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# Gravel Roads

## Maintenance and Design Manual

South Dakota Local Transportation Assistance Program (SD LTAP)

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# Gravel Roads
# Maintenance and Design Manual

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# 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.

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# Definition of Terms

**Articulation:** As used in this manual, it refers to a machine with a jointed main frame. This assists in steering the machine, allowing it to work in an angled configuration, yet move forward in a straight line.

**Ballast:** Extra weight added to a machine such as iron weights mounted to the wheels or frame. Liquid material such as a water/calcium chloride solution placed in the tires can also serve as ballast.

**Density:** The weight of material in pounds or kilograms per unit of volume (cubic feet or meters).

**Grader:** Any device either self-propelled or mounted on another machine used for final shaping and maintenance of earth or aggregate surfaces. Occasionally, a simple, towed drag-type device is referred to as a grader.

**Gravel:** A mix of stone, sand and fine-sized particles used as sub-base, base or surfacing on a road. In some regions, it may be defined as aggregate.

**Moisture Content:** (in percent) That portion of the total weight of material that exists as water.

**Moldboard:** The part of the grader that is actually used to cut, mix, windrow and spread material.

**Motor Grader:** Any self-propelled machine designed primarily for the final mixing and shaping of dirt or surfacing material. Sometimes referred to as a maintainer, patrol, or simply a "blade."

**Optimum Moisture:** The percentage of water (by weight) in material that allows it to be compacted to achieve greatest density.

**Paved Road:** Any road that has a semi-permanent surface placed on it such as asphalt or concrete. Gravel surfaced roads are virtually always referred to as unpaved roads.

**Pit:** An area where a natural deposit of stone, sand and/or fine material is removed from the earth.

**Quarry:** An area where solid stone is removed from the earth generally by ripping, drilling and/or blasting. The stone is then crushed and processed into useable sizes.

**Segregation:** A problem that arises when the coarse and fine material separates and no longer forms a uniform blend of material.

**Windrow:** A ridge or long, narrow pile of material placed by grader while performing construction or maintenance operations.

# List of Acronyms

| | |
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| 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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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.