

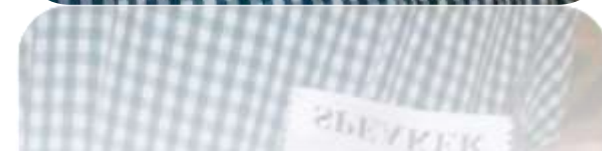
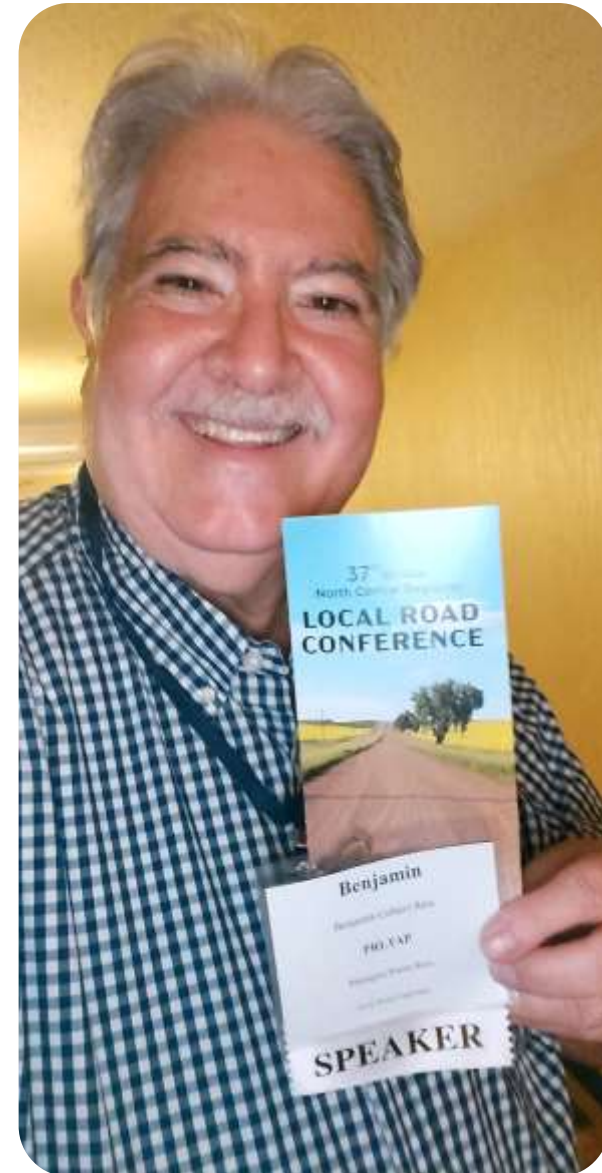


The Evaluation of Gravel/Unsurfaced Roads: Strength and Safety Considerations

BENJAMÍN COLUCCI- RÍOS, PUERTO RICO LTAP

OCTOBER 20, 2022

GOOD MORNING!



My Journey to Rapid City, South Dakota



Tripadvisor.com



In Memoriam

Eldon J. Yoder
&
O.G. SHURIG

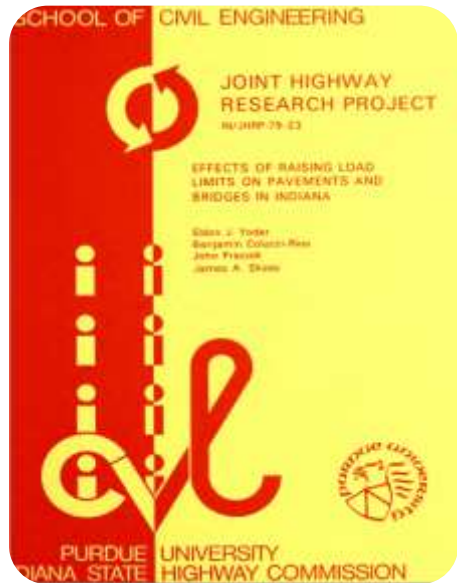


“Unpaved roads play an important role in the economic and social development of a country...

...unpaved roads are a fundamental means of communication between urban and rural areas, they allow internal movements, so that agricultural, industrial and other types of products to reach their destination, as well as access to services.”



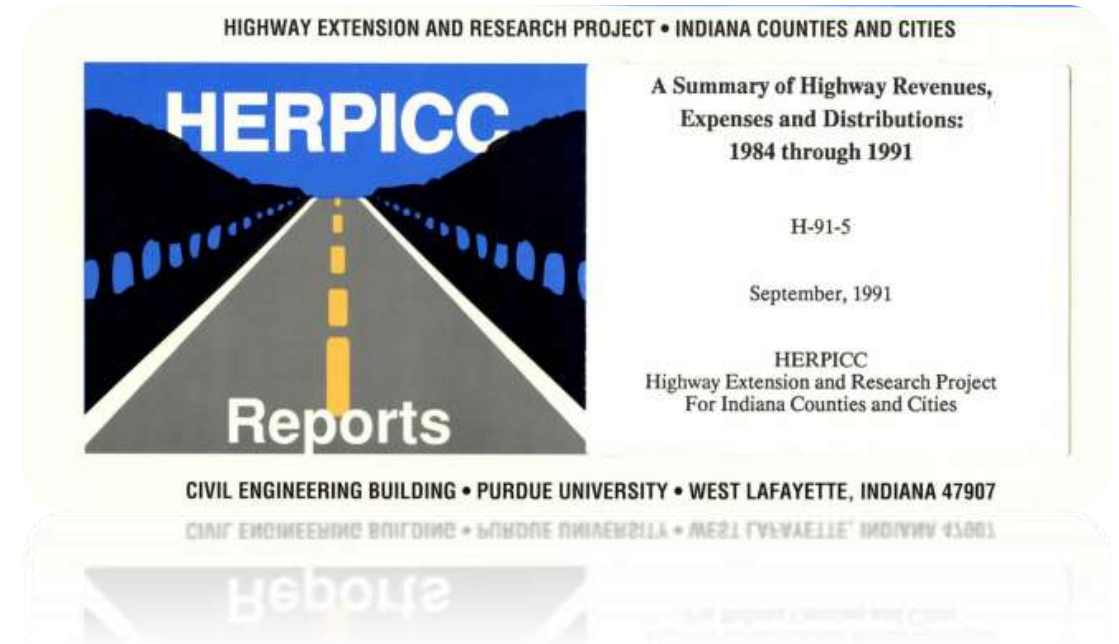
My Beginnings with Gravel Roads in the Late 70's and Early 80's



Thank you Prof. Yoder for the opportunity and motivation to always strive to be the best and to go for my dream

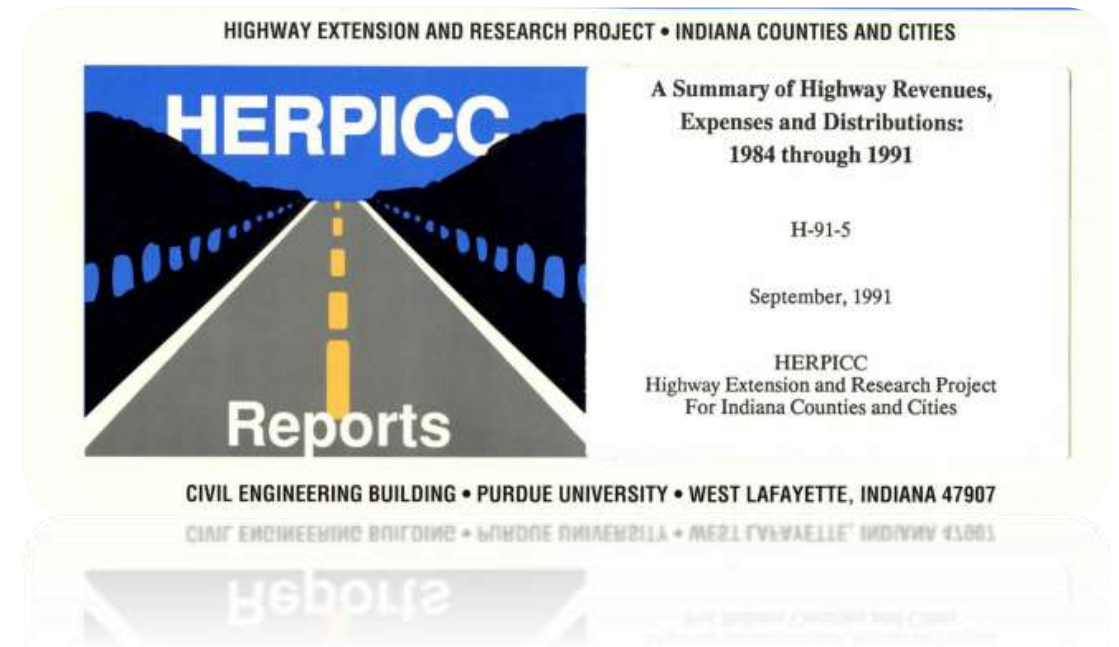
The Highway Extension and Research Project for Indiana Counties Chapter 331 of the 1959 Acts

- Provides for the conduct of county highway research and extension by Purdue University
- The policy of this act to facilitate the finding and dissemination of new knowledge concerning the county highway system, its application, and to seek ways of improving the financing and administration of the county highway system
- The purpose of developing and disseminating helpful information concerning county highway system planning, design, construction, operation, maintenance, financing, and administration



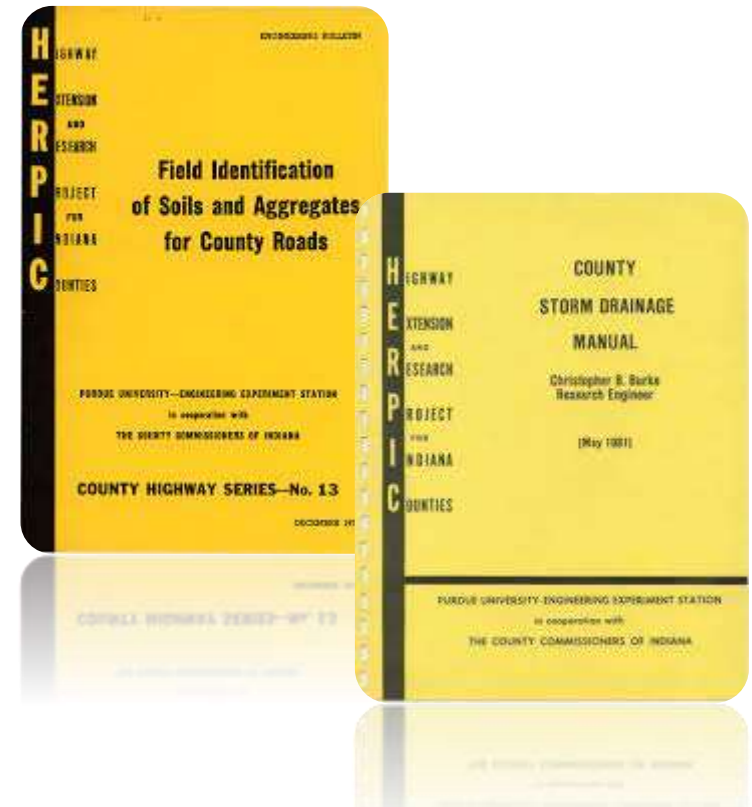
The Highway Extension and Research Project for Indiana Counties Extension Work with Individual Counties

- Assisting individual counties with specific problem
- Consultation and advice is given on the many phases of construction, maintenance and administration
- HERPIC extension activities tend to develop uniformity in policy, procedures and practices
- Consulting with individual counties much information is gathered on the types and extent of county highway problems



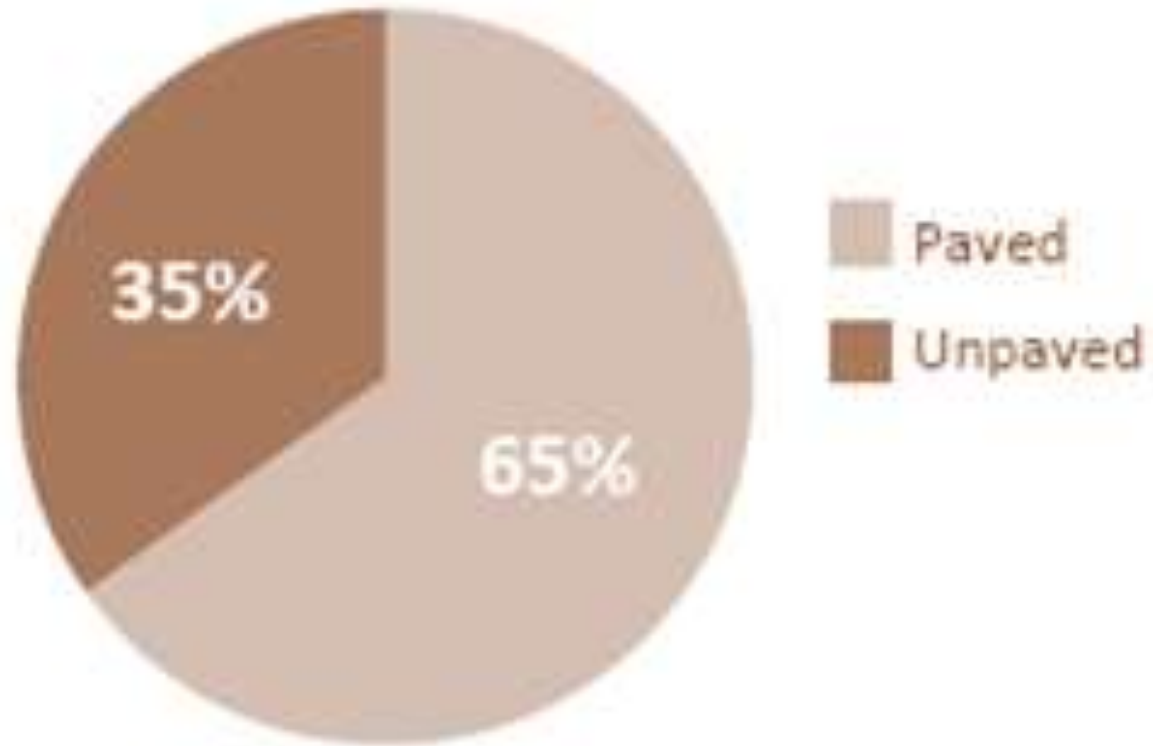
The Highway Extension and Research Project for Indiana Counties Area Road Schools

- Planning and conducting area road schools
- Each of the nine schools draws to it road officials from eight to 12 neighboring counties
- The geographic distribution of meeting locations stimulates a concentration or focusing on specific problems common to the particular locality
- Topics for the schools range from routine maintenance and construction practices through administration, planning, financing, traffic, safety, equipment, public relations and bookkeeping





Percent Paved and Unpaved Roadway Miles in USA





Context

- A major problem of counties in the United States is maintenance costs for local roads
- Local roads have been built in the United States over the past century
- As traffic loads and volume increased, so also has the need to perform surface maintenance on these unpaved roads



<https://hips.hearstapps.com/>



Road Surface Management

- According to FHWA is the application of pavement management practices to the needs of local governments including management of light-type pavements and unpaved surfaces
- According to Central New Hampshire Regional Planning Commission is a methodology intended to provide an overview and estimate of a road system's condition and the approximate costs for future improvements



<https://safety.fhwa.dot.gov>

v

Quick Field Tests Used to Evaluate Existing Aggregate Roads

- The quality of the existing base material needs to be determined before proceeding with the application of a surface
- Gravel surface that is satisfactory without a bituminous wear layer becomes water-soaked and unsuitable after paving
- There are rapid tests that could be used for the evaluation of unpaved road
- These tests measure the California Ratio (CBR) using rapid field tests



<https://static01.nyt.com/images/>

Clegg Impact Soil Tester

- To evaluate the strength of soil and properties of aggregates subgrades and base course materials
- CBR test values are using to selecting pavement and base thicknesses



Quick Field Tests Used to Evaluate Existing Aggregate Roads

Quick field tests:

- 1) Dynamic Cone Penetrometer (DCP)
- 2) Clegg Impact Soil Tester



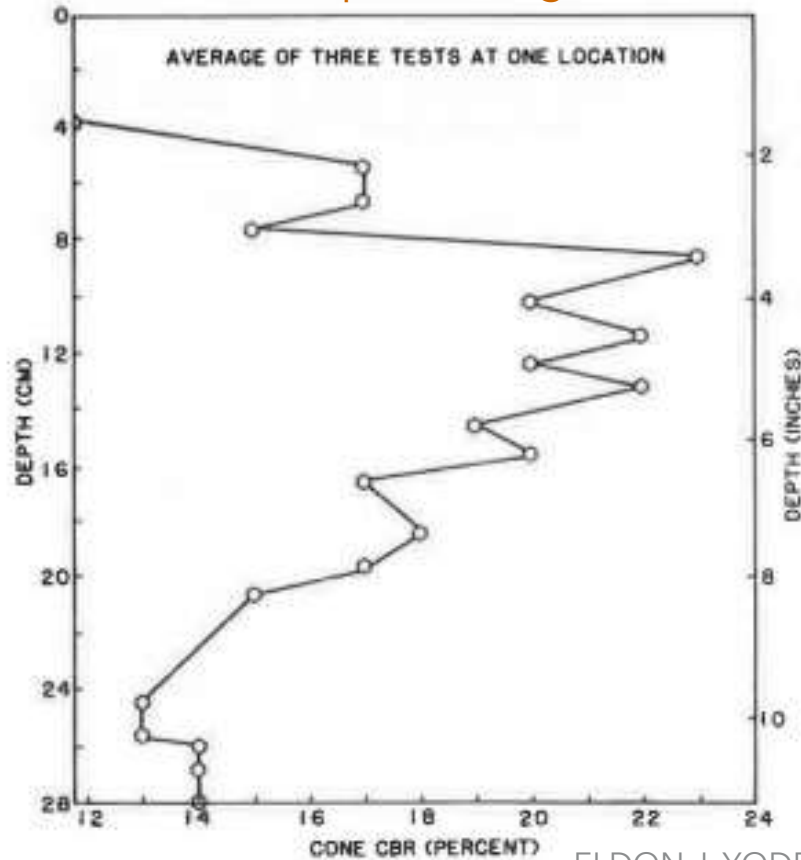
<https://www.researchgate.net/figure/>



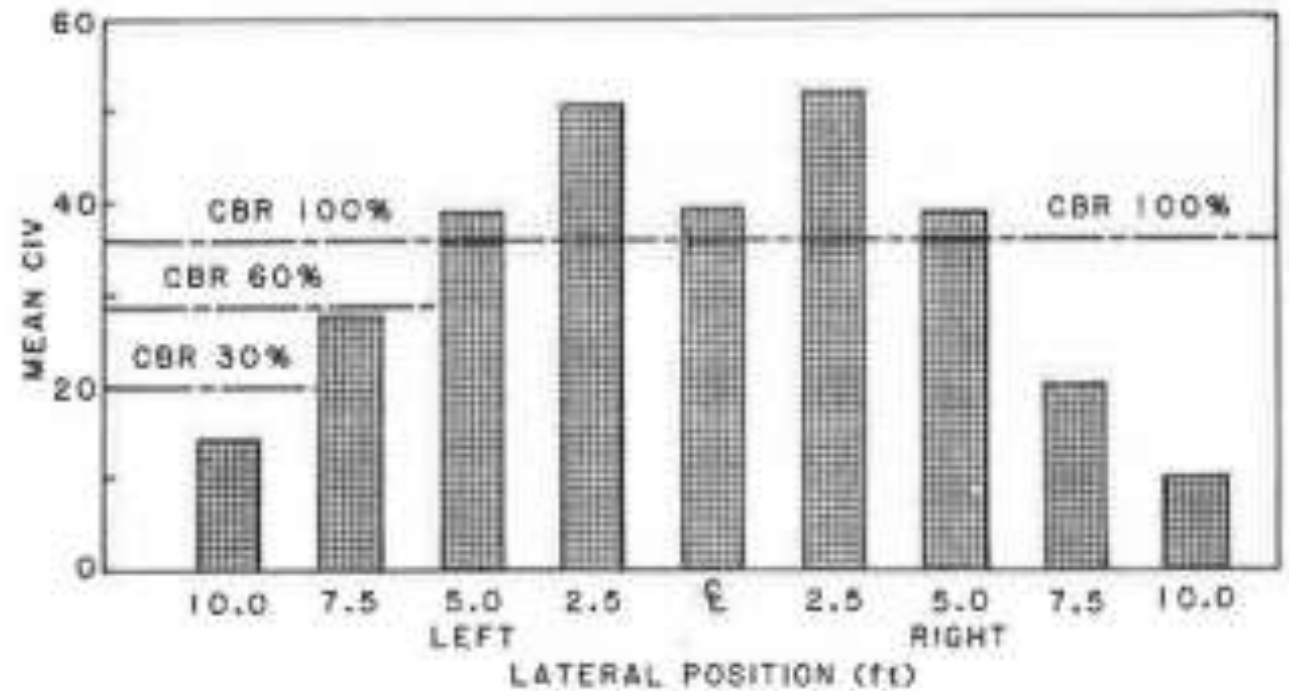
<https://i0.wp.com/theconstructor.org/>

Clegg Impact Device

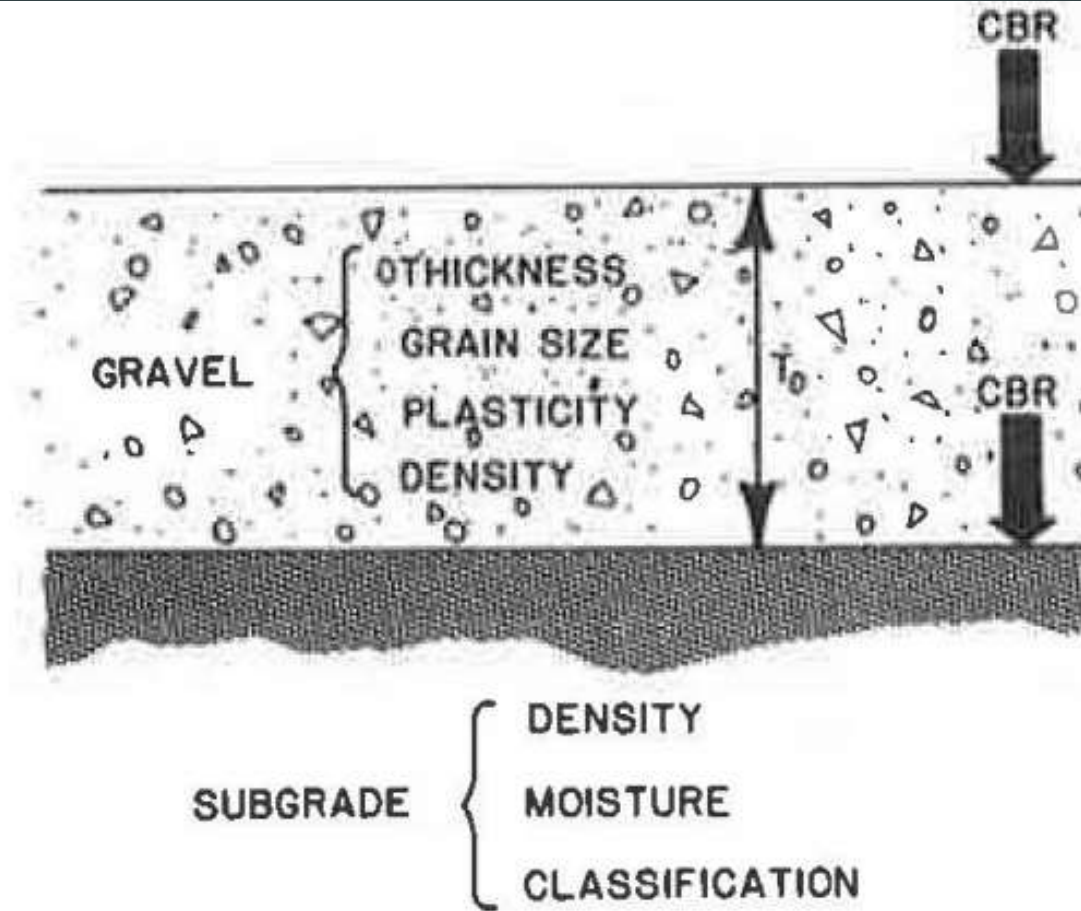
CBR versus Depth for a given location



CBR Across the Transverse Section of a Gravel Surface

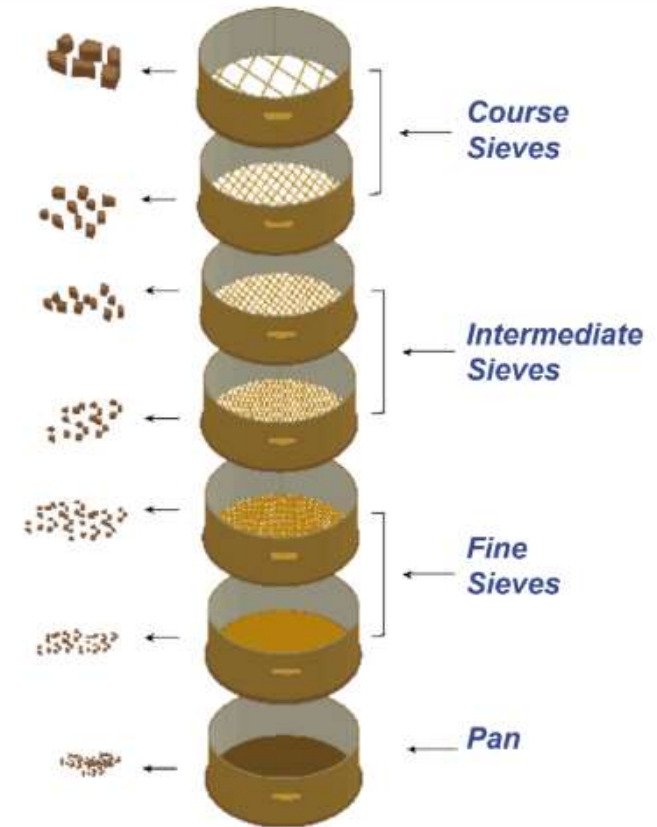


Factors to be Considered in the Evaluation Process



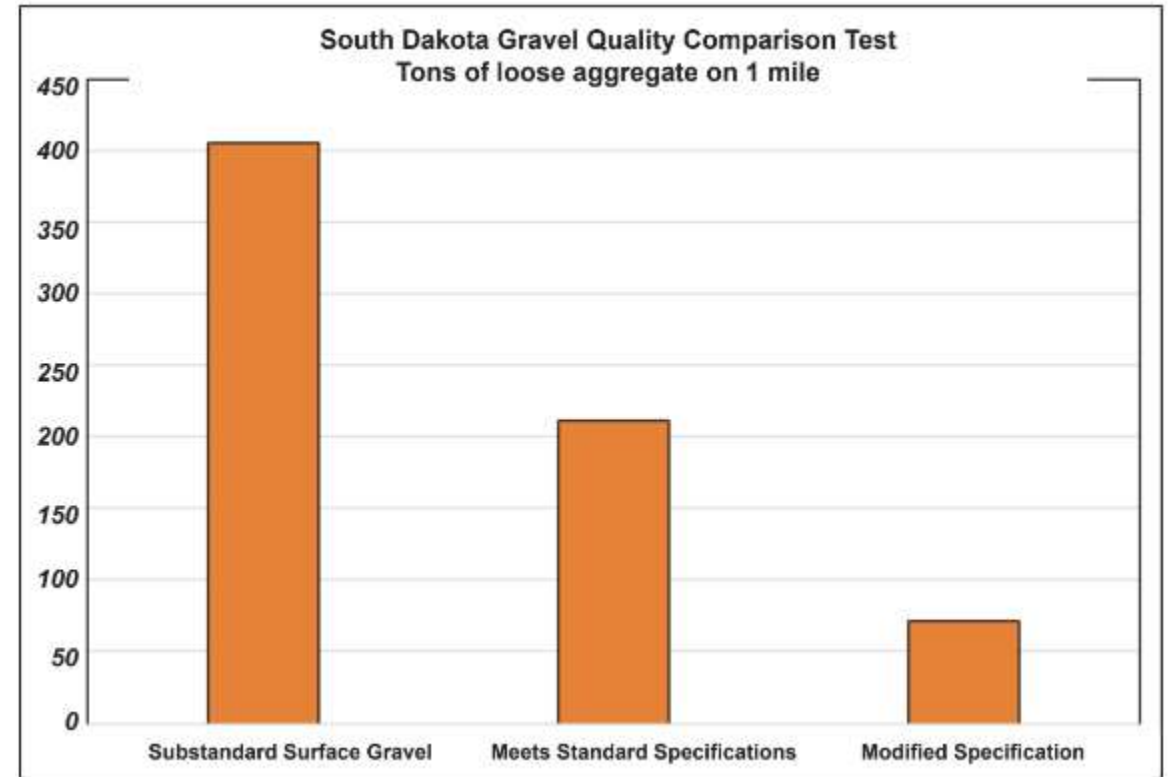
“Good” Gravel

- Aggregates such as limestone, quartzite and granite; glacial deposits of stone, sand, silt and clay; and river gravels
- Good gravel that has good gradation and plasticity will compact well
- Plasticity Index (PI) no less than 3 or as high as 12
- Gravel surfacing allows as little as 4% and up to 15% of the material to pass a #200 sieve
- Base course can have as little as 3%, but not more than 12% passing the same sieve.



“Good” Gravel

- 1) Substandard material with only top-size control of stone at 100 percent passing the one-inch sieve
- 2) Material that met the South Dakota DOT’s Gravel Surfacing specification but had near minimum required fines and PI
- 3) A modified material that had the maximum allowable of fine material and PI of 7



Reasons and Alternatives for Evaluation of Existing Aggregate Roads

Reason for Evaluation	Type of Evaluation	Alternative
Development of an area—sociological and economical	Network analysis	
Environmental factors—public opinion, public policy	Evaluate road materials	Stabilize base, apply surface
Safety—increased traffic, dangerous intersections, narrow bridges	Check grade, alignment, and other geometric factors	Widen, reconstruct
Planned staging other than for a new area	Economic analysis at the project level, evaluate structurally, evaluate materials	Continue to maintain, improve base, apply surface
Increased costs—maintenance, road user	Evaluate structurally, evaluate materials	Continue to maintain, apply surface



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

August 2015

GRAVEL ROADS **CONSTRUCTION &** **MAINTENANCE** **GUIDE**

Gravel/Unsurfaced Roads

Problems:

- Quality, volume, and size distribution of gravel
- Material
- Corrugation or “washboarding”
- Tire pressures due dramatic change in the vehicles and equipment using low volume roads



<https://www.ncei.noaa.gov/data/>

Importance of Satisfactory Gravel Cross Section

- Average annual precipitation is less than 10 inches per year
- Gravel roads can easily rut or form potholes in periods of prolonged wet weather



<http://www.sandgatevermont.com>



For the operator to maintain a gravel road properly

- a. A crowned driving surface
- b. A shoulder area that slopes directly away from the edge of the driving surface
- c. A ditch



<https://images.prismic.io/>

A wide gravel road curves through a rural landscape with golden-brown fields and green grass under a clear sky.

Satisfactory Cross Section



- Average annual precipitation exceeds 60 inches but it has a adequate section





Satisfactory Cross Section



The foreslope of this road is also shaped very well, which allows drainage of water from the road surface down to the ditch

Satisfactory Cross Section

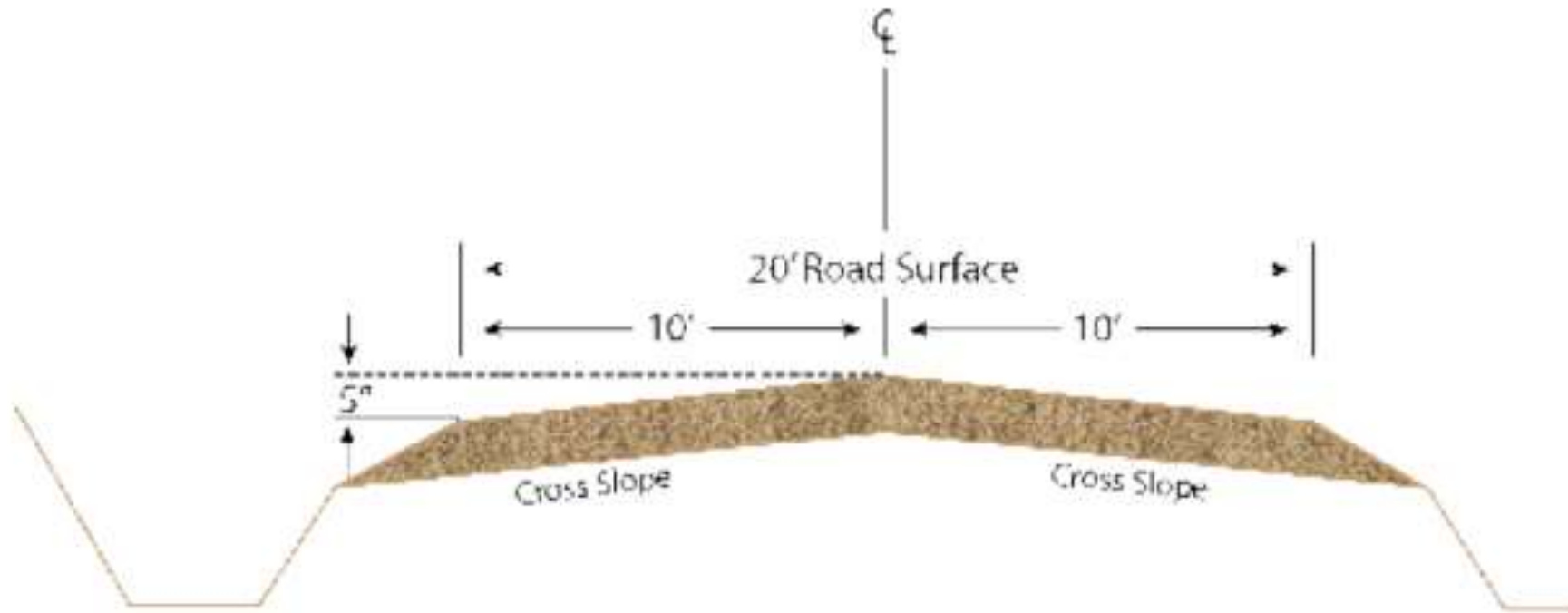
Depends:

- Proper use of a motorgrader (or other grading device)
- Use of good surface gravel



<https://assets.elpasoco.com/>

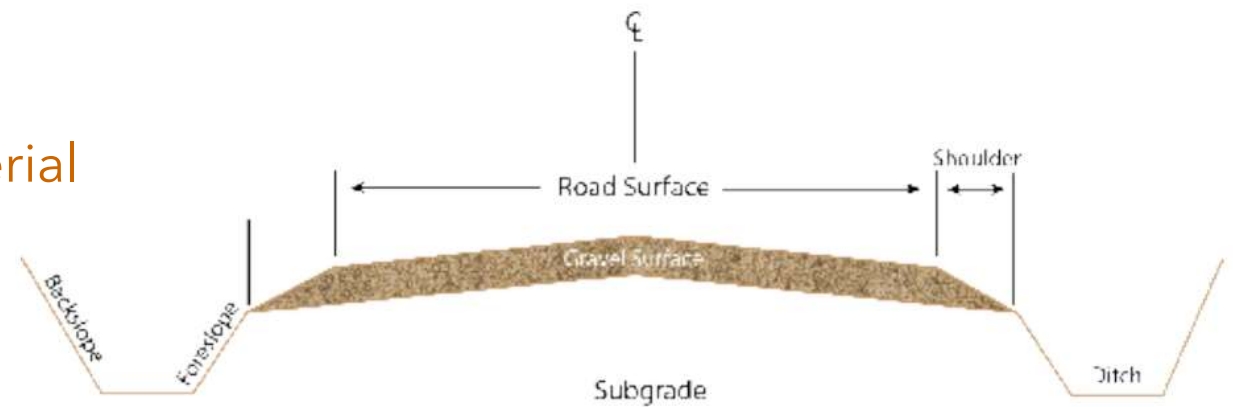
Satisfactory Cross Section



The recommended crown is a straight line from the shoulder to the centerline that rises approximately 1/2 inch per foot (or approximately 4 percent)

Road Shoulder

- Shoulder should meet the edge of the roadway at the same elevation
- High shoulders caused buildup of material that is eroded during heavy rain



Intersections with Paved Roads or Bridges

- Begin to eliminate crown on the gravel road approximately 100 feet from the edge of the pavement
- At the intersecting point, the gravel should match the paved surface
- Not to push gravel out onto the pavement since this causes a dangerous loss of skid resistance on the pavement



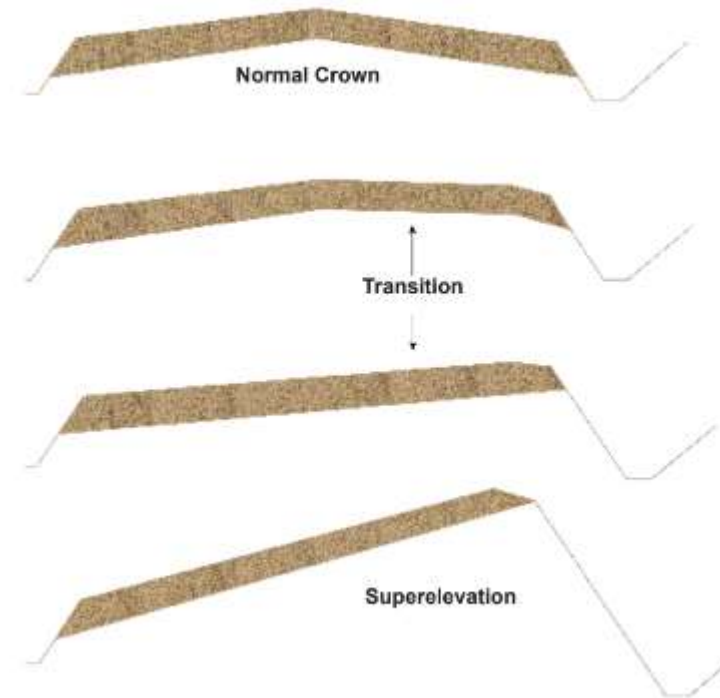
Superelevation at Curves

- Outer edge of the roadway is higher than the inside edge
- Road surface is shaped straight from the upper to the lower edge
- As the operator approaches a curve, adjustments should be made with the moldboard to take out the normal crown and begin to transition into a straight superelevated surface
- A gradual transition is then made at the other end back to a normal crowned road surface when you are once again on a straight section of road



Superelevation at Curves

- Crown to superelevation transition
- Illustration of the transition from a normal crown to the superelevated shape needed in a curve

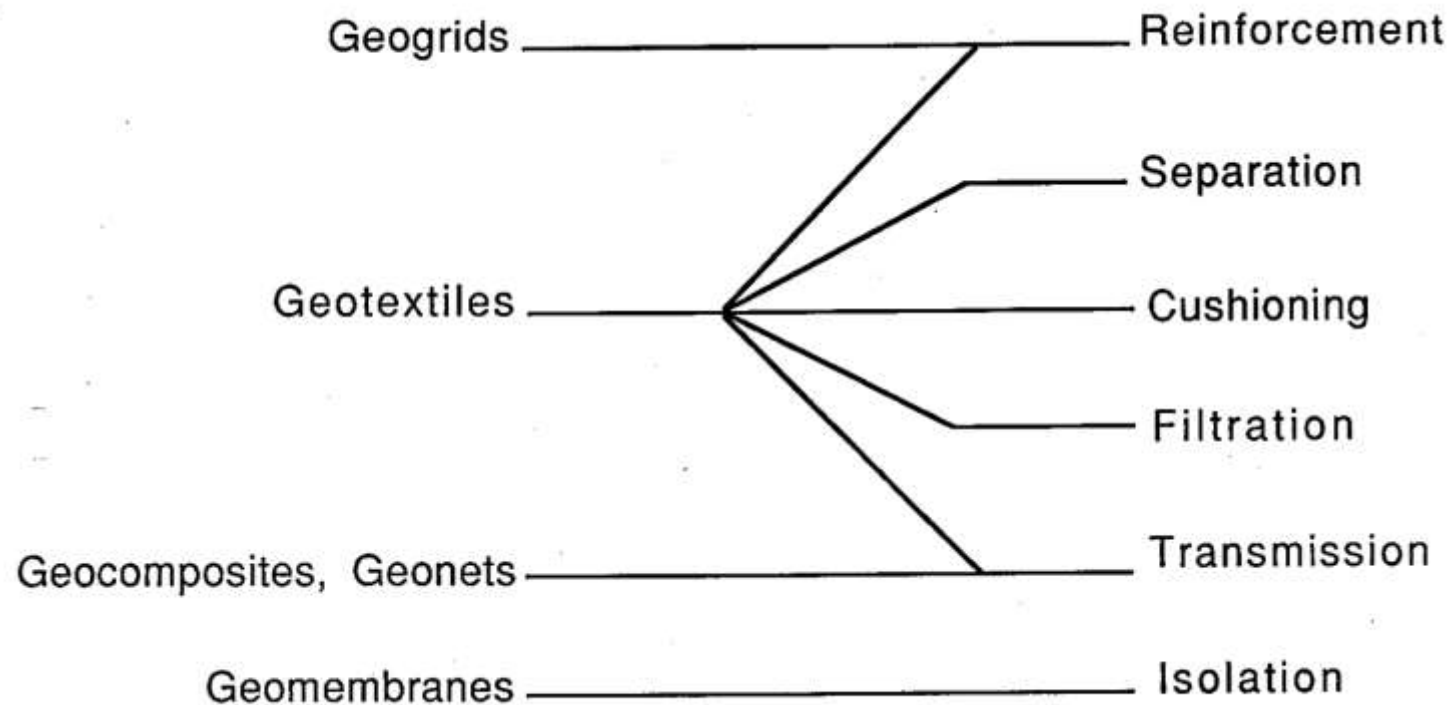


Geotextile or Geosynthetic

- ASTM D4439: A planar product manufactured from polymeric material
- Placed over the subgrade soil before the select material is brought in
- Becomes a separator between the weak soil and the new material placed above it
- This prevents very fine, wet silt and clay type soils from pumping or migrating up into the new material



Types of Geosynthetics and The Function they Perform



Juan B. Bernal, Ph.D., P.E.





Poor Cross Section

- No crown on the surface
- No ditches at the edge to drain water off of the surface
- Average annual precipitation is less than 10" per year



Poor Cross Section

- Corrugation “washboarding,” is caused by lack of moisture, hard acceleration, aggressive braking, and poor quality gravel
- Appears at an angle across the roadway with ridges and depressions 2 to 3 feet apart
- It is a good practice to loosen, mix and reshape gravel
- In a washboard-prone area while it is moist



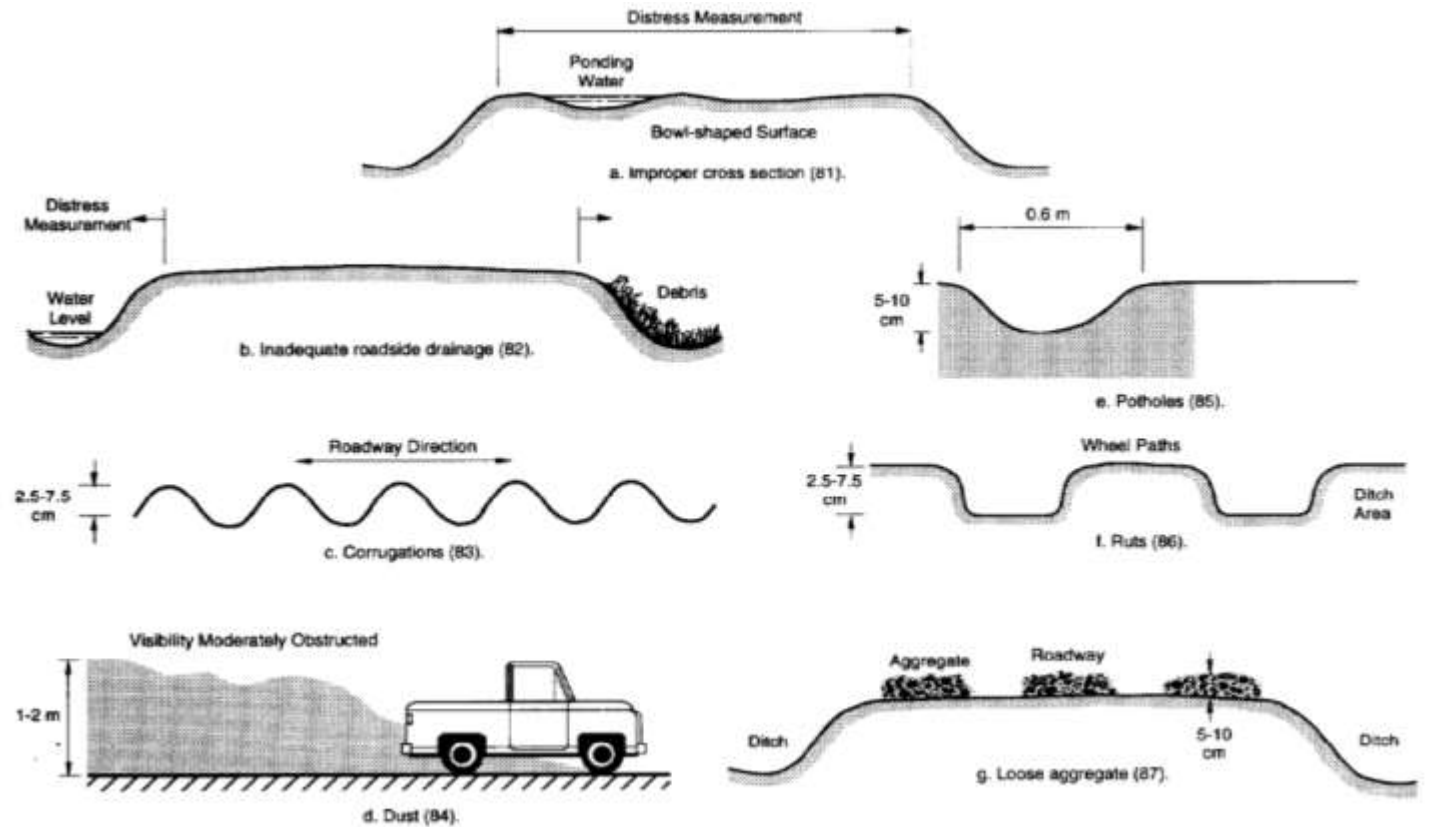
Poor Cross Section



A road section heavily damaged

Distresses

1. Improper cross section
2. Inadequate roadside drainage
3. Corrugations
4. Dust
5. Potholes
6. Ruts
7. Loose aggregate



Unsurfaced Road Condition Index (URCI)

- Numerical indicator based on a scale of 0 to 100
- Indicates the road's integrity and surface operational condition
- Is identical to the Pavement Condition Index (PCI) for surfaced roads

URCI	RATING
100	Excellent
85	Very Good
70	Good
55	Fair
40	Poor
25	Very Poor
10	Failed
0	

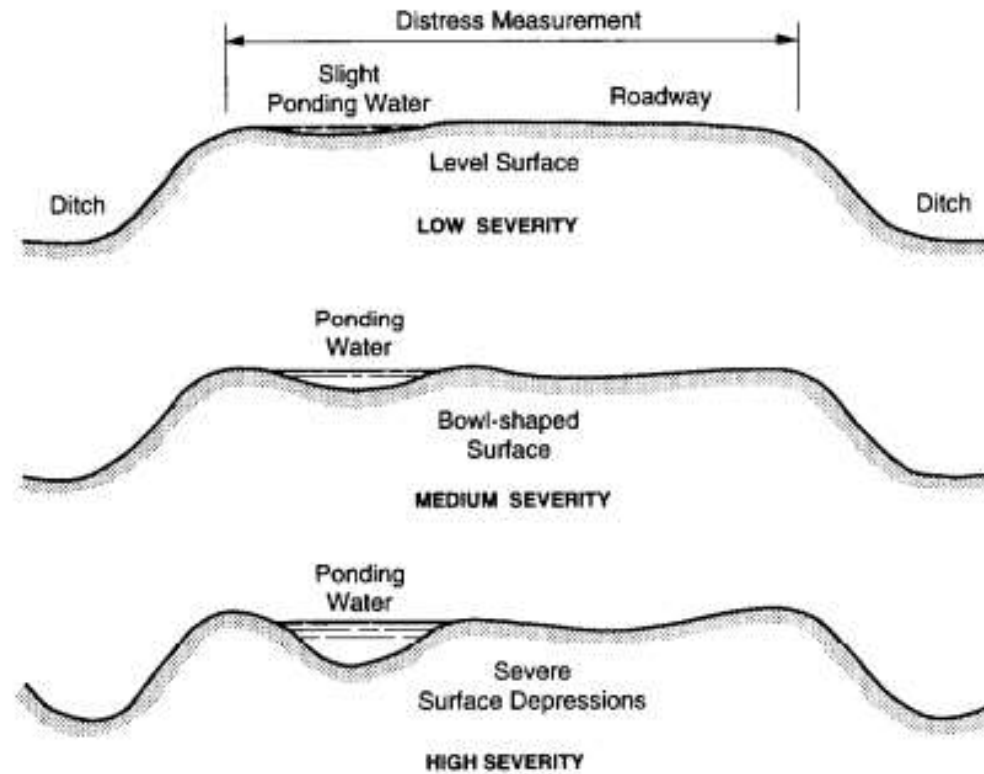
Poor Cross Section

- Causes: heavy trucks, traffic, winter plowing operations, erosion during a rain or poor routine blading techniques
- Standing water is the major reason for distress and failure of a road
- In wet conditions heavy loads cause the road to fail even with a correct section
- Road fail due to weak subgrade and marginal gravel depth



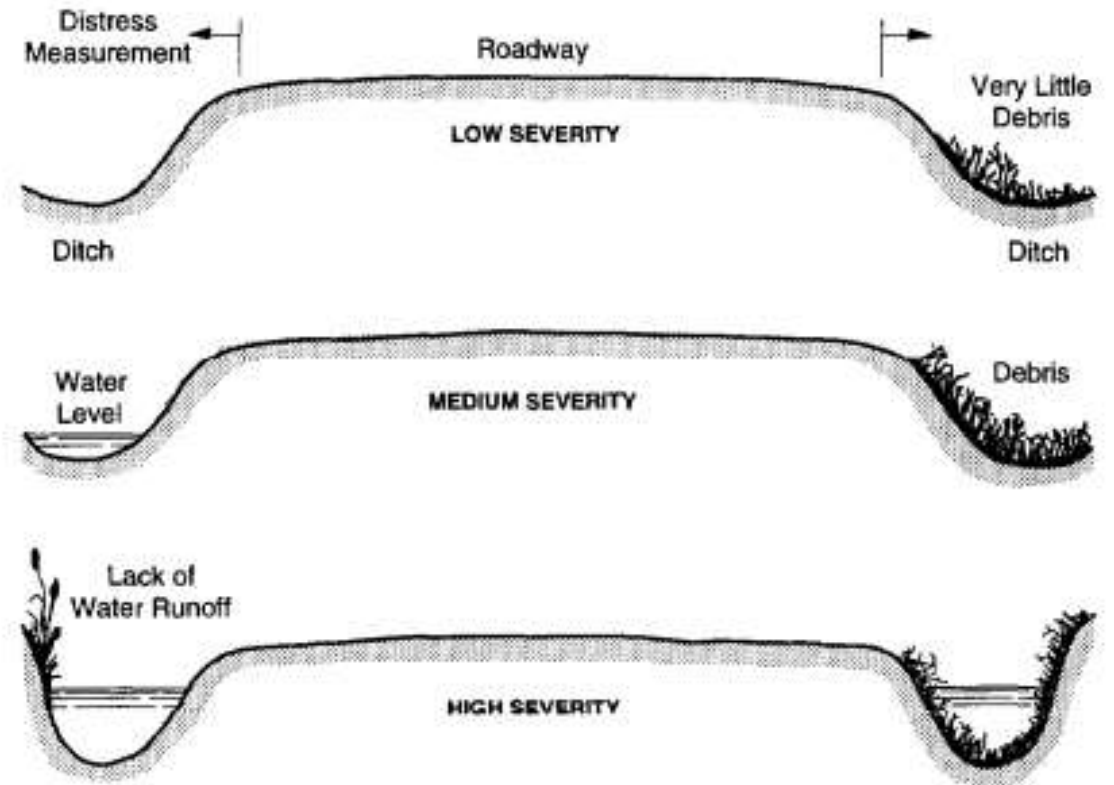
<https://thumbs.dreamstime.com/>

Improper Cross Section



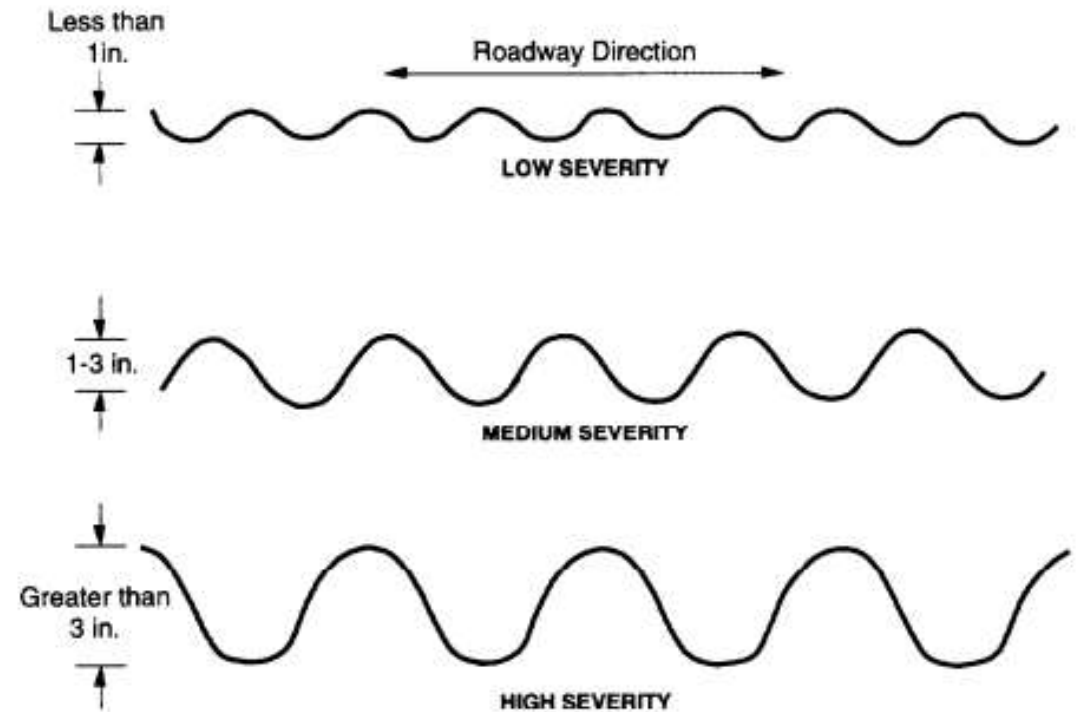
Inadequate Roadside Drainage

- Poor drainage causes water to pond
- Drainage becomes a problem when ditches and culverts are not in good enough condition to direct and carry runoff water



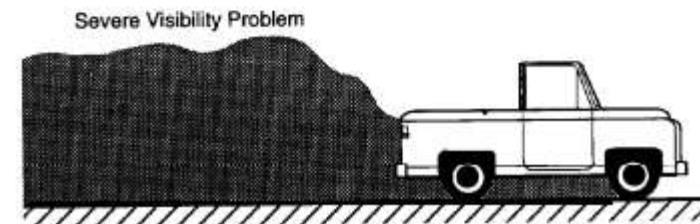
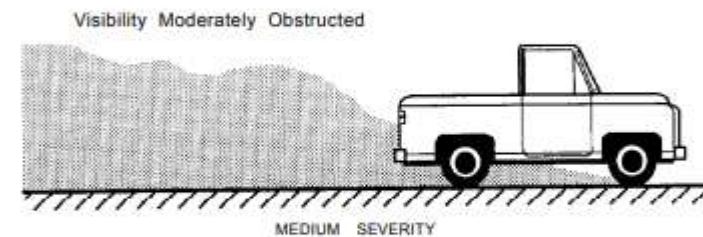
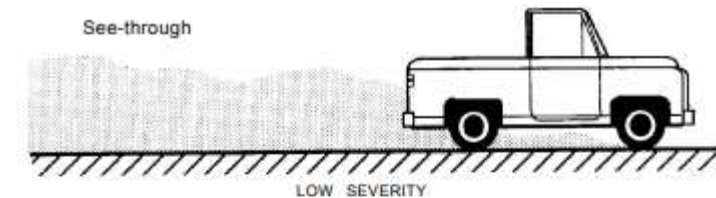
Corrugations

- Closely spaced ridges and valleys at fairly regular intervals
- Are perpendicular to the traffic direction
- Usually caused by traffic and loose aggregate
- Usually form on hills, on curves, in areas of acceleration or deceleration, or in areas where the road is soft or potholed



Dust Palliative

- The wear and tear of traffic on unsurfaced roads will eventually loosen the larger particles from the soil binder
- As traffic passes, dust clouds create a danger to trailing or passing vehicles and cause significant environmental problems



Dust Palliative Emissions

- The quantity of dust emissions from a given segment of unpaved road varies linearly with the volume of traffic
- Dust emissions from unpaved roads have been found to vary directly with the fraction of silt
- Silt content of a rural dirt road will vary with geographic location
- Silt fraction is determined by measuring the proportion of loose dry surface dust that passes a 200-mesh screen, using the ASTM-C-136 method



Dust Palliative Emissions

- Unpaved roads have a hard, generally nonporous surface that usually dries quickly after a rainfall or watering
- Recommended to feasible for industrial roads subject to very heavy vehicles and/or spillage of material in transport



<https://hansegrand.com/>

Dust Palliative Emissions

- Affects the safety of road users
- It affects the visibility of the users who transit
- It also affects the quality of life of people and the environment
- Chemical treatments can also be harmful to the quality of life of people and the environment



<https://bloximages.newyork1.vip.townnews.com/>

Control Emissions From Unpaved Roads

1. Vehicle restrictions that limit the speed, weight or number of vehicles on the road
2. Surface improvement, by measures such as adding gravel or slag to a dirt road
3. Surface treatment, such as watering or treatment with chemical dust suppressants



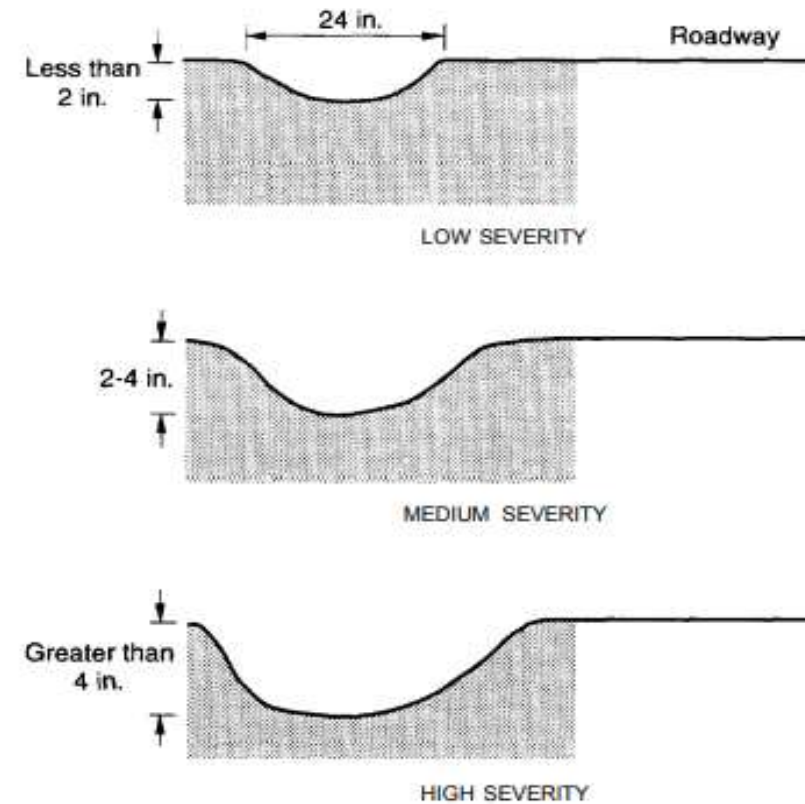
<https://xbijo1ps2oz3dwnvd2eyv3i1-wpengine.netdna-ssl.com/>

Control Emissions From Unpaved Roads



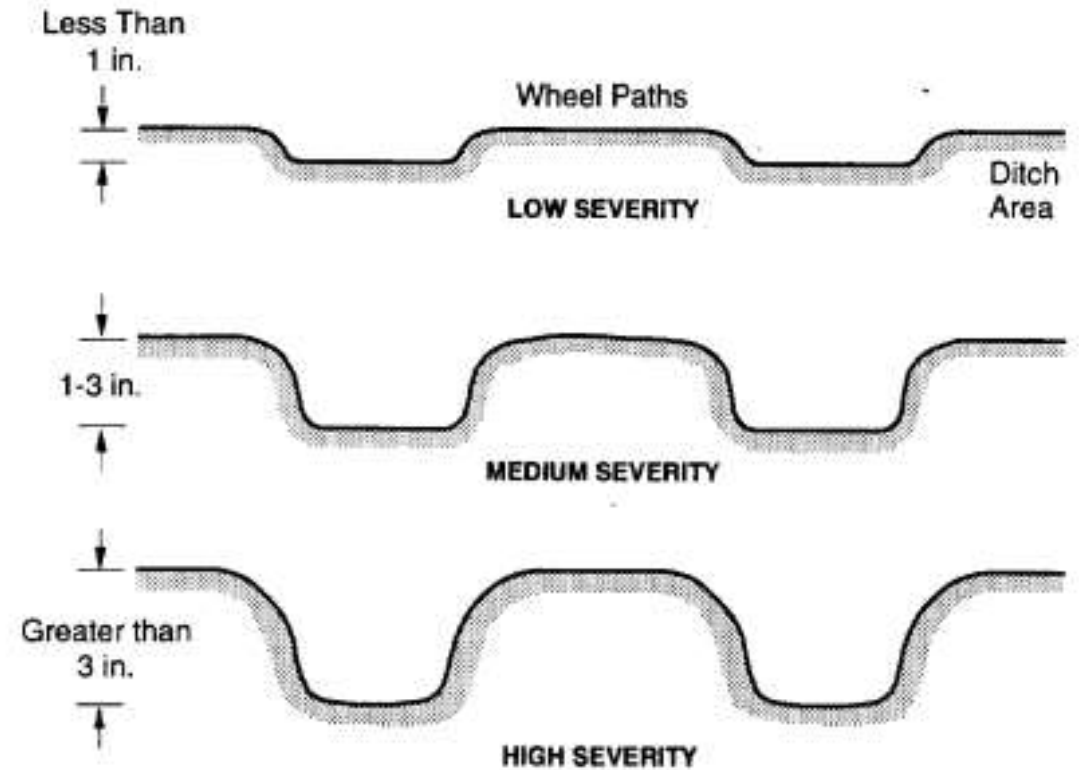
Potholes

- Depressions in the road surface
- Produced when traffic wears away small pieces of the road surface
- They grow faster when water collects inside the hole



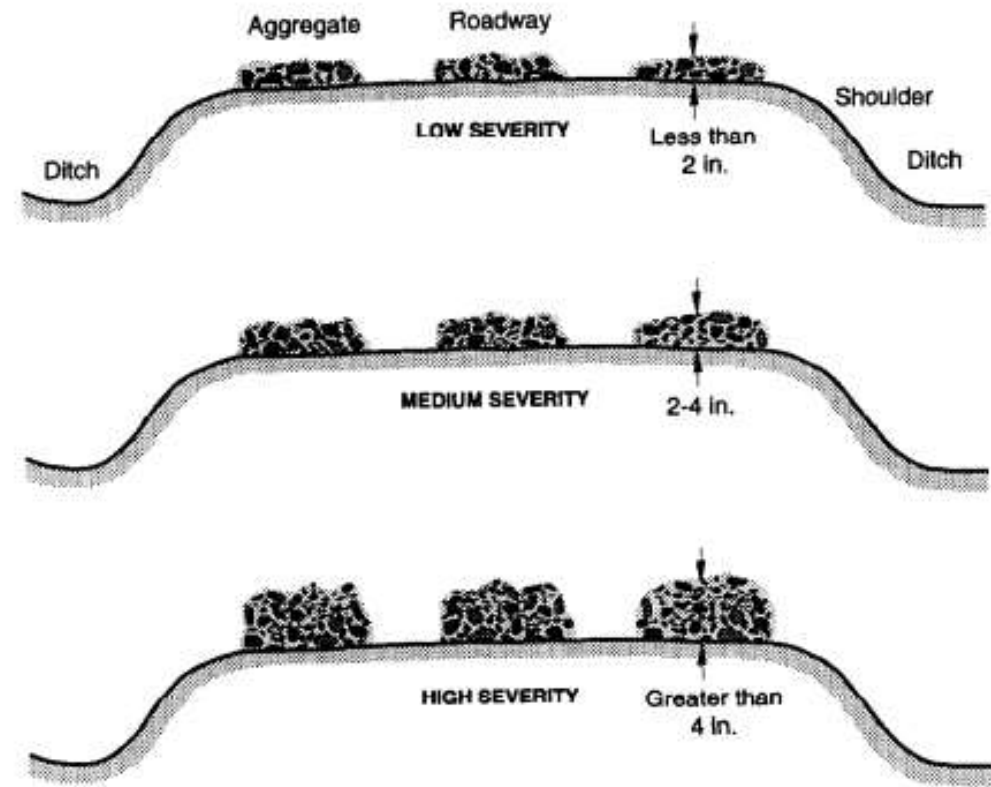
Ruts

- Is a surface depression in the wheel path that is parallel to the road centerline
- Caused by a permanent deformation in any of the road layers or subgrade
- They result from repeated vehicle passes, especially when the road is soft



Loose Aggregates

- The wear and tear of traffic on unsurfaced roads will eventually loosen the larger aggregate particles from the soil binder
- This leads to loose aggregate particles on the road surface or shoulder
- Traffic moves loose aggregate particles away from the normal road wheel path and forms berms in the center or along the shoulder (the less-traveled areas)



Maintenance Alternatives

<i>Distress</i>	<i>Severity code</i>	<i>cost code¹</i>	<i>Description</i>
81-Improper cross section	L	B	Grade only.
	M	B/C	Grade only/grade and add material (water or aggregate or both), and compact. Bank curve. Adjust transitions.
	H	C	Cut to base, add aggregate, shape, water, and compact.
82-Improper roadside drainage	L	B	Clear ditches every 1-2 years.
	M	A	Clean out culverts.
		B	Reshape, construct, compact or flare out ditch.
	H	C	Install underdrain, larger culvert, ditch dam, rip rap, or geotextiles.
83-Corrugations	L	B	Grade only.
	M	B/C	Grade only/grade and add material (water or aggregate or both), and compact.
	H	C	Cut to base, add aggregate, shape, water, and compact.
84-Dust stabilization	L	C	Add water.
	M	C	Add stabilizer.
	H	C	Increase stabilizer use.
			Cut to base, add stabilizer, water, and compact. Cut to base, add aggregate and stabilizer, shape, water, and compact.

Maintenance Alternatives

85-Potholes	L	B	Grade only.
	M	B/C	Grade only/grade and add material (water, aggregate, or 50/50 mix of calcium chloride and crushed gravel), and compact.
86-Ruts	H	C	Cut to base, add aggregate, shape, water, and compact.
	L	B	Grade only.
	M	B/C	Grade only/grade, add material, and compact.
87-Loose aggregate	H	C	Cut to base, add aggregate, shape, water, and compact.
	L	B	Grade only.
	M	B/C	Grade only/grade, add material, and compact.
	H	C	Cut to base, add aggregate, shape, water, and compact.

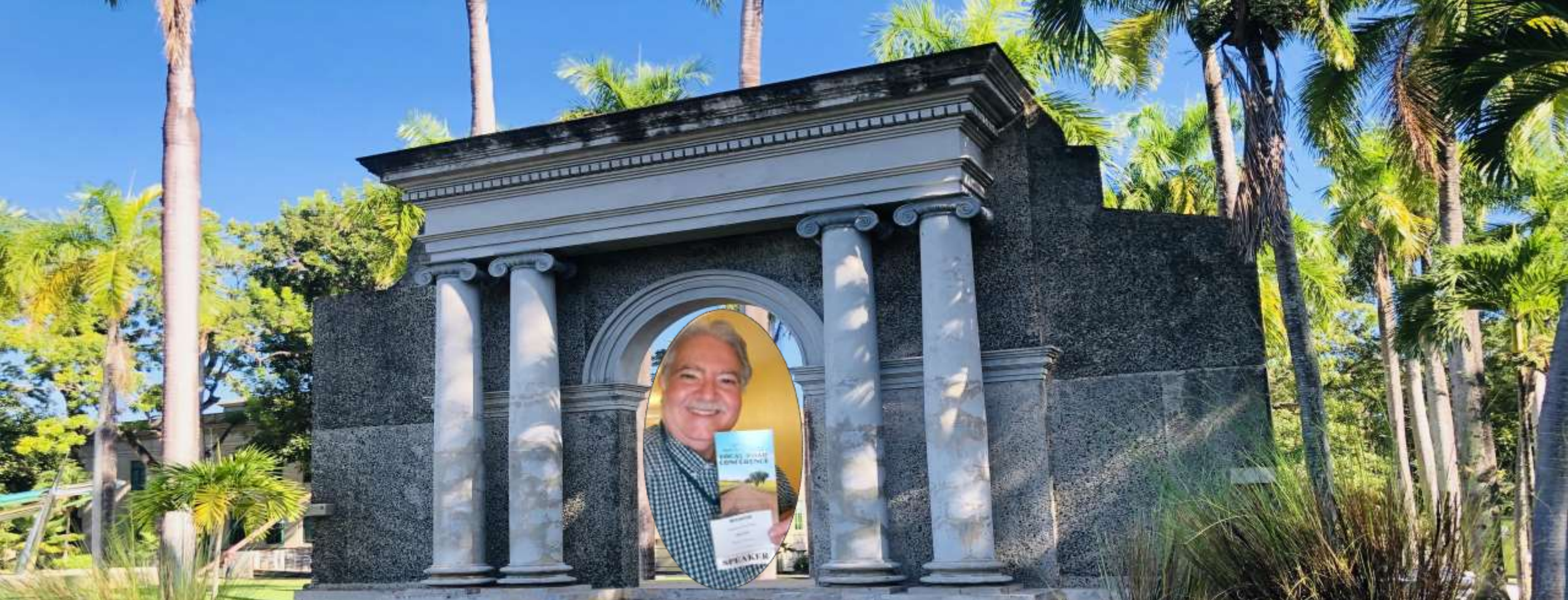
¹Cost code guide: A = labor, overhead; B = labor, equipment, overhead, C = labor, equipment, materials, overhead.

Erosion Control

- Keep water velocities low
- Keep sediment within work boundaries
- Avoid major reshape work during times with heavy rainfall



<https://dreamcivil.com/>



Thank you for the invitation