Effect of Aggregate Quality on Sediment Production from a Forest Road

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Aggregate is placed on forest roads in wet climates to provide structural support for traffic and in dry climates to reduce sediment production caused by precipitation. In both climates aggregate of suitable quality is often not readily available. The substitution of poorer-quality aggregate can cause greater amounts of sediment than those produced by good-quality aggregate. To measure the differences in sedimentation rates, the Forest Service of the U.S. Department of Agriculture conducted a sediment study using two aggregate qualities. The study was conducted using natural rainfall and logging truck traffic on an aggregate-surfaced road during the winters of 1992 and 1993 in western Oregon and using simulated rainfall following the winter of 1993. The results showed that the quality of the aggregate made a notable difference in sediment production. When subjected to heavy logging truck traffic, a marginal-quality aggregate produced from 2.9 to 12.8 times as much sediment as that from a similar section surfaced with good-quality aggregate. The greater difference occurred in the winter with the greater rainfall. ‘Whereas the good-quality aggregate provided the expected level of sediment mitigation, the marginal-quality aggregate did not. These results have important implications for road use and sediment production.

The U.S. Department of Agriculture Forest Service road network consists of 369,000 mi of which approximately 65 percent is unsurfaced, 30 percent is aggregate surfaced, and 5 percent is paved (D. Badger, unpublished data). In wet climates such as those in western Oregon and Washington, most roads are surfaced with 200 to 400 mm (8 to 16 in.) of aggregate (surface and base courses) to provide structural support during wet weather. High-quality road surfacing aggregates are not always readily available in many localities, and marginal-quality aggregates are used to reduce road-building costs. In some instances marginal-quality aggregates perform adequately from a structural reference but may generate sediment. The effects of aggregate quality on sediment production have not been adequately quantified to date.

Typical constructed profiles of logging roads in wet climates consist of a 25-mm (1-in.) minus dense-graded surfacing aggregate over a larger-sized base course aggregate. Even with these relatively large thicknesses of aggregate materials, sedimentation can be a problem.

In drier climates such as that of the intermountain West, placement of aggregate on the running surface is an accepted method of reducing the amount of sediment produced from unsurfaced forest roads. In these situations the aggregate thickness is less than it is in wet climates. Burroughs and King (1) developed an equation relating ground cover (i.e., aggregate layer) to reduction in sediment production. Their equation gave a 95 percent reduction in sediment for a 100 percent ground cover of aggregate. In a study (2) on the Nez Percé National Forest, Idaho, on “borderzone batholith” material of gneiss and schist using a 102-mm (4-in.) lift of 38-mm (1 1/2-in.) minus high-quality, gneissic, crushed rock, simulated rainfall gave a sediment reduction of 79 percent compared with an unsurfaced road of the same parent material. Swift (3) demonstrated the importance of the thickness of the aggregate layer. A Si-mm (2-in.) lift of 38-mm (1 1/2-in.) crushed rock resulted in no sediment reduction. A 152-mm (6 in.) lift of the same size gave a 92 percent reduction, and a 200-mm (8-in.) lift with a D_{50} of 76 mm (3 in.) resulted in a 97 percent reduction in sediment.

The Burroughs studies used high-quality aggregate. However, Burroughs and King stated that the mitigation of sediment production by the use of aggregate is a function of the erodibility of the aggregate surfacing and subgrade soil. High-quality aggregate is not always readily available at reasonable distances. National forests often have to use aggregate of lower quality that is more conveniently located.

These erosion mitigation studies measured sediment production without the concurrent application of traffic. These or similar reductions in sediment production are frequently used in forest road planning and design.

SPECIFYING AGGREGATES

Aggregate is typically specified to meet a series of established engineering standards relating to gradation and the quality of the aggregate particles. The quality tests address both the resistance to mechanical breakdown resulting from traffic and the chemical breakdown resulting from the presence of water. Minimum standards are typically established by an agency but are primarily established considering the structural adequacy for base course aggregates in pavements. Table 1 displays the quality standards generally in use by the Forest Service (4). These same tests are currently used to specify surface course materials, but the same minimum values may not apply when addressing sedimentation.

Gradation

Gradation (AASHTO T 11 and T 27) (5) controls specify the size distribution for an aggregate. Gradation requirements for surfacing materials need to be dense graded to provide adequate internal stability (maintain point-to-point contact for strength) and have sufficient fines to minimize water infiltration during wet weather. If too many fines are available (either during crushing or by breakdown of the aggregate), the aggregate can become unstable and produce unwanted sediments.

Mechanical Durability

Los Angeles Abrasion (AASHTO T 96) is a measure of an aggregate's tendency to break down from the direct pressure of traffic. The test consists of subjecting an aggregate sample to the impact of steel balls rotating in a drum. The breakdown is expressed as the percentage of wear based on the gradation change during the test. Aggregates that are susceptible to wear can become unstable because the aggregate particles are no longer in point-to-point contact.

TABLE 1 Aggregate Specifications

	Test Standard[a]	Pre-traffic, 1992		After 268 loads		After 884 loads	
		Marginal	Good	Marginal	Good	Marginal	Good
LAA	< 40	19.2	12.8	21.4	13.5	19.1	13
DUR Coarse	> 35	61	61	49	68	63	74
DUR Fines	> 35	31	63	28	57	31	60
PI	2-9	NP	NP	NP	NP	3	NP
SE	> 35	22	56	24	37	22	38
DMSO	< 20	20.5	26.9	22.1	27.9	15.7	12

LAA - Los Angles Abrasion (T96)
DUR - Durability (T210)
PI - Plastic Index (T90)
SE - Sand Equivalent (T176)
DMSO - DMSO Weathering
[a] - (*1*)

Chemical Durability

Chemical durability relates to the tendency of an aggregate to break down because of the presence of water. Various tests *(5—8)* have been used to measure this tendency, and local practice (4) utilizes the aggregate durability index (AASHTO T 210) and the accelerated dimethyl sulfoxide (DMSO) weathering test (FHWA Section 4.104).

The durability index test essentially subjects a test sample of the coarse and fine fraction to an agitated source of water. It is an empirical value determined from the level of sediment produced after the material is allowed to settle for a prescribed amount of time.

The DMSO test is an accelerated weathering test. An aggregate sample is submerged in DMSO, which can be absorbed into secondary minerals within the rock mass. Since these secondary minerals are clay or claylike, swelling and disintegration can occur. This effect is reported as the DMSO loss.

Characteristics of Fines

Gradation will provide a measure of the quantity of fines and the durability tests provide a measure of the tendency to produce more fine material, but neither is a direct measure of the characteristics of the fines. Typically, fines manufactured during crushing or silt-sized natural fines are not as susceptible to volume change (and instability) as clay fines. The Atterberg limits (AASHTO T 89 and 1 90) and the sand equivalent (AASHTO T 176) tests are measures of this tendency. The plasticity index is the measure of the claylike nature of the fines.

In the sand equivalent test, a sample of material is agitated in water and the sand equivalent value is determined empirically from the quantity of sediment that settles out after a prescribed amount of time. The higher the clay content, the longer the material stays in suspension and the lower the sand equivalent value.

Methodology

The Intermountain Research Station and the Willamette National Forest conducted a study of how aggregate quality affects sediment production during logging truck traffic. This study, conducted during the winter months of 1992 and 1993, was a part of a larger study that included the effect of tire pressure on sediment production (9) and a study of the development of ruts with traffic. Only the aggregate-quality study will be reported in this paper.

Test Site

A crowned section of forest road on the Lowell District of the Willamette National Forest, Oregon, was selected for the test. The section, which was 2.25 km (1.4-mi) long by 4.27 m (14 ft) wide, was chosen to meet the requirements of length, constant grade, and the ability to control nontest traffic. Two sections 61 m (200 ft) long that had similar grades and aspects were selected. One of the test sites was surfaced with a marginal-quality aggregate obtained from the Porcupine Materials Source on the Lowell Ranger District, whereas the other site was surfaced with a good-quality aggregate obtained from a private source, Springfield Quarry in Springfield, Oregon. Table 1 presents the aggregate specifications. Geologically both sites contain igneous extrusive materials, but whereas Springfield Quarry has consistently provided high-quality aggregate, the Porcupine Materials Source contains zones of weathering that produce marginal-quality aggregate. For this study, 102 mm (4 in.) of the specified quality of aggregate was compacted as surfacing on the existing aggregate. The existing aggregate varied from 304 to 406 mm (12 to 16 in.) of a 76-mm (3-in.) minus material on a clayey silt, ML subgrade.

At the lower end of each road section, a 2-rn-wide asphalt apron was installed across the width of the road, as shown in Figure 1. One-half of this asphalt apron contained a 12-mm (1/2-in.) aggregate with a high oil content to allow the apron to conform to the expected wheel ruts. The remaining half contained 19-mm (3/4-in.) aggregate. The apron ended in an open-top drain laid diagonally across the road. The drain emptied into a water and sediment measurement box. The apron and open-top drain arrangement was used to measure runoff and sediment flowing along the road grade. These measurements will be referred to as the drain source.

To measure the runoff and sediment flowing laterally off the road, a sheet metal gutter 16 m (SQ ft) long by 20 mm (8 in.) wide was installed on each side of the road section, as shown in Figure 1. A 16-m segment was utilized rather than the full length to reduce construction costs. Flow from these gutters, located approximately half way down the road section, was combined near the bottom of the road section and the combined flow was measured. These measurements will be referred to as the gutter source. Using the two measurements, both the concentrated flow in wheel ruts (from the drain pipe) and the shallow sheet flow (from the gutters) could be measured.

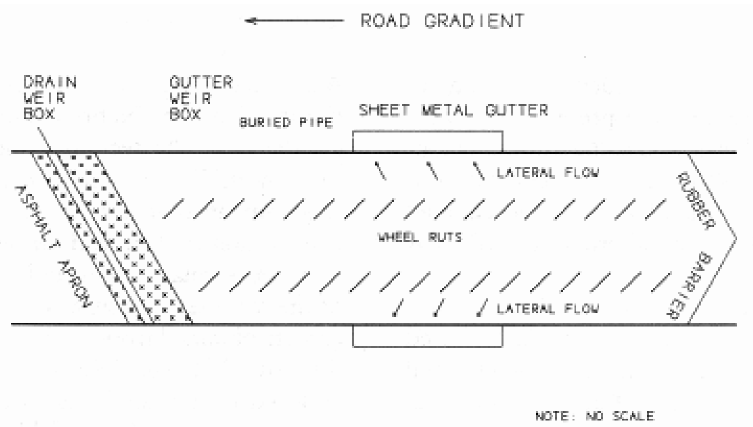

FIGURE 1 Typical road section layout.

Runoff and Sediment Measurements

The outlet of each runoff source (drain or gutter) was directed into a 0.15-rn^3 (1.6-ft^3) aluminum box with a modified 22.5-degree V-notch weir at the outlet. The weir was modified by adding a slot 6 mm (1/4 in.) wide by 13 mm (1/2 in.) long at the base of the V. Without this modification, water surface tension at the base of the V made maintaining a reference level difficult. Although this design sacrificed the accurate measurement of low flows, for this application the slot was an improvement over the original V-notch design.

The water levels taken at 1-mm intervals were converted to flow rates using a rating curve developed for the modified V-notch weirs. During runoff events, grab samples were taken from the weir overflow to characterize the effect of truck traffic. Sediment concentrations were determined by oven-drying the grab samples at 105°C. Sediment in the runoff was trapped in the settling box located above the weir. Sediment trapped in the settling boxes was removed three times during the 1992 test and four times during the 1993 test. All of the sediment was oven-dried at 105°C to determine the dry weight.

An estimate of the runoff and sediment production from the entire road section was made using the measured gutter and drain collectors. Since one gutter collector was placed on each side of the road and extended for one-fourth of the length of the entire road section, it was assumed that they collected one-fourth of the total runoff flowing from the crown of the road. Observation of the flow during the two test periods tended to validate this assumption. The runoff rate from the gutter collector was multiplied by four and added to the drain collector for an estimate of the entire road section.

Trap Efficiency

The material collected in the settling boxes represented only a portion of the material eroded from the road surface even though the boxes had two vertical barriers to minimize velocity. The sand and larger-size material were trapped by the box with efficiencies increasing with sediment size. The finer sizes, such as the silts and clays, did not have sufficient residence time to settle and were not captured efficiently in the box. Flow rates also changed the turbulence in the boxes, affecting the settling of individual particles.

Two methods were used to estimate the trap efficiency. One method compared runoff samples taken simultaneously at the inlet and outlet of the box. The second method compared the mass of sediment deposited in the weir with the mass of sediment calculated from the runoff flow rates and the inlet sediment concentrations. The two methods were averaged for each runoff source and used to adjust the sediment masses. When expressed as a percentage of the material remaining in the settling box, the average trap efficiency for the drain source was 35.6 percent and that for the gutter source was 40.2 percent.

Truck Traffic

To simulate the effects of road use from a timber harvest, loaded and unloaded trucks were driven on the test loop. During the winter of 1992, two trucks were used. One western-style logging truck with a 22 450-kg (49,400-Ib) load of logs was driven downhill. A dump truck with the same axle spacing as an unloaded logging truck carrying its trailer was driven up the hill. All trucks had a tire inflation of 620 kPa (90 psi). Other test sections had traffic with lower tire pressures but are not presented in this paper.

During the winter of 1993, a second loaded logging truck was added. It also had a 22 450-kg load of logs and was driven downhill. The dump truck made twice as many passes as the logging trucks to maintain the desired ratio of one loaded logging truck for each unloaded truck. Tire inflation remained at 620 kPa.

TABLE 2 Water Yields from Natural Events

Year	Traffic (loads)	Rainfall Depth (mm)	Marginal Quality		Good Quality	
			Runoff Depth (mm)	Runoff Rainfall Ratio	Runoff Depth (mm)	Runoff Rainfall Ratio
1992	268	147	83.6	0.57	37.5	0.25
1993	616	521	184.7	0.35	38.2	0.07

Rainfall Simulation

At the conclusion of the 1993 test, rainfall simulation was performed. A single simulated storm on each section with an intensity of 50 mm/hr (2 in./hr) and a duration of 30 mm was used. This intensity-duration storm was very rare for the Lowell area (in excess of 1,000 years), but has a reasonable return period for the intermountain regions of the Rockies. The simulator used was a modified CSU—type (10). The road sections were not graded but left in rutted condition and were shortened to 42.7 m (140 ft) to not exceed the capacity of the weirs. Water levels in the settling boxes were taken at 1-mm intervals during the simulation. Grab samples were taken at 70-sec intervals to determine sediment concentration. The settling boxes were cleaned before and after the simulations. An estimate for the entire road section was made in the same manner as for the natural rainfall except the factor for the gutter sources was changed to 2.8 (140 ft/SO ft).

RESULTS AND ANALYSIS

During the winter of 1992, the two trucks hauled the equivalent of 1.3 million board feet (268 loads) in 36 driving days between mid-February and April. During this test period of 51 days, there was 147 mm *(5.8* in.) of precipitation in 20 days. The greatest 24-hr precipitation depth was 31 mm (12.9 in.). The maximum 5-mm intensity was 18 mm/hr (0.71 in./hr).

During the winter of 1993, the three trucks hauled the equivalent of 3.0 million board feet (616 loads) in 25 driving days between January and April. Precipitation for the test period of 90 days was 521 mm (20.5 in.), which fell in 37 days. Of this amount, 249 mm (9.8 in.) fell as snow between January 7 and 22. The greatest 24-hr precipitation depth was 44 mm (1.7 in.) whereas the maximum 5-mm intensity was 17 mm/hr (0.67 in./hr).

Natural Rainfall

Table 2 presents the water yields from the natural rainfall events for the 2 years of the test. The good-quality road section had lower runoff than the marginal-quality section, indicating a higher infiltration rate. The higher infiltration rate was a result of the "cleaner" aggregate. In 1993 the runoff ratios were lower than the 1992 rates even though the precipitation was greater. Much of this was because 48 percent of the 1993 precipitation was snow, which slowly infiltrated into the road surface as it melted. In 1992 none of the precipitation was snow.

Table 3 shows the sediment production for the 2 years of the test. The sediment mass was adjusted for the trap efficiencies and therefore represents the amount of material eroded from the road surfaces. Virtually all of the eroded material, 96 to 99 percent, was smaller than 6 mm (1/4 *in.).* The amount of material smaller than 200 mesh (0.047 mm) in the runoff from both road sections was typically 65 percent.

The ratio of the marginal-quality to good-quality road section sediment production represents the increase in sediment resulting from the use of poorer-quality aggregate. This ratio was 2.92 for 1992, the year of 147 mm (5.78 in.) of rainfall, and increased to 13.31 for 1993, the year of 521 mm (21 in.) of rainfall.

The sediment ratio demonstrates the value of using the good-quality aggregate. In the year of lower precipitation, for every unit of sediment eroded from the good aggregate, nearly three units were eroded from the marginal-quality aggregate. The difference between sediment production was more pronounced in the year of higher precipitation in which, for each unit of sediment from the good-quality aggregate, the marginal quality aggregate produced 13.3 units.

Two factors, aggregate quality and rut depth, contributed to the differences. The aggregate quality reflected the amount of fines and the ability to resist additional fine generation resulting from traffic. The rut depth allowed concentrated flow on the marginal-quality road section. The fact that the concentrated flow was more erosive than the overland flow caused more erosion on the marginal-quality road. Of these two factors, only the rut depth was controllable. In this test the rut depth was controlled by the quality of the aggregate, since both sections had identical traffic. Alternatively, rut depth could be controlled by grading the road, but this approach may or may not reduce sediment production depending upon the depth of the rut removed and the amount of loose material left after grading. Grading on a road that is near saturation is difficult to recompact during wet weather. A looser surface is more susceptible to increased infiltration, the aggregate can become more unstable, and the sediment production can increase (11). Relating the timing of road maintenance to rut depth is an ongoing topic of research at the Intermountain Research Station.

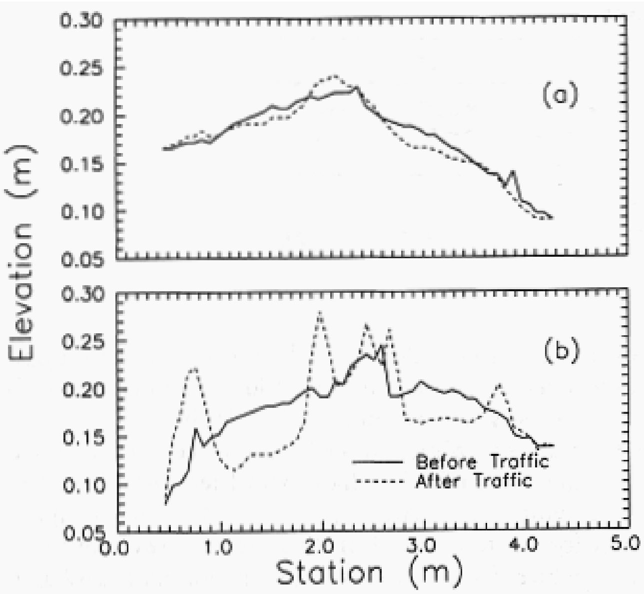

FIGURE 2 Road cross section surfaced with (*a*) good-quality aggregate and (*b*) marginal-quality aggregate; "before traffic" was after grading and before logging truck traffic; "after traffic" was after 3.0-million-board-feet haul (616 loads).

The cross sections shown in Figure 2 illustrate the degree of rutting that occurred. Each road section had the same number of truck loads as well as the same amount of precipitation. The lower-quality aggregate road showed a marked effect in the development of rutting. Using a peak-to-peak measure of the depth of a rut, the marginal-quality aggregate resulted in a rut 133 mm (5 1/4 in.) deep as opposed to a rut 25 mm (1 in.) deep on the good-quality aggregate. The deeper rut allowed a more concentrated flow to occur, resulting in greater sediment production, as shown in Table 3.

Simulated Rainfall

Table 4 gives the water yield results from the rainfall simulations. The marginal-quality aggregate again resulted in a higher runoff ratio. It also illustrates that overland flow predominated on the good-quality section as evidenced by the fact that the peak flow on the gutter source (lateral flow) was higher than that on the drain source (flow in the ruts). The opposite occurred on the marginal section, indicating a predominance of flow in the ruts. From this observation, one would expect more sediment from the marginal section.

Table S presents the sediment production results from the rainfall simulations. As was observed from the natural events and expected from investigation of the type of flow occurring on the road sections, greater sediment production occurred from the marginal quality section. A comparison of the sediment ratios from simulation, as shown in Table 5, and from natural events, as shown in Table 3, shows the simulation to be intermediate between the 2 test years (see Figure 3). There was no traffic during the single simulation event, so the immediate effect of the trucks during the event could not be measured. Neither was the measurement of the long-term effects of truck traffic, such as continued breakdown of the aggregate, possible during the simulation. The simulation more closely represents the effects of a single storm.

Aggregate Specifications After Traffic

At the end of the study, all gradations were well within the requirements for the 1-in, dense graded specifications (4), but the good-quality aggregate was closer to the coarse side of the specification requirement for the sand size and smaller material. The major differences between the good- and marginal-quality aggregates are in the durability index for the fine fraction and the sand equivalent value. The durability index (fine) for the good-quality aggregate averaged 60, whereas the durability index (fine) for the marginal averaged 31, which is out of specification. This difference indicated the tendency of the fine fraction of the marginal aggregate to break down and produce more fines. The sand equivalent value for the good-quality material was initially 56 and then averaged 38 after the first year of traffic. The sand equivalent value for the marginal aggregate, however, averaged 22 for both years, well below the

TABLE 4 Water Yields from Simulated Rainfall

Road Section	Rainfall Depth (mm)	Rainfall Intensity (mm/hr)	Runoff Depth (mm)	Runoff Rainfall Ratio	Peak Rate (ml/sec)	
					Drain	Gutter
Marginal	29.9[1]	59.8	26.2	0.88	3032	796
Good	27.3	54.6	17.8	0.65	681	1032

[1] - Includes 1.3 mm of natural rainfall.

TABLE 5 Sediment Yields from Simulated Rainfall

Aggregate Quality	Mass Sediment		Sediment Production		Average Concentration (g/l)
	(kg)	Marg/Good	kg/ha	kg/mm	
Marginal	116.0	8.7	5890	4.43	22.1
Good	13.4	1.0	680	0.77	3.8

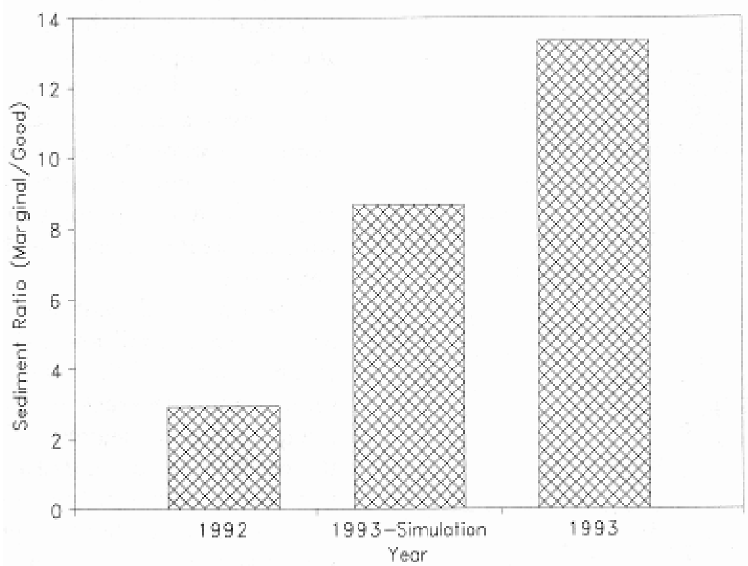

FIGURE 3 Ratio of marginal-quality aggregate sediment production to good-quality aggregate sediment production for 1992 natural rainfall, 1993 rainfall simulation, and 1993 natural rainfall. Simulation represents a 50-mm/hr storm for 30 min.

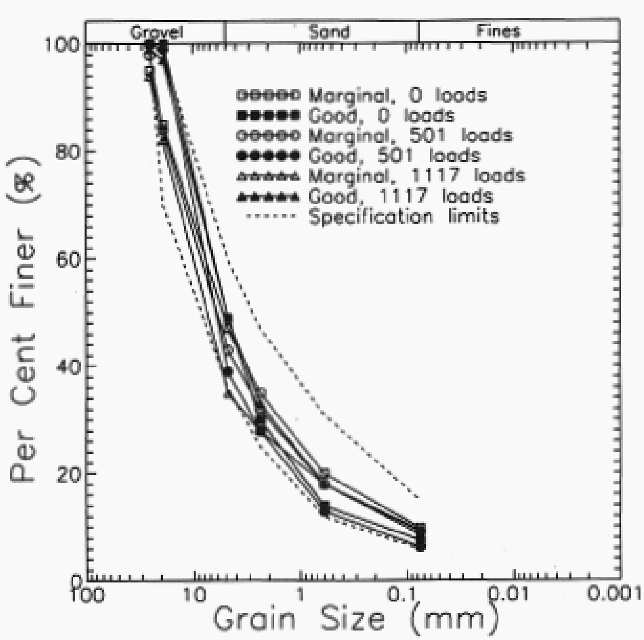

FIGURE 4 Gradations of marginal-quality and good-quality aggregates before traffic (0 loads), after 1992 test (268 total loads), and after 1993 test (884 total loads). Also included are the specification limits.

minimum value of 35. These two quality indicators are considerably different and best relate to the sediment production performance differences.

Figure 4 is a summary of the gradation tests of the marginal and good aggregate throughout the study. The gradation of the marginal aggregate varied little from the initial gradation, whereas the gradation of the good-quality aggregate, initially on the coarse side of the specification requirement, became finer and approached that of the marginal-quality aggregate. This gradation is indicative of the tendency of an aggregate to alter grain size to the center of the gradation band, which represents a maximum internal stability.

Comparing these sediment losses for each road section with the entire weight of the material finer than the No. 200 sieve for the 76-mm (4 in.) layer full width and length equates to 1.3 percent and 20 percent of the weights of material present. Since the gradation of the marginal material essentially did not change and the gradation of the good-quality material increased in fines, it is evident that the marginal aggregate broke down considerably to produce this quantity of sediment.

These aggregates are representative of good- and marginal-quality aggregates that have been used to surface low-volume roads. Under highway tire pressures, the good-quality aggregate produced only 7 percent of the quantity of sediment, whereas the poor-quality aggregate produced the remainder. The sand equivalent and durability index appear to be the tests that best relate to this difference. The sand equivalent value is essentially an indicator of the presence of claylike fines and the durability index is an indicator of the tendency of the aggregate to break down and produce more fines.

Mitigation

It is possible to estimate the sediment reduction for both the marginal- and the good-quality aggregates. The gradation of the subgrade at Lowell was similar to that of a coarse silt site in central Idaho reported by Foltz (11). A road section with a length of 38.1 m and a nearly saturated water content had a sediment production of 9200 kg/ha. The good-quality aggregate in the Lowell study resulted in an estimated sediment reduction of 92 percent, which compares favorably with Burroughs and King's (1) value of 95 percent. The estimated sediment reduction from the marginal-quality aggregate was 31 percent. When Burroughs and King's value is used, this level of reduction corresponds to an application rate of 15 tons/acre of 38-mm (1.5-in.) minus stone. The calculated application rate of 42 tons/acre results in a 2-mm (0.08-in.) lift of aggregate. From a sediment reduction viewpoint, the 152-mm (6-in.) lift was reduced to a 2-mm lift because of the quality of the aggregate. The good-quality aggregate retained its full mitigation potential.

Management Implications

Figure 3 summarizes the sediment production ratios for both the two seasons of natural rainfall events and the simulated events. Both the low-precipitation year, 1992, and the high-precipitation year, 1993, resulted in differences in sediment production because of the quality of the aggregate. The high-intensity, single simulated storm also showed sediment production differences between the two aggregate qualities. These sediment ratios—between approximately 3 and 13—combined with sediment production—1500 to 3200 kg/ha—were not trivial.

The lowest sediment ratio, 2.9, was under conditions of 147-mm rainfall and 268 truck loads. The highest sediment ratio, 12.9, was under conditions of 521-mm rainfall and 616 truck loads. This would suggest that the quality of the aggregate increased in importance as the traffic and the rainfall increased. The sediment ratios also demonstrated the importance of seasonal road closures during higher precipitation periods. The wetter year resulted in a sediment ratio of 12.9 whereas the drier year resulted in a sediment ratio of 2.9.

For wetter climates, such as those of western Oregon and Washington, the results from 1993 would be more appropriate. For drier climates, such as those of eastern Oregon and Washington, the results from 1992 could be used as guidelines. For areas that experience high-intensity summer thunderstorms, such as the inter-mountain West, the simulation results may be more applicable.

For agencies using aggregate on roads to reduce sedimentation, the implication of this study is clear. As stated by Burroughs and King (1) and as evidenced by this study, not all aggregates are equally effective in reducing sedimentation. The marginal-quality aggregate in this study at Lowell did not provide the expected mitigation. This marginal-quality aggregate used in this study was below the specification limit for the durability index (31, specification minimum 35) and considerably below the specification limit for the sand equivalent (22, specification minimum 35). This marginal aggregate clearly had lower-quality test values than the high-quality aggregate but does not represent the lowest-quality aggregate that is used as surfacing. For this reason agencies claiming sediment reduction from the use of aggregate need to ensure that the aggregate is of high quality to take full credit for the sediment reduction. If the aggregate is not of high quality, then the sediment reduction estimates need to be reduced.

CONCLUSIONS AND RECOMMENDATIONS

A 2-year study of sediment production from aggregate-surfaced roads with concurrent logging truck traffic demonstrated differences of 2.9 to 12.9 times as much sediment from the lower-quality aggregate. Two aggregate specification tests, the sand equivalent and durability index, were believed to be most indicative of the susceptibility to erosion. A comparison of the expected sediment mitigation from these two aggregates revealed that the good-quality aggregate performed as expected, whereas the marginal-quality aggregate failed to achieve the expected sediment reduction.

Though these test values indicate a large difference in performance for these materials, they do not allow predictions of intermediate performance with just two data points. In addition, these tests may not be the best predictors of sediment production especially considering other rock types. In order to better quantify sedimentation production, it would be necessary to evaluate the erosivity of various aggregate types and evaluate other test methods.

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