



PDHonline Course C186 (8 PDH)

Gravel Roads Design and Maintenance

Instructor: John C. Huang, Ph.D., PE

2020

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U.S. Department
of Transportation
**Federal Highway
Administration**

Gravel Roads

Maintenance and Design Manual

South Dakota Local Transportation
Assistance Program (SD LTAP)

November 2000



Notice

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Gravel Roads Maintenance and Design Manual

Ken Skorseth

Ali A. Selim, Ph.D., P.E.

Acknowledgements

The need for a comprehensive manual that addresses most issues that deal with gravel road maintenance has been recognized by several entities across the states and the world.

The Federal Highway Administration (FHWA) asked the South Dakota Local Transportation Assistance Program (SD LTAP) to put together a new Gravel Road Manual that can be used by all regions of the United States and even other countries. The SD LTAP formed a technical review committee to help guide the project. They critiqued several versions of this manual at various stages of development.

Our sincere appreciation is extended to the following committee members:

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Ali Selim, Ph.D., P.E., Director, SD LTAP
Ken Skorseth, Field Operation Manager, SD LTAP

List of Acronyms

| | |
|-----------------------|--|
| AASHTO | American Association of State Highway and Transportation Officials |
| ADT | Average Daily Traffic |
| ASTM | American Society of Testing and Materials |
| ΔPSI | Allowable serviceability loss |
| DOT | Department of Transportation |
| E_{BS} | Elastic modulus of aggregate base layer |
| E_{SB} | Elastic modulus of aggregate sub-base layer |
| ESAL | Equivalent single axle load (18,000 lbs.) |
| FHWA | Federal Highway Administration |
| LL | Liquid Limit |
| LTAP | Local Transportation (Technical) Assistance Program |
| M_R | Resilient Modulus |
| MUTCD | Manual on Uniform Traffic Control Devices |
| PI | Plasticity Index = LL – PL |
| PCF | Pounds per cubic foot |
| PL | Plastic Limit |
| PSI | Pounds per square inch |
| RD | Allowable rutting in surface layer |
| ROW | Right-of-Way |

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Forward

There are over 1.6 million miles of unpaved roads (53% of all roads) in the United States. In some nations, the road network is predominantly unpaved and generally consists of gravel roads. This manual was developed with a major emphasis on the maintenance of gravel roads, including some basic design elements.

Gravel roads are generally the lowest service provided to the traveling public and are usually considered greatly inferior to paved roads. Yet, in many rural regions, the volume of traffic is so low that paving and maintaining a paved road is not economically feasible. In many cases, gravel roads exist to provide a means of getting agricultural products in and out of farm fields, timber out of forests, or as access to remote areas such as campgrounds and lakes. Many gravel roads serve rural residents as well. Many of these roads will remain unpaved due to very low traffic volume and/or lack of funds to adequately improve the subgrade and base before applying pavement layer(s). In some countries, economic constraints mean gravel roads are the only type that can be provided.

The purpose of this manual is to provide clear and helpful information for doing a better job of maintaining gravel roads. It is recognized that very little technical help is available to small agencies that are responsible for managing these roads. Gravel maintenance has traditionally been "more of an art than a science" and very few formal standards exist. This leads to many arguments between grader operators, managers, and motorists over questions such as: What is enough surface crown? What is too much? What causes corrugation? This manual contains guidelines to help answer these and other questions about the maintenance of gravel roads.

This manual is designed for the benefit of elected officials, managers, and grader operators who are responsible for designing and maintaining gravel roads. The information provided in this manual is as nontechnical as possible without sacrificing clear guidelines and instructions on how to do the job right.

Introduction

Good gravel road maintenance or rehabilitation depends on two basic principles: proper use of a motorgrader (or other grading device) and use of good surface gravel. The use of the grader to properly shape the road is obvious to almost everyone, but the quality and volume of gravel needed is not as well understood. It seems that most gravel maintenance/rehabilitation problems are blamed on the grader operator when the actual problem is often material related. This is particularly true when dealing with the problem of corrugation or “washboarding.” The problem is often perceived as being caused by the grader but is primarily caused by the material itself. This manual will help provide a better understanding of what makes good surface gravel.

Another important matter to consider is the dramatic change in the vehicles and equipment using low volume roads. Trucks and agricultural equipment are increasing in size and horsepower. The trend is toward even larger machinery. The effect of larger and heavier vehicles on our paved roads is well understood. There is a definite need to build stronger bases and pavements. But the effect on gravel roads is just as serious and often is not recognized. For this reason, a section on the design of gravel roads is included. The strength of the subgrade and depth of the material needed to carry today’s heavy loads must be considered. Proper drainage is also important.

The final section of the manual covers innovations in the gravel road maintenance/rehabilitation industry. Change is constant in almost every aspect of this modern world and maintaining gravel roads is no exception. There are new ways of stabilizing roads, new methods of dust control, new and different kinds of equipment available for maintenance/rehabilitation of gravel roads, and even new surface materials such as recycled asphalt being used. Not all of these innovations may be available or practical for every local government entity, but everyone is encouraged to take an objective look at each of them. Then an informed decision can be made about changing the way gravel roads are designed and maintained within a particular jurisdiction.



Summary

The first and most basic thing to understand in road maintenance is proper shape of the cross section. The road surface must have enough crown to drain water to the shoulder, but not excessive crown, which makes the road hard to travel safely. Then, the shoulder area must not be higher than the edge of the traveled portion of the road. A high shoulder prevents water from draining to the ditch and therefore needs to be eliminated. Finally, a ditch must be established and maintained to drain water away from the roadside. Culverts and bridges at the right location and elevation are essential for carrying water under and away from the road.

Once the correct shape is established on a roadway and drainage matters are taken care of, attention must be given to obtaining and properly placing good gravel. It is very important to understand the makeup of good gravel. Simply stated, it is a proper blend of stone, sand and fine-sized particles. Materials vary greatly from region to region, but it is wise to use the best material available. Gravel must also be handled properly. Avoiding segregation while processing and handling material is important to maintain the quality of gravel. Calculating the volume of material and allowing for shrinkage from compaction is also needed to get the desired depth of surfacing on the road.

When proper shape is established and good surface gravel is placed, many gravel road maintenance problems simply go away and road users are provided the best service possible from gravel roads.



Key to Screen Analysis and P.I. Worksheet

1. This is important data, especially for the sake of others who may use the information in the future. Proper data when submitting the sample for testing is critical. Too often, certain information is missing from the heading of the analysis worksheet. Always check to see that the information is correct.
2. This section, along with the next section, gives the breakdown of size (gradation) of the material. This alone tells a lot about material. Is it too coarse or fine, or is the blend of stone, sand, and fines wrong? Notice that the top section of gradation shows all material retained on the #4 sieve and larger. This is the stone-size category.
3. The bottom left section gives the gradation breakdown of sand sized particles on the appropriate sieves from #8 through #80 as well as the percentage of fines which will pass the #100 or 200 sieves.
4. This section is important in determining the stability or strength that the material will have when used as a base material and also the "binding characteristic" that material will have as surface gravel. The PI or plasticity index is of particular importance. Surface gravel needs a minimum index of 3 to assure a small percentage of true clays for binder. Good base gravel needs no plasticity and ideally should be clean and drainable to retain strength for supporting the pavement above it.
5. This section is not as important for base or surface materials, but is critical in determining the quality of material for making asphalt concrete since it shows the durability or "soundness" of aggregate. However, in some regions where aggregate is known to be poor, this test is good even for surface gravel.
6. This final section is very important when testing material for use in asphalt or base. However, it can be very useful even in testing base or surface gravel because it shows what percentage of the stone has at least one fractured face. When crushing pit-run type gravels, many of the small, natural stones will go through the crushing plant without being fractured. Gravel has more strength when there are more crushed particles since they will interlock better with the particles surrounding them. Natural stone with a rounded shape will tend to shift and move under loads more easily.

Appendix D: When to Pave a Gravel* Road

by Kentucky Transportation Center, University of Kentucky at Lexington,KY

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- A Word About the Term “Paved”
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*Gravel as used here may refer to sand and gravel,or to crushed stone.

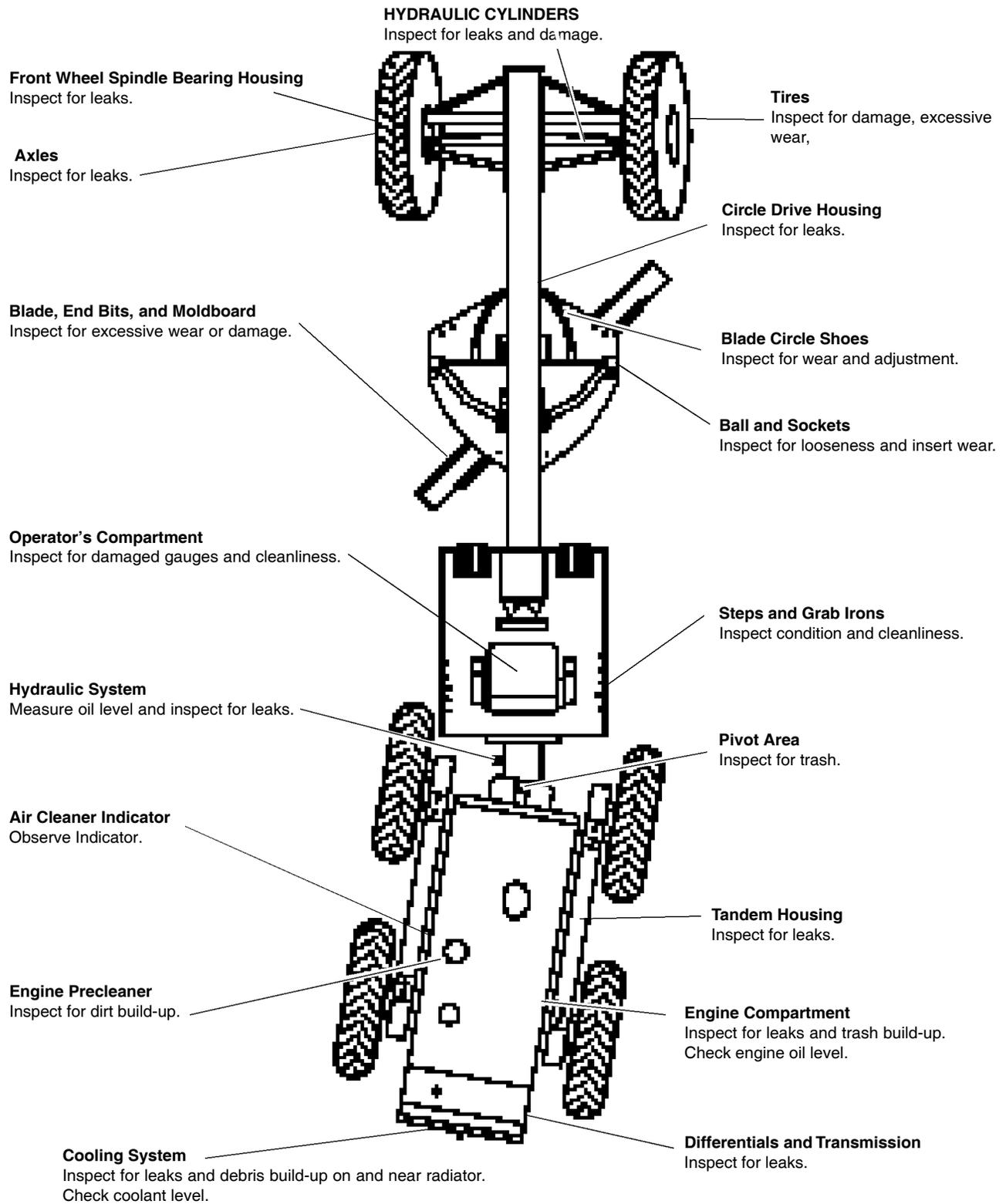


Figure 19: Walk-around Inspection Diagram (From *Maintaining Gravel Roads Training Manual*, 1999. Maine Department of Transportation, Federal Highway Administration.)

