Reduced Tire Inflation Pressure—A Solution for Marginal-Quality Road Construction Rock in Southeast Alaska

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When marginal-quality rock is encountered in Southeast Alaska, the rock often does not provide adequate support for truck haul. The road surface tends to rut and the rock continually breaks down after heavy repeated wheel loads combined with wet conditions. This process reduces the gravel to fine silt and clay-sized particles that will not support construction vehicles. The traditional solution has been to blade this material off the road and haul additional higher-quality rock to support the traffic. This procedure results in higher costs and additional stream sediment. By using radial tires with lowered tire pressures, the road surface became more compact with repeated wheel loads. This result has produced large savings, exceeding $500,000 on one project, and this concept is expected to provide future contract savings for road building and logging activities.

High-quality, durable rock is available for most road contracts in Southeast Alaska, but in some areas only poor- to marginal-quality rock borrow materials are available for road construction. This fact can result in a road surface too weak to support truck haul, especially in the wet climate and soft, highly organic, subgrade conditions encountered on the Tongass National Forest. Immediately after placement, the marginal-quality rock breaks down with repeated applications of heavy construction traffic, resulting in deep ruts within the wheel path. The conventional solution typically involves blading the decomposed aggregate slurry off the roadway, and importing better-quality materials from a distant source. This solution increases construction costs significantly and also increases the amount of potential stream sediment delivery. An alternative solution is described that was used on a timber access road construction project, the Toncan timber sale, that used reduced constant tire pressure and radial tires. Although conditions described here are representative of southeast Alaska, they may also apply to other areas where poor- to marginal-quality road surfacing material, combined with high rainfall, are encountered.

TYPICAL ROAD CONSTRUCTION

In Southeast Alaska, the typical road construction process involves preparing the subgrade with a hydraulic backhoe that levels the saturated subgrade material to the pioneer-grade elevations. Because the saturated excavated material is usually too weak to be incorporated into the road embankment, and rain frequency makes drying impractical, most of the roadway excavation is wasted. During pioneer operations, the hydraulic backhoe incorporates the clearing debris, such as limbs, tree tops, cull logs and stumps, into the prepared subgrade as a debris-reinforced mat. Once the subgrade is prepared, pit-run quarry rock is end-dumped on the debris-reinforced mat and spread with a bulldozer. The depth of rock on the finished road typically ranges between 30 and 48 in., except occasional weak muskeg may require more rock, sometimes exceeding 10 ft. Road surface failures can be caused either by inadequate subgrade support or the degradation of rock borrow materials. Photographs of the construction of the Toncan timber sale road, which is typical in Southeast Alaska, are shown on Figures 1–3.

PROJECT HISTORY

The Toncan timber sale is located approximately 20 mi southwest of Petersburg, Alaska, on Kupreanof Island, as shown in the key map of Figure 4. The project involved harvesting approximately 50 million board feet (mmbf) of timber and the construction of 21.5 mi of permanent, 16-ft-wide, low-standard, low-volume roads. During the early planning stages of the Toncan timber sale, it was recognized that for the first 8.5 mi, the rock barrow materials available for construction were of marginal quality, on the basis of past road construction in the vicinity. As a result, an intensive geotechnical field evaluation was done to identify the better-quality sites along the proposed road construction corridor. When the timber sale contract was prepared, the best of the marginal-quality borrow sources were designated and incorporated into the contract. Because how these marginal materials would perform on the road was still uncertain, construction personnel were notified that rock quality problems could be anticipated. The site map of the Toncan timber sale shown in Figure 5 indicates the planned road location and the area of the sale, where only marginal borrow materials were available for construction.

The Toncan timber sale was awarded in the spring of 1986 to Mitkof Lumber Company, of Petersburg, Alaska. Road

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FIGURE 1 Road subgrade preparation.

FIGURE 2 End-dumping rock used for road construction.

FIGURE 3 Bulldozer used to shape desired road prism.

construction for the project began in the spring of 1987, and continued throughout the drier summer months. The two initial quarries contained suitable rock; however, when the third quarry site was developed in late July, Forest Service and contractor personnel had serious reservations that the material could sustain heavy haul once the fall rainy season began. The contract called for the development of approximately 40,000 yd^3 of material from quarry Site 3.

Rock quality testing results met Forest Service standard specifications, but the material tended to break down when it became wet, and the aggregate did not support the heavy construction traffic being used to build the road. The fine-grained, highly fractured, phyllite schist historically has created problems on previous road construction projects in southeast Alaska. Both authors of this paper have experienced similar situations in the Cascade Mountains of Oregon and Washington, where rock quality problems occurred when

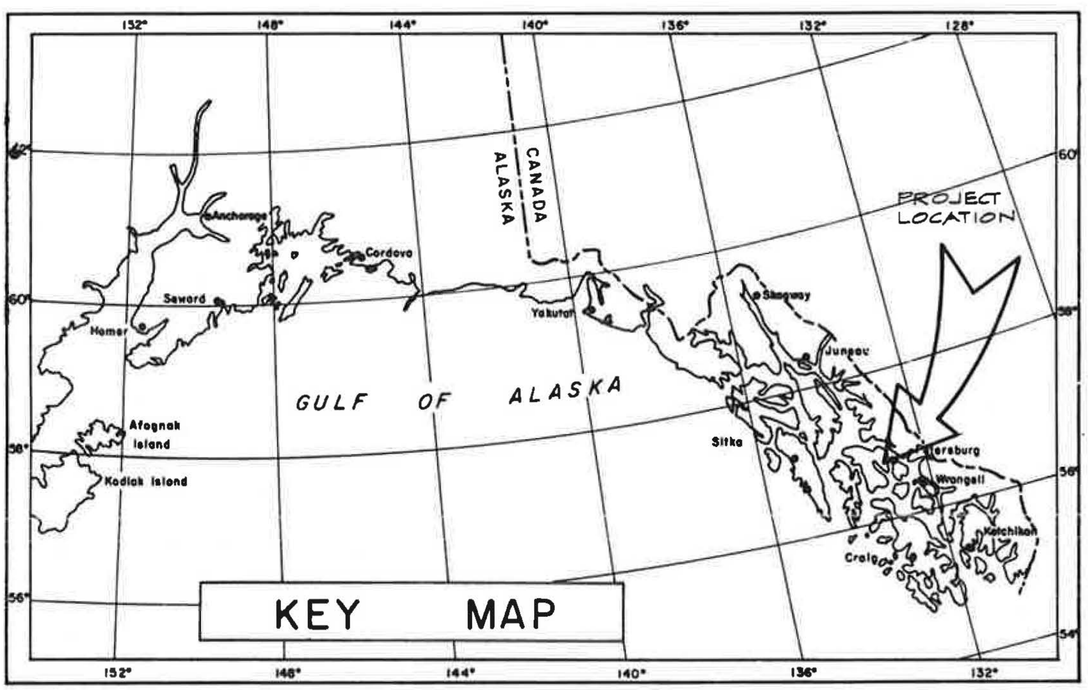

FIGURE 4 Key map.

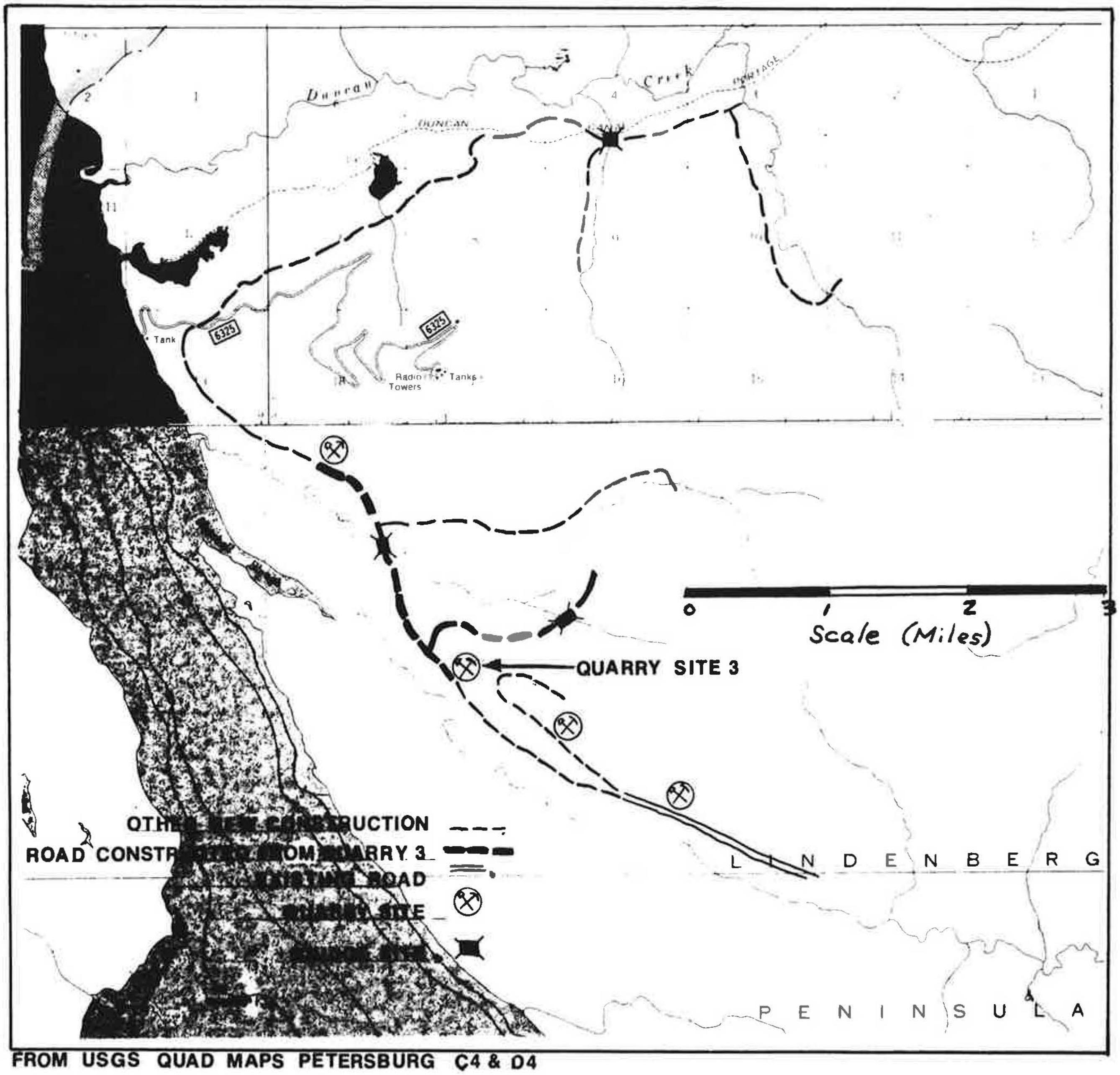

FIGURE 5 Toncan timber sale area.

material testing results narrowly passed Forest Service standard specifications. Materials testing for rock quality is presented in Table 1.

Gradation testing was performed on the pit run material immediately after placement and after several days of haul. The purpose of the testing was to specifically determine what percentage of mechanical breakdown was occurring through abrasion during rock haul. The results of gradation testing are displayed in Table 2.

Severe rock degradation was experienced during rock haul. This process, concurrent with heavy rainfall, resulted in 12- to 18-in.-deep ruts, excessive sedimentation, and daily blading was required to continue operations. During some periods of heavy rainfall, haul operations could not continue for an entire day without performing maintenance because of the poor performance of the material. Figure 6 shows the conditions of the rock after the initial placement, and Figure 7 shows the conditions during rock haul.

CONSIDERATIONS FOR PROJECT MODIFICATIONS

On the basis of studies that were conducted by the Forest Service in California, the use of radial tires, central tire inflation (CTI), and reduced tire pressure significantly reduced road maintenance and road surface damage. This fact was initially reported by Dela-Moretta (*1*) in 1984, when a loaded western-style log truck was operated on the Klamath National Forest with tubeless radial tires at a tire pressure of 25 psi.

TABLE 1 MATERIAL TEST RESULTS FOR ROCK BORROW MATERIAL FOR TONCAN TIMBER SALE

	Los Angles Abrasion (AASHTO T 96)	Durability Index (AASHTO T 210) Coarse	Fine	Sand Equivalent (AASHTO T 176)
	%	%		%
Specification	40 maximum	35 min.	35 minimum	35 minimum
Test Result	29	41	73	40

TABLE 2 MATERIAL GRADATION BEFORE AND AFTER TRUCK HAUL

	Finer than 7mm (3inch)	Finer than #4 sieve 4.7mm (sand size)	Finer than #200 sieve .074mm
	%	%	%
Before Haul	100	17	3
After Haul	100	30-50	17

In controlled testing conditions, Hodges (*2*) compared road damage by operating identical western-style log trucks, one operated with reduced tire pressure and one operated at high tire pressure, on parallel traffic lanes near Carson City, Nevada. Hodges reported a significant reduction in road damage in the low–tire pressure traffic lane. Since that time, similar reports have supported this concept. Considerations were therefore made to use CTI for solving rock quality problems on the Toncan timber sale. There was an initial reluctance to use low tire pressure because the poor performance problems of the rock were so extensive. It was difficult to imagine that simply lowering the tire pressure would prevent the 18-in. ruts that developed daily on the project.

The total contract cost was $2.5 million to construct 18.7 mi of road. A cost analysis indicated that the additional expense to import higher-quality materials would exceed $550,000. This amount was compared to $49,400 to equip the contractor's trucks with radial tires. Because of the wide difference, an 11 to 1 differential, it was decided to try the lower tire pressure alternative with the knowledge that some risks of failure would be assumed, because there was no previous testing at the time to indicate whether reduced tire pressure would work on poor-to-marginal road-surfacing materials. If this alternative did not solve the rock performance problem, the higher-cost alternative of importing higher-quality rock could be implemented.

FIGURE 6 Rock borrow after initial placement.

Significant differences in conditions and equipment existed on the Toncan project when compared to the earlier low–tire pressure studies. Virtually all the earlier reporting pertained to tubeless radial tires. Tubeless radial tires are available for standard-sized highway trucks, but were not available in the U.S. market for the loads and vehicles being used on the Toncan project. The contractor used four hauling vehicles, two Mack DM–800s and two Hayes trucks similar in size to the Mack DM–800. The gross weight is 85,000 lb with a 45,000-lb load capacity. The front axles were rated at a capacity of 20,000 lb and the rear at 65,000 lb. Scales were not available on this project, although on other projects the front axles normally weigh about 16,000 lb with 70,000 lb on the rear. On the basis of the load capacity of the Hayes and Mack dump trucks being used, 12.00R24 tube-type tires were needed to carry the loads, as shown in Figure 8. Because the haul route was all on a low-speed (less than 35 mph), low-volume, Forest Service road system, and CTI equipment was still in the developmental stages and was not readily available for immediate installation, it was decided to use a constant reduced tire pressure, rather than using CTI equipment. On the basis of the testing done by Hodges (*2*), tire pressures should be adjusted on the basis of the concept of percent deflection, or the ratio of the difference between unloaded and loaded tire section height to the unloaded section height. Accepting this concept, the optimum tire deflection to reduce road damage was reported to fall in the range of 20 to 22 percent. Conventional high tire pressure normally falls in the range of 10 to 12 percent deflection. Final tire pressures were set through a trial-and-error method on the basis of the loaded truck,

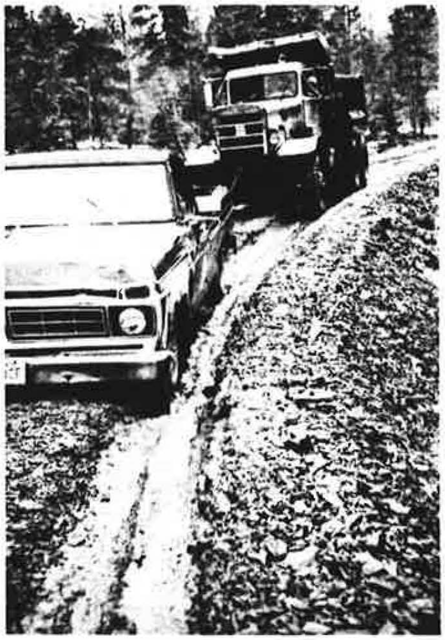

FIGURE 7 Deep ruts resulting from construction haul.

using a large caliper to measure tire section heights as shown in Figure 9. The final tire pressures varied because of the different load capacity of the trucks used on the project as well as the difference between front- and rear-axle loading. Final pressures selected ranged from 42 to 62 pounds per square inch (psi). Normal tire inflation pressures of 100 to 110 psi are used for the same tire and load.

RESULTS USING REDUCED TIRE PRESSURES

In late November 1987, rock haul resumed with the newly installed radial tires operated with reduced tire pressures as described earlier. To everyone's surprise, immediate results were realized. The deep rutting was virtually eliminated with the reduced tire pressure. The low-pressure radial tires acted similarly to pneumatic rollers and compacted the road surface, rather than producing deep agitation of the road base. Where road widths allowed, the drivers varied the wheel path of the construction vehicles that served to compact and seal the entire roadway, effectively preventing further moisture infiltration, as shown in Figure 10. In narrower road segments, typically on steep 10 to 15 percent grades, traffic was concentrated to a confined wheel path and some rutting did develop (see Figure 11). However, measured rut depth rarely exceeded 4 in. The road contractor was extremely pleased with the results and elected to equip his entire log haul fleet with radial tires to take advantage of the reduced road damage and maintenance.

Work continued on the Toncan project for several weeks until snow prevented further operations. No road maintenance was required during this late season of operations, a

FIGURE 8 Mounted 12.00R24 radial tires.

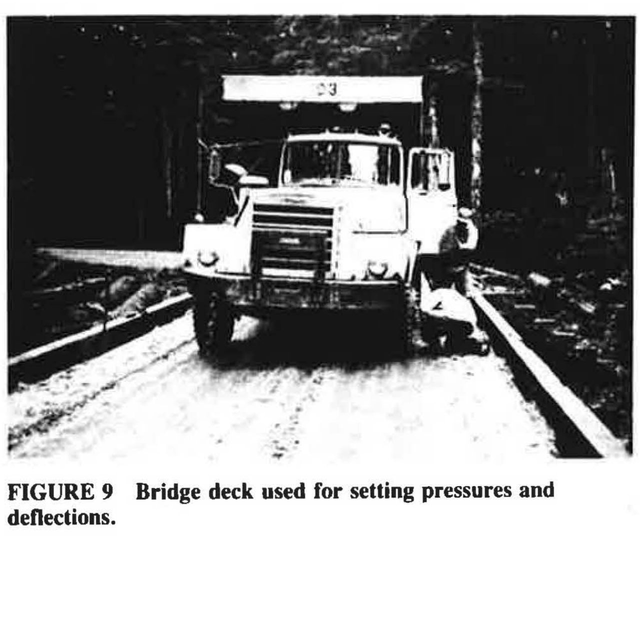

FIGURE 9 Bridge deck used for setting pressures and deflections.

FIGURE 10 Resulting road surface, full-width travel.

FIGURE 11 Maximum rutting where trucks could not vary wheel path.

big change from the almost continuous blade maintenance that was required with high-pressure tires. When haul commenced the following spring, the road again began to deteriorate and deep rutting started to develop. Frost in the road prism was suspected and a work shutdown was considered; however, a check of tire pressures revealed that one truck was operating with conventional high tire pressures (90 psi). When the pressures where reduced, the road immediately began to heal and continued to do so until construction was completed.

CONCLUSIONS

At present, the Forest Service spends a considerable amount of money to pay for importation of high-quality aggregates. On the basis of the results of the Toncan project, the use of radial tires operated at a reduced constant tire pressure may substantially reduce road damage and maintenance, at a relatively low cost, on roads built with poor- to marginal-quality rock. On the Toncan sale alone, it saved the Forest Service an estimated $450,000 and also reduced the amount of fine silty soil that could have reached high-valued fish streams. More savings potentially could have been realized if CTI systems had been available to reduce pressures even more on the return empty truck, but with additional up-front expense. Lower-quality materials could be used for road construction in other parts of the nation for low-volume, low-speed, road systems if low-pressure radial tires are used. This process could dramatically reduce road construction and maintenance costs in some parts of the United States. In Alaska, this process can be used successfully at many sites where only poor-quality materials are present, at considerable savings to the government.

When considering the use of this concept of reduced tire pressure and CTI, care must be exercised in the proper selection of tires and wheels. In some instances where haul includes operation on high speed state highways systems, CTI equipment is necessary. In order for successful application of CTI equipment, proper installation and maintenance is extremely important.

REFERENCES

1. L. Della-Moretta. *Proof of Concept Test for Central Tire Inflation*. U.S. Department of Agriculture, Forest Service, San Dimas Equipment Development Center, 1984, pp. 1–10.
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