitudinal cracks that form blocks greater than 6 feet per side | Interconnected transverse and longitudinal cracks that form blocks from 3 ft to 6 ft per side | Interconnected transverse and longitudinal cracks that form blocks less than 3 ft per side |

# CONCRETE DISTRESS SURVEY FORM

DATE:_____ RATERS:_____

| HIGHWAY | D CRACKING ASR | | | JOINT SPALLING | | | CORNER CRACKING | | | JOINT SEAL DAMAGE | | | PUNCHOUTS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SEGMENT | L | M | H | L | M | H | L | M | H | L | M | H | L | M | H |
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INSERT DISTRESS EXTENT RATING UNDER THE PROPER SEVERITY COLUMN FOR EACH DISTRESS

| DISTRESS TYPE | EXTENT RATING | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| **D Cracking/ASR** | 1 to 9 % of slabs | 10 to 24 % of slabs | 25 to 49% of slabs | >49% of slabs |
| **Corner Cracking** | 1 to 9 % of slabs | 10 to 24 % of slabs | 25 to 49% of slabs | >49% of slabs |
| **Joint Spalling** | 1 to 9 % of joints | 10 to 24 % of joints | 25 to 49% of joints | >49% of joints |
| **Joint Seal Damage** | 1 to 9 % of joints | 10 to 24 % of joints | 25 to 49% of joints | >49% of joints |
| **Punchouts** | < 10 per mile | 10 to 25 per mile | > 25 per mile | |

| DISTRESS SEVERITY LEVELS | | | |
|---|---|---|---|
| **DISTRESS TYPE** | **LOW** | **MEDIUM** | **HIGH** |
| **D Cracking / ASR** | Cracks are light, with no loose or missing pieces. | Cracks are well defined and some small pieces are loose or missing. | Cracks are well developed pattern with a significant amount of loose or missing material. |
| **Joint Spalling** | Spalls < 3 inches with no significant loss of material. or Joint & Spall repair patch with cracking. | Spalls 3 to 6 inches with loss of material. | Spalls > 6 inches with significant loss of material. |
| **Corner Cracking** | Crack not spalled with no faulting & piece not broken. | Crack spalled slightly, or faulting < ½ inch, or piece broken. | Crack spalled, or faulting > ½ inch, or piece broken. |
| **Joint Seal Damage** | damage to < 10% of joint. | Damage to 10 to 50% of joint. | Damage to > 50% of joint. |

# VISUAL SURVEY DISTRESSES - FLEXIBLE PAVEMENT

## TRANSVERSE CRACKING

**APPEARANCE:**

Appears as cracks perpendicular to pavement centerline.

**CAUSES:**

- Poorly constructed paving joint
- Shrinkage of the AC surface due to low temperatures or hardening of the asphalt
- Load and Moisture may accelerate the deterioration of the cracks

**LOCATION:**

May occur anywhere on the pavement surface

**SEVERITY LEVELS:**

**LOW:**

Crack width is less than 1/4 inch
or
Routed & sealed crack width less than 1/2 inch

**MEDIUM:**

Crack width is greater than 1/4 inch and less than 1 inch
and / or
Depression caused by crack is less than 1/4 inch

**HIGH:**

Crack width greater than 1 inch
or
(Crack width is greater than 1/4 inch
and
Depression caused by crack is greater than 1/4 inch)

Note: Associated cracking (Random Cracking) should cause the severity level to be increased by one level.

**EXTENTS:**

**LOW:**

Crack spacing is greater than 50 feet average spacing

**MODERATE:**

Crack spacing is less than 50 feet and greater than 25 feet average spacing

**HIGH:**

Crack spacing is less than 25 feet average spacing

LOW SEVERITY TRANSVERSE CRACKING

LOW SEVERITY TRANSVERSE CRACKING

MEDIUM SEVERITY TRANSVERSE CRACKING

MEDIUM SEVERITY TRANSVERSE CRACKING

HIGH SEVERITY TRANSVERSE CRACKING

HIGH SEVERITY TRANSVERSE CRACKING

HIGH SEVERITY TRANSVERSE CRACKING

HIGH SEVERITY TRANSVERSE CRACKING

# FATIGUE CRACKING

**APPEARANCE:**

Appears as a series of interconnected cracks resembling alligator skin or chicken wire.

**CAUSES:**

- Fatigue failure of the asphalt concrete surface (or base) under repeated traffic loading.
- Temperature and moisture may accelerate the initiation and propagation of the cracks.

**LOCATION:**

Found in the wheel paths and turning movement locations

**SEVERITY LEVELS:**

**LOW:**

Fine parallel cracks in the wheel path(s)

**MEDIUM:**

Alligator pattern clearly developed

**HIGH:**

Alligator pattern clearly developed with spalling and distortion

**EXTENTS:**

**LOW:**

1 to 9 % of the wheel path is affected

**MODERATE:**

10 to 24 % of the wheel path is affected

**HIGH:**

25 to 49 % of the wheel path is affected

**EXTREME:**

Greater than 49 % of the wheel path is affected.

LOW SEVERITY FATIGUE CRACKING

LOW SEVERITY FATIGUE CRACKING

MEDIUM SEVERITY FATIGUE CRACKING

MEDIUM SEVERITY FATIGUE CRACKING

HIGH SEVERITY FATIGUE CRACKING

HIGH SEVERITY FATIGUE CRACKING

# PATCHING AND PATCH DETERIORATION

**APPEARANCE:**

Appears as an area where the pavement surface has been removed and replaced, or as a localized overlay covering up another distress. A major concern with patching is whether you have a patch or an overlay, and the effect the patch has on the distress indices that the patch is covering up. To help with the determination of whether to rate a patch as a patch or an overlay, refer to page 26.

**CAUSES:**

- Often repair for some other distress
- May be caused by utility trenches across the roadway
- Traffic load, patch material, environment, and / or poor construction can accelerate deterioration

**LOCATION:**

Patches can occur anywhere on the pavement surface

**SEVERITY LEVELS:**

**LOW:**

Patch shows no visual distress of any type and with a smooth ride

**MEDIUM:**

Patch shows low or medium severity distress of any type and/ or notable roughness

**HIGH:**

Patch shows a high severity distress of any type and/ or distinct roughness

**EXTENTS:**

**LOW:**

1 to 9 % of the section is affected

**MODERATE:**

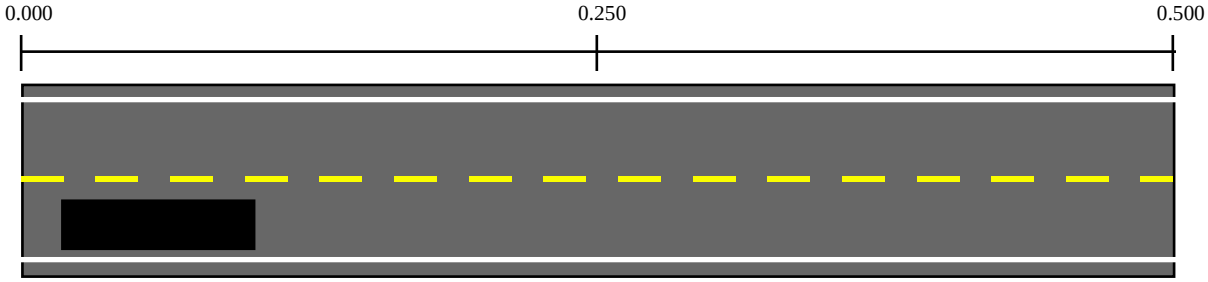
10 to 24 % of the section is affected

**HIGH:**

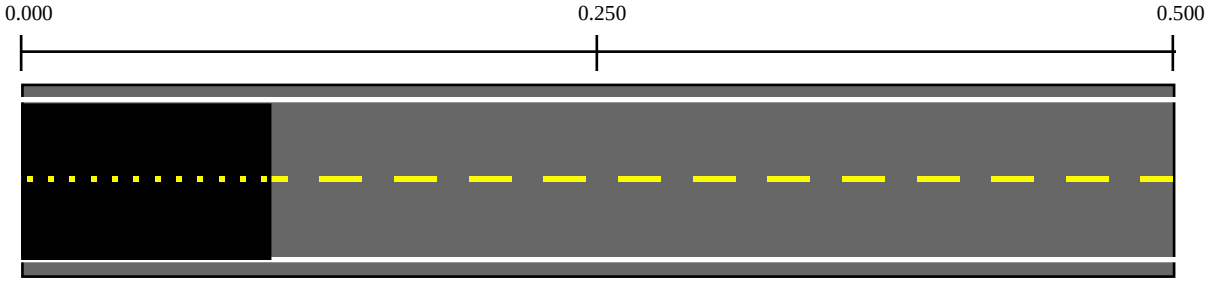
25 to 49 % of the section is affected

**EXTREME:**

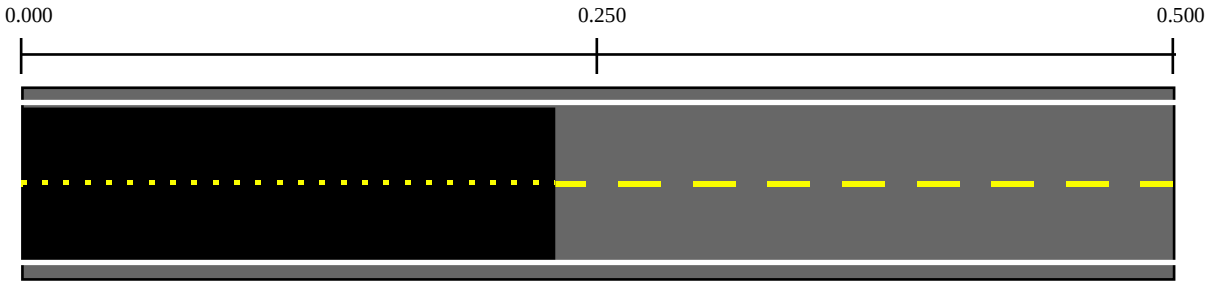
Greater than 49 % of the section is affected.



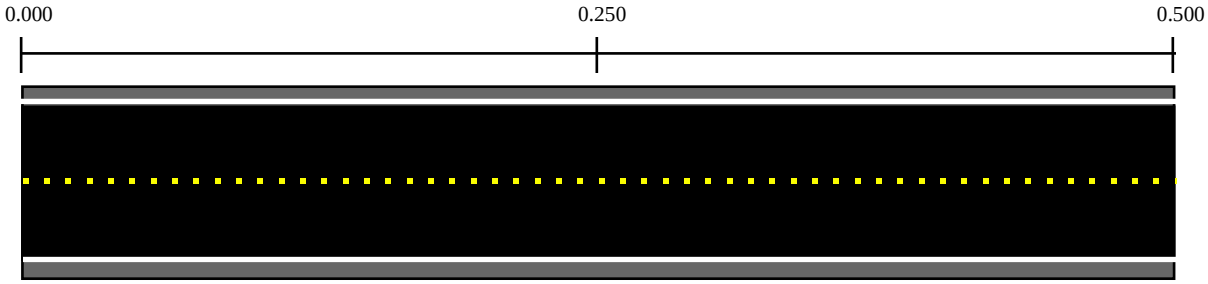

SCENARIO 1: RATE AS PATCH ONLY



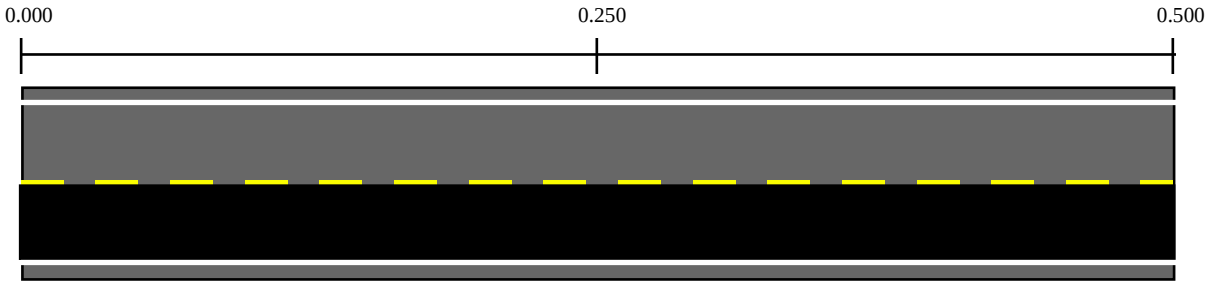

SCENARIO 2: LESS THAN HALF A SECTION, RATE AS PATCH ONLY




SCENARIO 3: GREATER THAN HALF A SECTION, RATE AS PATCH AND RATE DISTRESSES AS THEY SHOW THROUGH PATCH




SCENARIO 4: OVERLAY, RATE DISTRESSES AS THEY SHOW THROUGH




SCENARIO 5: RATE AS PATCH ONLY

**PATCH RATING SCENARIOS**

LOW SEVERITY PATCHING

LOW SEVERITY PATCHING

MEDIUM SEVERITY PATCHING

MEDIUM SEVERITY PATCHING

HIGH SEVERITY PATCHING

HIGH SEVERITY PATCHING

# BLOCK CRACKING

**APPEARANCE:**

Appears as cracks which divide the surface into approximately rectangular (or block) pieces.

**CAUSES:**

- Shrinkage of the asphalt concrete surface
- Daily temperature cycling that results in daily stress/strain cycling
- Load can increase severity of block cracking

**LOCATION:**

Normally occurs over a large portion of pavement area, but sometimes it may occur only in non-traffic areas

**SEVERITY LEVELS:**

**LOW:**

Random longitudinal cracks between the wheel paths, **Or** interconnected transverse and longitudinal cracks that form blocks greater than 6 feet per side

**MEDIUM:**

Interconnected transverse and longitudinal cracks that form blocks 3 feet to 6 feet per side

**HIGH:**

Interconnected transverse and longitudinal cracks that form blocks less than 3 feet per side

**EXTENTS:**

**LOW:**

1 to 9 % of the section

**MODERATE:**

10 to 49% of the section

**HIGH:**

Greater than 49 % of the section

LOW SEVERITY BLOCK CRACKING

LOW SEVERITY BLOCK CRACKING

MEDIUM SEVERITY BLOCK CRACKING

MEDIUM SEVERITY BLOCK CRACKING

HIGH SEVERITY BLOCK CRACKING

HIGH SEVERITY BLOCK CRACKING

## DURABILITY CRACKING
## (D-CRACKING)

**APPEARANCE:**

Appears as a series of closely spaced crescent-shaped hairline surface cracks. The crack often causes dark coloring of the surface in the surrounding area.

**CAUSES:**

- Presence of water
- Freeze-thaw cycles of the aggregate

**LOCATION:**

Adjacent and parallel to transverse and longitudinal joints and cracks, and the free edge of the pavement

**SEVERITY LEVELS: (Note: Asphalt patches on concrete pavement should be rated as if the asphalt isn't there.)**

**LOW:**
Cracks are light, with no loose or missing pieces

**MEDIUM:**
Cracks are well defined and some small pieces are loose or missing

**HIGH:**
Cracks are well developed pattern with a significant amount of loose or missing material

**EXTENTS:**

**LOW:**
1 to 9 % of the slabs are affected

**MODERATE:**
10 to 24 % of the slabs are affected

**HIGH:**
25 to 49 % of the slabs are affected

**EXTREME:**
Greater than 50 % of the slabs are affected

LOW SEVERITY D-CRACKING

LOW SEVERITY D-CRACKING

MEDIUM SEVERITY D-CRACKING

MEDIUM SEVERITY D-CRACKING

HIGH SEVERITY D-CRACKING

HIGH SEVERITY D-CRACKING

# ALKALI SILICA REACTIVITY
# (ASR)

**APPEARANCE:**

Appears as a series of interconnected cracks. Frequently, larger cracks are oriented in the longitudinal direction of the pavement and interconnected by finer transverse or random cracks.

**CAUSES:**

- Chemical reaction between the silica in the aggregate and the alkali in the sand
- Climatic conditions affect the rate of deterioration

**LOCATION:**

Entire slab, may be more noticeable in the wheel path

**SEVERITY LEVELS: (Note: Asphalt patches on concrete pavement should be rated as if the asphalt isn't there.)**

**LOW:**

Cracks are light, with no loose or missing pieces

**MEDIUM:**

Cracks are well defined and some small pieces are loose or missing

**HIGH:**

Cracks are well developed pattern with a significant amount of loose or missing material

**EXTENTS:**

**LOW:**

1 to 9 % of the slabs are affected

**MODERATE:**

10 to 24 % of the slabs are affected

**HIGH:**

25 to 49 % of the slabs are affected

**EXTREME:**

Greater than 49 % of the slabs are affected

LOW SEVERITY ASR

LOW SEVERITY ASR

MEDIUM SEVERITY ASR

MEDIUM SEVERITY ASR

HIGH SEVERITY ASR

HIGH SEVERITY ASR

# JOINT SPALLING

**APPEARANCE:**

Appears as the cracking, breaking, chipping, or fraying of slab edges within 2 feet of a joint or crack.

**CAUSES:**

- Excessive stresses at the joint caused by infiltration of incompressible materials and subsequent expansion or by traffic loading
- Disintegration of the concrete
- Weak concrete at the joint (Caused by overworking) combined with traffic loads
- Poorly designed or constructed load transfer device

**LOCATION:**

Along slab edges

**SEVERITY LEVELS: (Note: Asphalt patches on concrete pavement should be rated as if the asphalt isn't there.)**

**LOW:**

Spalls less than 3 inches wide with no significant loss of material

or

Joint & Spall Repair Patch with cracking

**MEDIUM:**

Spalls 3 to 6 inches wide and may have loss of material

**HIGH:**

Spalls greater than 6 inches wide and may have significant loss of material

**EXTENTS:**

**LOW:**

1 to 9 % of the joints are affected

**MODERATE:**

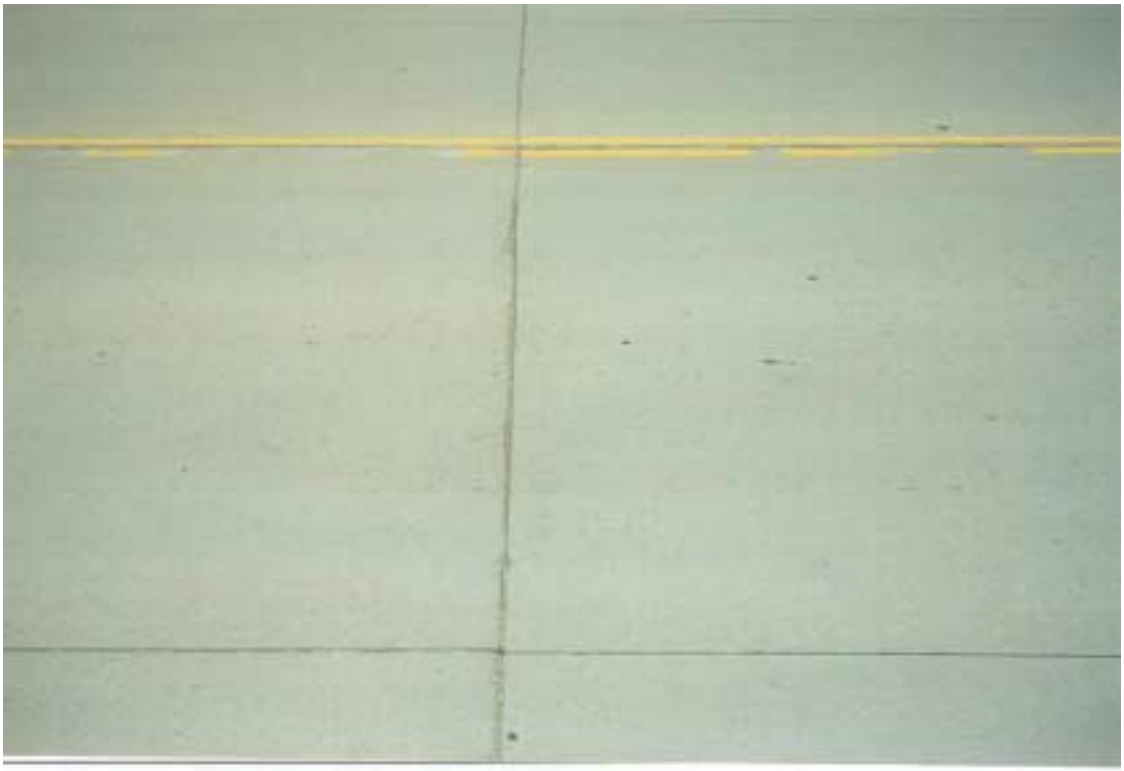
10 to 24 % of the joints are affected

**HIGH:**

25 to 49 % of the joints are affected

**EXTREME:**

Greater than 49 % of the joints are affected.



LOW SEVERITY JOINT SPALLING

LOW SEVERITY JOINT SPALLING

MEDIUM SEVERITY JOINT SPALLING

MEDIUM SEVERITY JOINT SPALLING

HIGH SEVERITY JOINT SPALLING

HIGH SEVERITY JOINT SPALLING

# CORNER CRACKING

**APPEARANCE:**

Appears as a crack extending vertically through the entire slab depth which intersects the joints at a distance less than 6 feet from the corner of the slab

**CAUSES:**

- Heavy repeated loads combined with pumping, poor load transfer across the joint, and thermal curling and moisture warping of the slab

**LOCATION:**

Located at slab corners

**SEVERITY LEVELS: (Note: Asphalt patches on concrete pavement should be rated as if the asphalt isn't there.)**

**LOW:**

Crack is not spalled with no faulting & piece is not broken

**MEDIUM:**

Crack is spalled slightly, and / or faulted less than 1/2 inch, or piece broken with tight crack

**HIGH:**

Crack is spalled, and / or faulted greater than 1/2 inch and / or piece is broken

**EXTENTS:**

**LOW:**

1 to 9 % of the slabs

**MODERATE:**

10 to 24 % of the slabs

**HIGH:**

25 to 49 % of the slabs

**EXTREME:**

Greater than 49 % of the slabs

LOW SEVERITY CORNER CRACKING

LOW SEVERITY CORNER CRACKING

MEDIUM SEVERITY CORNER CRACKING

MEDIUM SEVERITY CORNER CRACKING

HIGH SEVERITY CORNER CRACKING

HIGH SEVERITY CORNER CRACKING

# PUNCHOUTS

**APPEARANCE:**

Appears as the area enclosed by two closely spaced (usually less than 2 feet) transverse cracks, a short longitudinal crack, and the edge of the pavement or longitudinal joint. **Will occur on CRCP only.**

**CAUSES:**

- Loss of aggregate interlock at one or two of the transverse cracks
- Loss of support due to pumping

**LOCATION:**

Located near the pavement edge and / or longitudinal joints

**SEVERITY LEVELS:**

NO SEVERITY LEVELS ARE RECORDED

**EXTENTS:**

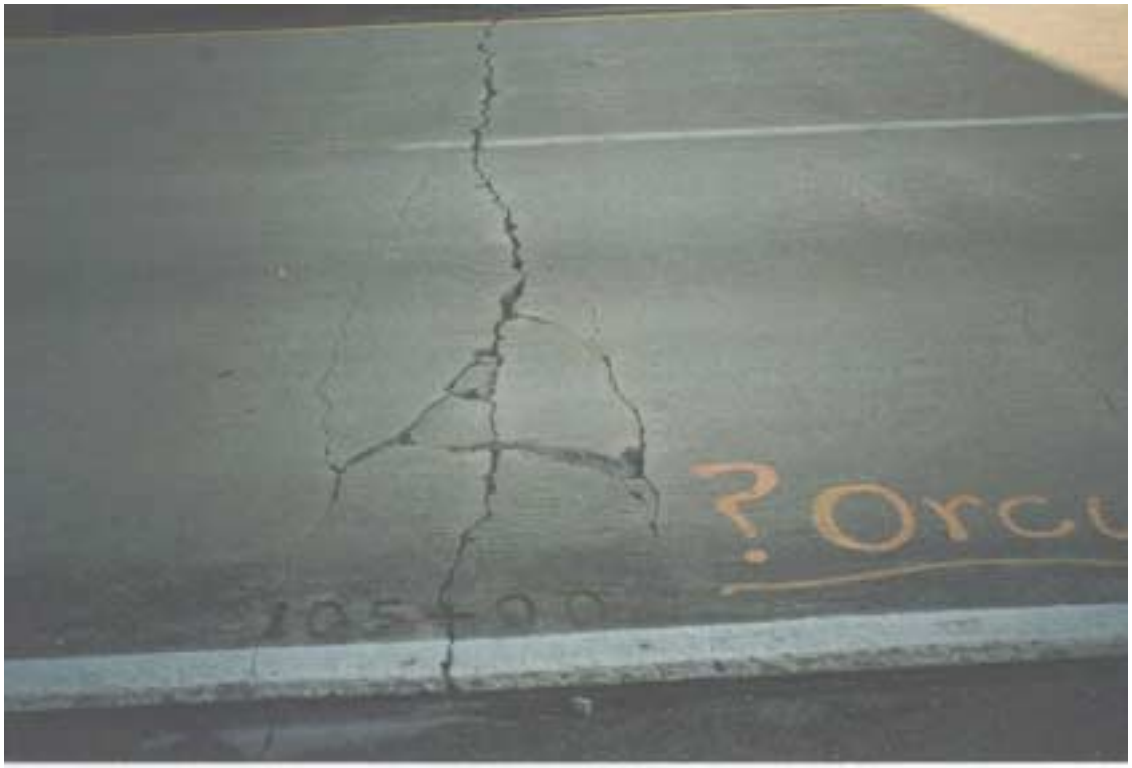
**LOW:**
Less than 10 per mile

**MODERATE:**
10 to 25 per mile

**HIGH:**
Greater than 25 per mile

PUNCHOUT

PUNCHOUT



PUNCHOUT

PUNCHOUT

# JOINT SEAL DAMAGE

**APPEARANCE:**

Appears as any condition which enables incompressible materials and / or significant amount of water to infiltrate the joint from the surface.

**CAUSES:**

- Failure to clean joint before sealing
- Infiltration of incompressible material into the joint
- Inability of material to meet performance requirements

**LOCATION:**

Along transverse joints

**SEVERITY LEVELS:**

**LOW:**
Seal damage to less than 10 % of the joint

**MEDIUM:**
Seal damage to 10 % to 50 % of the joint

**HIGH:**
Seal damage to greater than 50% of the joint

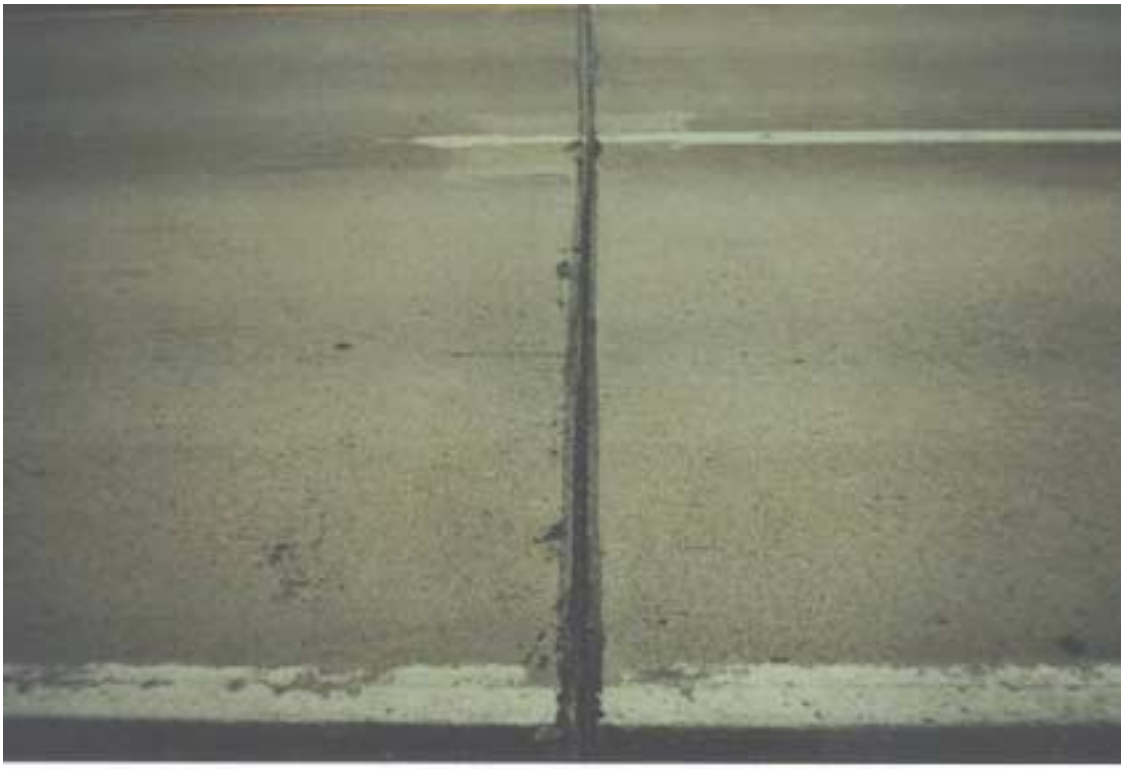
**EXTENTS:**

**LOW:**
1 to 9 % of the joints are affected

**MODERATE:**
10 to 24 % of the joints are affected

**HIGH:**
25 to 49 % of the joints are affected

**EXTREME:**
Greater than 49 % of the joints are affected.



LOW SEVERITY JOINT SEAL DAMAGE

LOW SEVERITY JOINT SEAL DAMAGE

MEDIUM SEVERITY JOINT SEAL DAMAGE

MEDIUM SEVERITY JOINT SEAL DAMAGE

HIGH SEVERITY JOINT SEAL DAMAGE

# VISUAL DISTRESS SURVEY ON GRAVEL SURFACED HIGHWAYS

Beginning in the Summer of 1996, the pavement distress survey included the rating of gravel surfaced state highways. The rating of gravel sections of the state highway system was included as an attempt to have a condition rating for every segment of highway on the state system. The rating of gravel surfaced highways is a combination of the procedure used on the paved highway system and the rating guide provided by the *Rural Road Condition Survey Guide* published by SDDOT's Office of Research in September 1995.

The rating is performed in a similar manner as on paved highways in that it is a continuous survey over the entire section. Sections for gravel surfaced highways are longer than those for paved highways in that section breaks are at every Uniform MRM only and hence are approximately 1.00 mile in length. The van does not drive on the shoulder of the road, but rather as close to center of highway as possible. The driver is still responsible for running the DMI and ensuring the correct location of the section being rated. The speed of the van while conducting the survey should be less than 40mph. The rater should move to the front passenger seat of the van in order to get a better feel for the roadway cross-section.

The rating of gravel surfaced highways differs from rating paved surfaced highways in that the highway is rated for an overall condition value. No individual distresses are rated. Each section is given a rating from 0 to 100, with 0 being unpassable and 100 being perfect condition. Gravel distresses that affect the rating are listed in Table 5. Gravel Rating Guidelines can be found in Table 6 and Maximum Condition Ratings are found in Table 7. The Gravel Distress Survey Form is following.

**DISTRESS SEVERITY LEVELS**

| DISTRESS TYPE | DEFINITION | LOW | MEDIUM | HIGH |
|---|---|---|---|---|
| **Corrugation** (Washboarding) | Closely spaced ridges & valleys at fairly regulare intervals | Ridges < 1inch deep | Ridges 1 to 3 inches deep | Ridges > 3 inches deep |
| **Dust** | Loose, flying small particles of binder & aggregate | See through | Visibility moderately obstructed | Severe visibility problem |
| **Improper Cross Section** | Road surface is not shaped or maintained to carry water to the ditches | Level Surface | Bowl-shaped Surface | Severe Surface Depressions |
| **Inadequate Roadside Drainage** | Ditches & culverts are not in good enough condition to direct & carry runoff water | Very little debris | Debris, some standing water | Lack of water runoff |
| **Loose Aggregate** | Loose aggregate particles moved away from the normal wheelpath and berms formed in the center and / or along the shoulder of the roadway | Loose < 2" thick | Loose 2 to 4 inches thick | Loose > 4 inches thick |
| **Potholes** | Bowl-shaped depressions in the roadway surface | < 2 inches deep | 2 to 4 inches deep | > 4 inches deep |
| **Ruts** | Surface depression in the wheelpath parallel to the centerline | < 1 inch deep | 1 to 3 inches deep | > 3 inches deep |

**Table 5: Gravel distress definitions and severities**

## RATING GUIDLINES

| |
|---|
| **Rating = 100 to 81** |
| Roadway surface is in excellent condition with very good rideability. The roadway has a good gravel thickness and excellent drainage. The only distress that is typically present is dusting in dry conditions. |
| **Rating = 80 to 61** |
| The roadway has adequate gravel thickness, a good crown, and good drainage characteristics. Distresses that may be present include loose aggregate and washboarding. Some slight rutting (< 1in) may exist in some areas during wet weather. |
| **Rating = 60 to 41** |
| The roadway has a good crown (3 to 6 in). Primary ditches are present on more than 50 percent of the roadway. Secondary ditches are evident along the shoulder line, and some culvert cleaning is necessary. The gravel layer is adequate, but additional aggregate is needed in isolated areas. Moderate washboarding (1 to 2 in deep) exists over 10 to 25 percent of the area, and moderate rutting (1 to 2 in) occurs in wet weather. Occasional small potholes (<2 in deep) and some loose aggregate are present. |
| **Rating = 40 to 21** |
| Travel at slow speeds (<25 mph) is required. There is little or no roadway crown, moderate to severe washboarding, severe loose aggregate, and moderate potholing. Up to 25 percent of the roadway has little or no aggregate. More than 50 percent of the ditches are inadequate, secondary ditches exist along most of the roadway, and the culverts are partially filled with debris. |
| **Rating = 20 to 0** |
| Travel on the roadway is very difficult. There is either no roadway crown or the roadway is bowl-shaped with extensive ponding. Severe ruts and potholes exist over more than 25 percent of the roadway, and many areas (> 25 percent) have little or no aggregate. There are few if any primary ditches, and secondary ditches are evident along most of the roadway. Culverts are either damaged or filled with debris |

**Table 6: Gravel rating guidelines**

## MAXIMUM CONDITION RATINGS

| DISTRESS CONDITION | SEVERITY LEVEL | | |
|---|---|---|---|
| | LOW | MEDIUM | HIGH |
| CORRUGATION > 10 PERCENT ROADWAY | 80 | 70 | 60 |
| DUSTING | 98 | 96 | 85 |
| IMPROPER CROSS SECTION > 10 PERCENT ROADWAY | 80 | 70 | 60 |
| INADEQUATE ROADSIDE DRAINAGE >10% ROADWAY | 80 | 70 | 60 |
| LOOSE AGGREGATE | 80 | 75 | 65 |
| POTHOLES | 70 | 50 | 30 |
| RUTTING | 70 | 65 | 50 |

**Table 7: Maximum gravel ratings**

# GRAVEL DISTRESS SURVEY

DATE: ______________________________ RATERS: ________________________

| SEGMENT | RATING |
|---|---|
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## RATING GUIDLINES

**Rating = 100 to 81**

Roadway surface is in excellent condition with very good rideability. The roadway has a good gravel thickness and excellent drainage. The only distress that is typically present is dusting in dry conditions.

**Rating = 80 to 61**

The roadway has adequate gravel thickness, a good crown, and good drainage characteristics. Distresses that may be present include loose aggregate and washboarding. Some slight rutting (< 1in) may exist in some areas during wet weather.

**Rating = 60 to 41**

The roadway has a good crown (3 to 6 in). Primary ditches are present on more than 50 percent of the roadway. Secondary ditches are evident along the shoulder line, and some culvert cleaning is necessary. The gravel layer is adequate, but additional aggregate is needed in isolated areas. Moderate washboarding (1 to 2 in deep) exists over 10 to 25 percent of the area, and moderate rutting (1 to 2 in) occurs in wet weather. Occasional small potholes (<2 in deep) and some loose aggregate are present.

**Rating = 40 to 21**

Travel at slow speeds (<25 mph) is required. There is little or no roadway crown, moderate to severe washboarding, severe loose aggregate, and moderate potholing. Up to 25 percent of the roadway has little or no aggregate. More than 50 percent of the ditches are inadequate, secondary ditches exist along most of the roadway, and the culverts are partially filled with debris.

**Rating = 20 to 0**

Travel on the roadway is very difficult. There is either no roadway crown or the roadway is bowl-shaped with extensive ponding. Severe ruts and potholes exist over more than 25 percent of the roadway, and many areas (> 25 percent) have little or no aggregate. There are few if any primary ditches, and secondary ditches are evident along most of the roadway. Culverts are either damaged or filled with debris.

## MAXIMUM CONDITION RATINGS

| | SEVERITY LEVEL | | |
|---|---|---|---|
| DISTRESS CONDITION | LOW | MEDIUM | HIGH |
| CORRUGATION > 10 PERCENT ROADWAY | 80 | 70 | 60 |
| DUSTING | 98 | 96 | 85 |
| IMPROPER CROSS SECTION > 10 PERCENT ROADWAY | 80 | 70 | 60 |
| INADEQUATE ROADSIDE DRAINAGE >10% ROADWAY | 80 | 70 | 60 |
| LOOSE AGGREGATE | 80 | 75 | 65 |
| POTHOLES | 70 | 50 | 30 |
| RUTTING | 70 | 65 | 50 |

## DISTRESS SEVERITY LEVELS

| DISTRESS TYPE | LOW | MEDIUM | HIGH |
|---|---|---|---|
| **Corrugation** | Ridges < 1inch deep | Ridges 1 to 3 inches deep | Ridges > 3 inches deep |
| **Dust** | See through | Visibility moderately obstructed | Severe visibility problem |
| **Improper Cross Section** | Level Surface | Bowl-shaped Surface | Severe Surface Depressions |
| **Inadequate Roadside Drainage** | Very little debris | Debris, some standing water | Lack of water runoff |
| **Loose Aggregate** | Loose < 2" thick | Loose 2 to 4 inches thick | Loose > 4 inches thick |
| **Potholes** | < 2 inches deep | 2 to 4 inches deep | > 4 inches deep |
| **Ruts** | < 1 inch deep | 1 to 3 inches deep | > 3 inches deep |

# A Discussion Regarding Pavement Distress Surveys in South Dakota

June 22, 1994

By

Newt Jackson
and
Rick Deighton

## Introduction

The purpose of this report is to present SDDOT with some recommendations regarding pavement distress data collection. This report was not specifically identified as being part of the current pavement management study. However, both the consultant and SDDOT thought it would be appropriate to provide SDDOT with a formal statement of the consultant's opinion to assist them in making a decision regarding pavement distress data collection. The opinion, offered as a set of recommendations, is based entirely on the consultant's past experience and a general understanding of the situation in South Dakota. It must be clear, however, that the recommendations made here are not the result of a rigorous study of South Dakota's data collection procedures, practices or requirements.

South Dakota DOT has already provided data collection leadership in the development of the South Dakota Profilometer, a low cost fairly accurate means to collect road roughness data. This illustrates that they are already familiar with the process of defining a data collection procedure. For the sake of completeness, however, this report will begin by presenting a review of the issues which must be addressed throughout this process.

## Distress Survey Issues

Conducting a distress survey in an agency is a process which can only begin after much thought and study has already taken place. Like many other things, there are some trade-offs to be balanced when deciding which data collection procedure to adopt. The literature is not particularly helpful in this regard. However, Paterson offers some general guidelines which will be repeated here (see: Paterson, W.D.O., & Scullion, T.; Information Systems for Road Management: Draft Guidelines on System Design and Data Issues; World Bank; Washington D.C.; September 1990; Report INU 77).

Although Paterson's report talks about data and data collection in a general sense, the discussion is particularly relevant to distress data collection. Paterson defines the following criteria to consider when selecting data items for a management system:

**Relevance:**
Every data item collected and stored should be relevant to a decision or assessment which is made regularly from the database.

**Reliability:**
The reliability of the data should be at least commensurate with the reliability desired for the decision or assessment outcome, and appropriate to the analytical model used to process the data. The reliability of data is determined from its accuracy, its spatial coverage, its completeness and its currentness.

**Affordability:**
The scope and quality of data are choices that are to be weighed against the resources required to sustain and maintain them in the long-term, and against the value of the decision outcomes.

**Appropriateness:**
The technology and resources involved in acquiring, processing and managing the data should be appropriate to the agency's capacity for maintaining the equipment, conducting the surveys, and sustaining the data processing.

It is important to mention the above issues because, so far, the pavement management study has only really addressed the first issue, relevance, to any degree of detail. The recommendations presented later in this report cover the collection of the basic pavement distress data which is definitely relevant to South Dakota conditions. In fact, these pavement distresses were the result of the first set of expert opinion meetings. They were also specifically used in the pavement performance questionnaire (see the questionnaire for a description of the distress data items). There is, therefore, no question as to the relevance of these items.

However, with respect to reliability, affordability, and appropriateness, there is some question. Indeed, settling these issues is precisely the decision facing SDDOT right now. At the risk of being criticized for talking about motherhood and apple pie, the following discussion is presented to put SDDOT's decision in the proper context.

It is very important to mention the relationship between reliability, affordability and appropriateness. This is important because the decision SDDOT faces relates to striking a balance between all of these. In other words, increasing the reliability of the data raises the cost of collecting it. It also influences the procedures which must be supported. Hence, the decision to increase reliability cannot be made without considering its effect on the cost and on the appropriateness of the final set of procedures.

At the same time, however, it would be remiss not to mention the models where this data will be used. The system being designed for SDDOT purports to be able to make project-level decisions in the context of network-level constraints. Although unlike a typical project-level system, SDDOT's system will not "design" treatments for specific projects, it will categorize the general type of treatment required over time for each pavement section. To do this, the system will need a fairly reliable description of the current level of distress and a fairly reliable method of predicting it. The system will also use the distress data to assist in getting the cost of a treatment in the proper ballpark. This too requires a fairly reliable description of the current level of distress and a fairly reliable method of predicting it. Finally, to obtain a fairly reliable method of predicting future distress, the system requires a historic record of fairly reliable distresses.

Several factors affect reliability. These are:

**Subjective versus Objective:**

Subjective rating relies on the perception of the rater. Perceptions are very sensitive to either selective or general exposure to different standards. Therefore, survey procedures should be as objective as possible and should rely to rigorous training practices.

**Manual versus Automated:**

There is an impression in the industry that automated data collection is more reliable than manual. The argument for this always seems to be related to the subjective versus objective argument. Although this is definitely true for measuring conditions such as deflection, skid, roughness and rutting, it is not true for the other distress data. The consultant has not seen any research to prove that automated distress data collection produces more reliable data than manual. In fact, the only automated means of collecting distress data is image processing, which is still very much in its infancy. All remaining methods of collecting distress data rely on a human to interpret the values.

**Sample versus continuous:**

One of the mechanisms to reduce the cost of a data collection survey is to reduce the size of the sample. Some work has been done in this area which shows that sampling can be effective. However, in general it would seem reasonable to assume that continuous data collection produces more reliable results than sampling.

**Frequency**

One of the biggest issues related to the reliability of the data refers to its currentness. Obviously, five year old distress data is less reliable than current distress data. Therefore, the more frequently the data is collected the more reliable it is.

**Safety**

Another factor affecting the reliability of distress data is the safety of the raters. If a rater is standing in the middle of a busy highway he is likely to have his mind focused on avoiding cars as opposed to counting cracks. For this reason a method of filming in the field and rating in the office was developed and is used in a number of state DOTs. Film, however, has a limitation on its ability to capture and reproduce everything a rater needs to see in order to assign a reliable value.

In light of the entire discussion presented above, it is clear that SDDOT has to make some trade-offs. With this in mind, the following discussion gives the consultant's recommendations.

## Recommendations for Pavement Distress Survey in South Dakota

### Relevance

The consultant recommends that at the very least all the distress types identified in the questionnaire be collected in South Dakota using the severities and extents discussed there. In addition, the punchout distress as described in the SHRP manual should be included for concrete pavements. Any additional distresses which SDDOT deems required should be based on the SHRP manual.

### List Types

### Manual versus Automated

The second recommendation is that South Dakota DOT begin collecting the full range of distress data manually, using well-trained field survey crews. There is still some question as to the reliability of automated pavement distress collection equipment. The collection by field survey crew in the beginning will provide a stronger basis of understanding of the process within the agency. Then, as automated collection equipment proves itself, SDDOT will be in a better position to prepare contract requirements and establish quality checks and control procedures.

### Sample versus continuous

The manual distress survey can be either by sample or continuous. Two decisions must be made to form a sample survey; 1) the length of the sample, and 2) the frequency of sampling. Unfortunately, the literature is not particularly helpful in this regard. There is no clear evidence as to the actual reliability of sampling. The limited work that has been done focuses on specific geographical areas and specific techniques. Therefore, this work is only representative of those areas and those techniques. The consultant is not aware of comparisons of this type being done on South Dakota highways.

However, common sense says that some of the advantages and disadvantages of sampling are diminished when more but shorter test sections are used. For instance, using 100m samples every 1/2 kilometer is better than using one 200m sample every kilometer.

The benefits of conducting a sample survey are:

1) Reduced cost and effort.

2) Considered adequate for network level decisions, possible adequate for some project level decisions.

3) Possible more continuous with time if the survey is conducted in the same location each time.

4) Easier to conduct check sample of 5% of the set sections.

The disadvantages of conducting a sample survey are:

1) Sample may not be truly representative.

2) Costs to conduct survey may be 1/4 to 1/2 that required for continuous survey, though the sampled area is only 1/10 to 1/5.

3) High risk of loss of district support if sample is not completely representative of the entire roadway.

The benefits of conducting a continuous survey are:

1) A continuous survey produces the most reliable results (once again this is not based on scientific evidence).

2) A continuous survey has the best odds of representing the distress the district personnel see. This is most likely to encourage and foster district acceptance of the full system.

3) Since, SDDOT is about to make a fairly significant change in its pavement management system anyway, major changes are probably more acceptable at this time than later after processes have been reestablished. Changing to a continuous survey at this time will be a lot easier and more dependable than changing one to two years from now after trying a sample survey.

The disadvantages of conducting a continuous survey are:

1) The cost is much higher than sample.

2) The amount of data produced is significantly greater which adds to the database administration costs.

The consultant recommends that SDDOT begin the new pavement management process with a continuous survey. The consultant also recommends that SDDOT begin its own research into the reliability of sample surveys in South Dakota for their collection technique. Then, SDDOT will be in a position to compare the reliability between the continuous and sample survey process. If there is a strong correlation between survey procedures for all classes of highways specific to South Dakota, then SDDOT can modify their survey procedure with no loss of data. If, on the other hand, SDDOT approaches it the other way around (starts with a sample survey and later compares that data to a continuous survey) there is a great risk of a) losing all prior data, b) losing district support, and. c) losing momentum.

The differences between sample and continuous surveys is expected to be lowest on highways whose condition is most uniform, and highest on highways whose condition is least uniform. Thus, it is expected that the difference will be least on high classification routes such as Interstate, and greatest on low classification routes such as Principal or Secondary. However, the decisions being made with the data are worth more on the higher class than the lower. Recall that the reliability of the data should be <u>at least</u> commensurate with the reliability desired for the decision or assessment outcome, and appropriate to the analytical model used to process the data. (Paterson, 1992)

**Distress Survey Process**

The distress survey processes must be able to identify and document the type, extent and all levels of severity, particularly the first stages of severity.

The continuous survey is conducted by driving the shoulder of the road at 5 to 10 mph. The survey should be conducted from a van or minivan to provide the best (highest) perspective of the pavement deficiencies. The survey uses a two person team, with driver and recorder. Both people must work as a team. Usually the driver counts the traverse cracks in flexible pavement and cracked panels in rigid pavement. The recorder keeps track of the other deficiencies and records the rating (after discussions with the driver) on either paper forms or notebook computers. The notebook computers add the obvious advantage of eliminating later key punch time and costs.

All types of required pavement distress are recorded during the survey. Where there is more than one level of severity of a single deficiency than the “predominate” severity is recorded as well as the total extent of all severities.

In conducting the continuous survey from a van, the driver must pay attention to the direction of the sun. When driving into the sun, the most distresses can be seen. When driving away from the sun, the raters may not see all or even any of the pavement distresses. The driver must constantly check the pavement distresses in the rearview mirror so as not to miss any. A van equipped with trailer mirrors are a real benefit in this regard.

**Frequency**

How often should the distress data be collected? The consultant recommends that SDDOT collect the distress data on every road section, every two years, or half the network every year. The need to collect the data at yearly intervals is usually driven by the low classification roads that may deteriorate rapidly over the winter or during the spring thaw. If this rapid deterioration results in a significant number of new projects being added to the construction program, or it results in shifting the relative position of a project within the program, then an annual survey is warranted.

Alternatively, other road agencies have used a stepwise approach to data collection. To do this SDDOT would set a threshold value on certain condition indices. If the condition index for any road section fell below this threshold, the road section would be put on the annual survey cycle. Road sections above this threshold would stay on the two year survey cycle. The only problem with this approach is the complexity involved in scheduling the survey locations every year.

**Calibration**

How can SDDOT ensure that the severity levels condition raters see are the same as those imagined by the experts when they estimated performance curves? Although calibrating the raters with the experts is difficult, it is not a big problem. First, the basic premise behind developing expert opinion curves was that they would eventually be replaced by curves developed from real data. Several years of actual data will provide the best and only calibration for the performance curves. Given the fact that the data received from the expert panel looks quite reasonable, using actual data to modify the curves will probably only result in small adjustment, say in the 10 to 30 % range.

Another reason calibration is not a big problem is that the experts can be used to develop and teach the training program. In distress data collection, precision is more important than accuracy. This means that it is far better to focus on staying consistent with time than it is to focus on trying to match the original perception of the experts exactly. This statement recognizes that : (a) SDDOT will eventually use real data to enhance expert opinion, and (b) training and quality control are the most important issues to focus on. The greatest importance to the long term use of the PMS is the development of people and procedures to ensure the continuity of the observation of the pavement deficiencies over many years and changes in personnel.

**Training**

Given the above discussion and the experience of many other road agencies, it is important to state that the survey raters must be trained and calibrated before they conduct the survey. Training usually takes a minimum of one week. During training, the raters are given a review of the process, along with details regarding location referencing, effects from sun, recording their observations, etc. Then, the raters are given a slide review of the various distresses. The slides emphasize the difference between the levels of severity and the raters are taught how to identify these differences. Basic guidelines on extents are also covered.

After a review of the basics through photos and the full range of distresses. there should be a session of random slides with the raters asked to identify the distress. This process will take most of one day. This is followed by a field exercise where the raters rate 50 + miles of pavement that has been rated by the instructors (almost mapped). The result survey are compared and reviewed with all the raters, and a second run of the slides of pavement distresses. If there are very minor differences between the raters, the process is stopped. Most likely there will be significant difference after the first run. In this case, raters are taken back through the calibration process; particularly the second run at the 50 mile survey. If major differences persist after the second cycle, there should be a strong consideration to change raters.

Finally, the distress survey is conducted on the entire highway system.

Remember, distress surveys are a measure of observed conditions not of perceived needs.

**Checking**

The reliability of the subsequent survey is measured with a check survey that is conducted by those responsible for calibrating the raters. The quality assurance survey should cover about 5% of the survey to begin with if South Dakota conducts the survey. This can later be reduced to about 2% of the first survey after several surveys. If the survey is conducted under contract then the 5% sample should be continued.

The checking approach developed in Washington State is attached for information.

# PILOT DISTRESS SURVEY SUMMARY

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The survey was conducted by Mr. Mark Potter from Nichols Consulting Engineers from Reno Nevada, with van and driver supplied by South Dakota DOT.

The consultant estimated that it would take about 200 hr. to conduct the survey. The actual time required to conduct the survey was very close to this time limit.

There were no major problems encountered during the survey processes. There was a minor problem with the time required to enter the condition survey in the computer program during the field survey. The problem seemed to relate mostly to very short distance between Mile Reference Markers MRM's listed in the MRM file. The survey was designed to enter survey data for approximately every 1/4 mile of highway. To accomplish this the computer program was loaded with all MRM's plus the added MRM's for 1/4 mile breaks. This resulted in a large number of segments with very short lengths, some as short as 30 ft. The very large number of short segments in the file made it very time consuming to enter the data into the program in the field. To correct this the data was recorded on hard copy at longer section lengths then transferred to the computer program in the office. This problem can be corrected in the future by screening the MRM locations loaded into the computer file and limiting the sections to the 1/4 mile or greater section length recommended by the consultant.

For future pavement condition surveys the Consultant recommends that SDDOT set up a check scheme to confirm the reliability of that survey. We recommend a procedure similar to that recommended by Dr. Joe Mahoney at the University of Washington [1,2].

This procedure would consist simply of SDDOT collecting their own pavement condition data on a randomly selected 5% sample of those highways rated either by SDDOT personnel or by a contractor. It assumed that the SDDOT personnel would use a manual collection procedure while the contractor would use either manual or automated collection procedures. In either case the DOT's sample would be collected manually.

The pavement condition survey data should be converted to Pavement Deficiency Index values using the defect weighting values recommended earlier in this report for the various pavement defects for both the contractors data and the matching DOT data. Both sets of data would then be tested using standard statistical paired t-tests. The paired two sample Student's t-test for means using a standard significance value of 5% would be the easiest to interpret.

To reduce the cost of collecting pavement condition the SDDOT could consider the collection only a sample of the entire State highway system. There is yet very little information about what the sample size should be that fully represent the entire pavement system. Some work was done in Texas by Dr. Joe Mahoney based on a full sample from one of the 26 Districts in the State. He found that a sample size of about 10% could be used to reasonably represent the average found on the highway system. Similar work was done in Virginia with somewhat the same findings. In the new NHI class on Pavement Management for Local Agencies Dr. Roger Smith reviewed the same issue about necessary sample size. The recommendations he put in the class notes was that a 10% sample was needed to represent the average pavements conditions. For reasonable network pavement performance projections a sample size of 20% was needed. To estimate costs associated with pavement condition over time and various actions a sample size of 30% was needed[3.] The consultants recommend that SDDOT look at the data collected on SR 281 check the sensitivity of the pavement condition data at various sample levels to represent the average conditions found on that route. Test a 5%, 10%, 15% and a 20% randomly selected sample from the same route and check to see how well it represents the same average. If a 10% sample reasonably represents the same average as the original sample then the sample sizes noted above may be followed. If higher or lower value provides a more reasonable estimate of the average value then the ranges noted above should be shifted to match.

1. Letter from Joe Mahoney to Newton Jackson dated Sept. 10, 1993

2. Telephone discussion between Newton Jackson and Joe Mahoney June 9, 1994

3. "Pavement and Road Surface Management for Local Agencies - Course Notebook" Aug. 1994 prepared by Texas Transportation Institute.