

ENGINEERING STUDY
IOWA HIGHWAY RESEARCH BOARD
PROJECT HR-223

MAINTAINING GRANULAR SURFACED ROADS

BY
STEVEN L. TRITSCH
SECONDARY ROAD RESEARCH COORDINATOR

FEBRUARY 1981

ABSTRACT

Approximately 65% of Iowa's roads are surfaced with aggregates composed of crushed limestone and/or gravel. Rural Iowan's regard these roads as a very important part of their lives. Therefore, the slide-tape presentation, "Maintaining Granular Surfaced Roads" was developed to aid the motor grader operator to better understand the procedures required to maintain aggregate surfaced roads.

A typical cross-section is presented with the proper nomenclature assigned to the roadway features to facilitate the operator's understanding of the basic terms used throughout the program. The following areas are expanded: safety, dragging, cutting, intersections, superelevations, and reporting any discrepancies.

The operator's attention to detail can enhance the economy of the state and contribute to the savings of lives on rural highways.

MAINTAINING GRANULAR SURFACED ROADS

Music up-Quick busy style

1. Black slide
 2. Scenic county road
Des Moines River Valley
 3. Farm truck on country road
 4. Mail carrier
 5. Shopping center truck
 6. Historical shot of road workers
 7. Historical shot
 8. M.S.
Farmer talking to Operator
 9. Title - "Maintaining Granular Surfaced Roads"
- ²
* Rural Iowans living along secondary roads regard those roads as a very important part of their lives. These highways provide a means of ³ transporting their commodities to market, their children to school, ⁴ * mail to their homes, and act as links ⁵ * to metropolitan shopping centers. ⁶ *
- Many rural Iowans still remember when the poll tax could be worked off by three days labor on the roads bordering ⁷ * their farms. Even today, the people assigned to maintain the county systems find that people in their district ⁸ * take a very personal interest in the roads, and don't hesitate to point out areas that are improperly maintained. ⁹ *

This presentation was developed to aid the motor grader operator in maintaining granular surfaced roads. The presentation is a guide and is not intended as a standard specification or regulation. Most of the information presented¹⁰ * can be found in the Blading Aggregate Surfaces manual available through the National Association of County Engineers.¹¹ *

Over 69,000 miles of Iowa's highways are surfaced with aggregates composed of a mixture of coarse and fine particles.¹² *

Approximately 65 percent of the roads are surfaced with crushed limestone from quarries.¹³ *

Another 35 percent is surfaced with natural sands or gravel, which are found in river beds or as natural deposits along old stream beds.¹⁴ *

Different sizes of aggregates are blended to provide the qualities needed to pack and interlock the particles.¹⁵ *

The largest aggregate is ordinarily not more than one inch in diameter.¹⁶ *

Fade music out

10. Cover of Manual

11. W.S. Gravel Road

12. Quarry

13. W.S. Gravel/sand pit

14. W.S. Crusher

15. C.U. Handful of aggregate

16. C.U. Handful of fines

- 17. W.S. Mounds of fines
- 18. Artwork of Cross-section of county road

Particles smaller than sand, called fines, are used with the larger aggregates and act as a cement ¹⁷ * when moisture is ¹⁸ present to bind the aggregates together. *

- 19. Artwork of shoulders

County roads, as seen in this cross-section, have a raised centerline which is referred to as the crown. Retaining the crown is very important and is maintained ¹⁹ by correct motor grader operation. *

- 20. General grading shot County road with good profile

Also note that the shoulders maintain continuity with the road surface before ²⁰ breaking sharply at the foreslopes. *

- 21. L.S. Grader on hill-good shoulder and profile

Correct motor grader operation maintains the crown and shoulder profile, and provides correct elevations ²¹ * and drainage which make the road safe for motor vehicle

- 22. C.U. Operator at controls

movement at speeds up to 55 MPH. ²² *

- 23. C.S. Grading moist areas

Grader operators maintain smooth aggregate roadbeds through an action referred to as dragging. ²³ *

- 24. M.S. Mixture rolling off blade

This is preferably done when the aggregate and fines are moist in order to provide a lasting binding action. ²⁴ *

The dragging and rolling action created by the grader's moldboard helps to remix the fines and aggregates and respreads them across the road's surface. * ²⁵

25. L.S. - Historical shot horse drawn grader

The grader's speed depends on the type of grader, the angle of the blade and the road's condition. Too much speed will make the blade bounce. * ²⁶ This causes alternate high and low areas which are commonly referred to as washboarding. A safe speed is about 3 miles per hour in 2nd gear. * ²⁷

26. M.S. Washboard

27. L.S. Grader with passing traffic

Because the grader operator is constantly exposed to traffic, the grader is furnished with safety equipment which must be checked on a daily basis. * ²⁸

28. M.S. - Operator places flags on moldboard

The flags on the ends of the moldboard must be in place and in good condition. * ²⁹

29. C.U. Operator cleans triangle

Check the reflective "slow moving vehicle" emblem to make sure it is in place and clean. * ³⁰

30. C.U. Operator checks headlights

All lights including the headlights, brake lights and * ³¹ turn signals should be checked, cleaned, and bulbs should be replaced if necessary. * ³²

31. C.U. Operator checks turn signals
32. C.U. Operator checks beacon

The rotating beacon or flashing light on the cab should also be clean and operational. ³³ *

33. M.S. - Operator works on grader in garage

If visibility is cut to a dangerous level by fog, rain or snow, the operator ³⁴ should not take the grader on the road. *

34. M.S.
Operator gets out of cab

The next several steps will help you set up and adjust your grader so you can produce a smooth surface. ³⁵ *

35. M.S. - Operator checks wear at middle of blade

Before starting, check the condition of the grader blade for gouges and wear. If necessary, take the worn sections from the middle and invert them so they are now at the outside of the blade. ³⁶ *

36. C.U. - Double thickness of blade at center

A double thickness of blade can also be placed across the center to increase the blade's life. In either case, when the blade is heavily worn, you will need to install new blades. ³⁷ *

37. M.S.
Blade at shoulder edge

Next, place the moldboard so the outer end is at the edge of the road's surface and next to the shoulder line. ³⁸ *

38. C.U.
Moldboard tilted forward

Tilt the moldboard forward to get a dragging action rather than a cutting action. ³⁹ *

39. M.S.
Moldboard at 30 degrees

Then adjust the angle of the mold-
board between 30 and 45 degrees. ⁴⁰ *

40. M.S.
Front end/wheels tilted

In most cases you should tilt or lean the front wheels slightly 10 to 15 degrees towards the direction you want the aggregate to roll. ⁴¹ *

41. L.S. - Grader opposite side
Gathers gravel at bridge end

Occasionally blade the road surface against the flow of traffic. This eliminates drifting of the aggregate onto the ends of bridges, intersections and railroad crossings. ⁴² *

42. M.S.
Operator with shovel

And finally, when necessary, don't hesitate to stop and repair holes, rutted areas and poor surface drainage conditions with your shovel. ⁴³ *

43. L.S.
County road with obvious crown

As you have seen, aggregate-surfaced roads are graded higher in the middle than the sides to form a crown. ⁴⁴ * The crown ⁴⁵ allows water to flow into the ditch. *

44. Art work
Road with crown
45. M.S. - Historical shot
Lincoln Way - Jefferson

Roads with poor crowns trap water, causing the crust to become saturated and break up, eventually producing ⁴⁶ * potholes, washboards and a poor riding surface. ⁴⁷ *

46. M.S. - Pothole area/lack
of crown
47. Artwork
Total road/slope

The degree of crown is the amount of slope from the middle of the road toward the shoulder. Good drainage requires a crown of 1/2 to 3/4 inch for each foot of width, measured from the center of the roadway to the outside edge.⁴⁸ *

48. M.S.
Operator looks at controls

There are several things to keep in mind when setting up your machine to obtain the proper crown.⁴⁹ *

49. C.U.
Crown gauge

The best way to measure crown is to use the "crown gauge", commonly called a slope meter, which is mounted on the motor grader.⁵⁰ *

50. M.S.
Blade sloped up at center

Use your slope meter to set your blade to the correct amount of slope by raising the end of the blade nearest the center of the road so it is higher than the blade at the outside edge of the road.⁵¹ *

51. M.S. - Secondary ditch
with water entrapped

Do NOT cut a groove at the outer edge of the road surface. If a groove is made, a secondary ditch will be formed preventing proper drainage of the road surface.⁵² *

52. C.U. - Finger scratches
hard surface of crust

Correct grading will promote the formation of a crust. When properly blended, aggregates and fines will dry to form a hard crust that provides a smooth wearing surface.⁵³ * This crust will carry traffic until that crust breaks down. It also functions to keep the base stable by shedding water.⁵⁴ *

53. C.U. - Crust with tire rolling over it

54. M.S.
Grading over a crust

When grading, the operator must not break this crust, but only smooth the surface and drag excess material across the road.⁵⁵ *

55. L.S.
Example after grading

56. M.S. Washboard area

⁵⁶
PAUSE FOR SLIDE 5 SEC. *

But eventually, traffic and climatic conditions will completely break down the crust and the road will again need reshaping.⁵⁷ *

57. M.S.
Grader at shoulder

58. C.U.
Grader on shoulder

Shoulders require maintenance procedures similar to those which apply to the roadbed.⁵⁸ *

59. C.U.
Blade at grass line

The shoulder must be shaped to allow water to drain to the foreslope. Therefore, the slope of the shoulder must be equal to or greater than the road surface.⁵⁹ *

Follow these steps for shoulder blading. Adjust the blade so the inside edge of the shoulder is at the same elevation as the outside edge of the road surface. This will allow the water to drain and eliminate the possibility of secondary ditches. ⁶⁰ *

60. M.S.
Cutting vegetation

Blade the shoulders as needed to recover loose aggregate and valuable fines. At the same time, you will destroy unwanted vegetation in these areas. ⁶¹ *

61. M.S.
Spreading windrow

Spread the loose fines and aggregate on the road surface to help build the crown and stabilize the surface aggregate. ⁶² *

62. L.S.
Blading toward shoulder

During long periods of dry weather, blading is done to remove excess loose aggregate. ⁶³ *

63. C.U. - Windrow at shoulder by covered bridge

You can store this aggregate in windrows along the shoulder. ⁶⁴ *

64. L.S. - Spreading windrows back across road

However, when adequate rainfall returns, these windrows should be spread back across the road's surface again. ⁶⁵ *

65. L.S.
Car driving along windrow

Still, windrows should be kept to a minimum to reduce the possibility of cars hitting them and causing the drivers to lose control of the vehicle. ⁶⁶ *

- 66. L.S.
Ponding at crown area

During periods of moisture caused by heavy rain or melting snow, reshaping of the road surface may be required. ⁶⁷ *

- 67. L.S.
Historical shot of mud road

Just like the good old days, under these conditions, traffic tends to scatter the aggregate, flatten the crown, ⁶⁸ * make deep ruts in the road and create rough surfaces

- 68. L.S. - Historical shot of deep pothole

similar to ⁶⁹ * washboarding. These conditions cannot be corrected by smoothing the surface. Reshaping is required. ⁷⁰ *

- 69. M.S.
Washboard

- 70. M.S.
Remixing by cutting into road

Reshaping involves mixing the aggregate base to get the correct blend of fines and different size aggregates. This BLENDED material is then bladed into a properly crowned road surface. ⁷¹ *

- 71. M.S. - Operator & foreman on county road talking

Check with the foreman to see if more aggregate or fines need to be added to the surface, particularly in rough spots, thin or washed out areas. This is called remixing. ⁷² *

- 72. M.S.
Adding new material

- Remixing is largely learned by experience and correct mixing depends on the materials at hand.⁷³ * The following steps will provide you with a foundation of knowledge from which to work.⁷⁴ *
- 73. L.S.
Historical shot of wagons
 - 74. C.U.
Moldboard at cutting position

- Tilt the moldboard UPRIGHT so it is in the CUTTING position.⁷⁵ *
- 75. M.S. - 45 degree angle swing in moldboard

- Adjust the moldboard to a 30 to 45 degree angle to produce a⁷⁶ * moving and rolling action of the mixed aggregate
- 76. M.S. - Rolling action of mixing aggregate

- toward the center of the road.⁷⁷ *
- 77. M.S.
Front wheels lean in

- Lean the front wheels at a 10 to 15 degree angle from vertical in the direction the aggregate will roll across the blade.⁷⁸ *
- 78. C.U. - Blade approaching washboard area

- Put enough pressure on the blade to cut washboard ridges.⁷⁹ *
- 79. M.S.
Washboard area

- When necessary, due to potholes or washboarding, scarify 2 to 4 inches deep. This should be done only when the aggregate is moist so it will quickly compact again.⁸⁰ *
- 80. C.U. - Operator looks out door
Shot past head into blade

- Watch the blade action and adjust as necessary to assure correct cutting and mixing.⁸¹ *
- 81. M.S. - Operator checks out partly finished area needing more passes

Check to see if more passes are needed for remixing, or to cut to the bottom of potholes and washboards, or to windrow more aggregate to the center of the road. *

- 82. M.S. - Spreading road
Sequence shots

When cutting is completed, spread the aggregate back over the road. *
Be sure to blade the material into the proper crown. *

- 83. Grader on shoulder
- 84. Artwork
Road profile

Special techniques are used at road intersections. At the intersection of two aggregate surfaced roads, you must gradually eliminate the crown on each road, * starting approximately 50 to 100 feet before the intersection. *

- 85. Artwork
Cross-section
- 86. L.S.
Grader at intersection

Check to see if another pass or two is needed to eliminate the crown. *

- 87. Crown retained on
aggregate roads

However, the crown will be retained on "through roads" which are intersected by county roads having stop signs. *

- 88. M.S. - Shoulder slope
at intersection

The shoulders should still slope in the usual fashion. Do not allow excessive superelevations to develop in the radii of intersections. *

- 89. Artwork - Paved and aggregate
road intersection and crown

At the intersection of aggregate surfaced roads and paved roads, the crown of the aggregate road is gradually eliminated 50 to 100 feet in front of the intersection. ⁹⁰ *

90. L.S. - Grader pulling aggregate on paved road

Do not allow loose aggregate to remain on the paved road. When traffic permits, pull onto the pavement, ⁹¹ * drop the blade, put the machine into reverse and pull the loose aggregate back onto the aggregate road. ⁹² *

91. M.S. - Pulling aggregate off paved road

92. M.S. - Grader runs parallel to highway

Because traffic safety procedures must be carefully observed at intersections, the operator may wish to blade PARALLEL to the pavement edge ⁹³ * or even clean it with a shovel or broom. ⁹⁴ *

93. M.S. Cleaning with shovel

94. C.U. Aggregate on tracks

Where aggregate roads cross railroads, the operator must assure that the road adjacent to the tracks is cleaned. ⁹⁵ * Once again lower the blade and pull the excess aggregate away from the tracks. ⁹⁶ *

95. M.S. Grader backing away from tracks

96. L.S. New driveway

Driveways also require special consideration. The driveway should meet the roadway at the shoulder line.

97. L.S. - Bad example driveway

⁹⁷
PAUSE 5 SEC. *

Make sure you do not grade a hump into the road where it meets the driveway.⁹⁸ *

98. M.S. - Grader at the shoulder

To grade a driveway properly, the moldboard should be adjusted to insure that the elevation of the road and the driveway are on the same plane at the shoulder line.⁹⁹ *

99. L.S. Grader approaches driveway

Where possible, correct the grade of the driveway so there is no difference in grade where it connects with the road.¹⁰⁰ *

100. M.S. - Artwork Showing no hump at shoulder

The crown of the driveway must be eliminated at its junction with the edge of the road or there will be a hump.¹⁰¹ *

101. M.S. Wood bridge/no aggregate

Bridges also require special consideration, depending on the bridge type. Most wooden bridges do not have a crown; however, most others,¹⁰² * particularly concrete bridges, do in order to provide drainage.¹⁰³ *

102. M.S. Concrete bridge/no aggregate

103. C.U. - Aggregate on concrete bridge

First check to see if the bridge is designed for aggregate cover; if there is a question, ask the County Engineer. * ¹⁰⁴

104. L.S.
Bare wood deck

Gradually shape the crown of the approach 50 to 100 feet from the bridge to fit the floor. Several passes may have to be made to insure * ¹⁰⁵ that an abrupt depression does not develop at the bridge ends. * ¹⁰⁶

105. M.S. - Bridge approach with a severe drop-off

106. M.S.
Aggregate build up

Don't let aggregate build up at the ends of a bridge. Drop your blade, * ¹⁰⁷ put the grader in reverse, and pull off the excess aggregate. * ¹⁰⁸

107. M.S.
Grader backing off deck end

108. Artwork - good example
1. approaching hill
2. top of hill
3. over the hill

Hilltops also require special care. As the front and then the rear wheels pass over the hilltop, you must gradually adjust the blade up, then back down again. * ¹⁰⁹ Otherwise, you will cut the crest off the top of the hill, as illustrated here.

109. Artwork
bad example

110. L.S.
Grader going down a hill

¹¹⁰
PAUSE 5 SEC. *

When going down hill, shift into a lower gear. This will tend to reduce washboarding due to a bouncing blade action caused by too much speed. * ¹¹¹

111. Artwork
1. grader on hill
2. grader at hill bottom

Do not use the blade as a brake on hills. Increased blade pressure will cause you to cut the grade steeper and also cause an accumulation of excess aggregate at the bottom of the hill.¹¹² *

112. Artwork
1. front wheels on bottom
wheels raised
 2. wheels straddle valley
blade lowered
 3. wheels on high side
blade raised

Therefore, when grading valleys, retain the blade in normal position as the front wheels pass over the valley bottom; then gradually lower the blade as it passes over the lowest elevation and gradually raise it again as the rear wheels pass over the bottom of the valley.¹¹³ *

113. L.S. - Covered bridge
at a curve

At curves, superelevations must be retained to prevent vehicles from sliding off the road due to centrifugal force.¹¹⁴ *

114. Artwork
superelevation

Superelevation is where the outside edge of the road surface is higher than the inside edge. The tighter the curve, the more superelevation will be needed.¹¹⁵ *

115. Artwork
Incremented superelevation

Grading from a non-elevated area with a crown into a superelevated curve without a crown, and into a crowned area again, should be done gradually. Begin to eliminate the crown 50 to 100 feet from the curve. ¹¹⁶ *

116. Artwork
shoulder at curve

At curves, shoulders are to be sloped downward from the superelevated part of the road's edge to the foreslopes. ¹¹⁷ *

117. C.U. - Operator at
cracked bridge

At district meetings, or even while blading, the conscientious operator must inform the foreman about certain conditions that need attention. ¹¹⁸ *

118. C.U. - Plugged culvert

Typical situations may include damaged culverts and pipes, ditches that no longer drain, ¹¹⁹ * broken reflectors, signs that need replacing or moving, ¹²⁰ * or areas with high degrees of erosion.

119. C.U. - Broken reflector

120. M.S. - Erosion

121. M.S. Farmer talking
to grader operator

¹²¹
PAUSE 3 SEC. *

MUSIC UP
(Quick-busy style)

In addition, all complaints of people living in the district should be reported to the foreman for consideration. ¹²² *

122. C.U.
Operator in grader

As you have seen, a proficient and responsible operator has an important job. The operator's attention to detail can enhance the economy of the State ¹²³ * and contribute to the saving of lives through safe secondary road systems. ¹²⁴ *

123. W.S.
Operator waves to farmer

124. Credit slide

Iowa Highway Research Board
Project HR-223
Highway Division
November, 1980

125. Credit Slide

¹²⁵
* Special thanks for their assistance.
Boone, Grundy, Madison and Story
County Secondary Road Departments.

126. Credit Slide

¹²⁶
* Technical Assistance
Steven L. Tritsch

Photography
W. C. Burns

Narration
Skip Nelson

127. Black Slide

¹²⁷
*

Fade music out