

AN EVALUATION OF PAVEMENT WEAR CAUSED  
BY PERMA-T-GRIPPER TIRE STUDS



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MICHIGAN DEPARTMENT OF  
STATE HIGHWAYS AND TRANSPORTATION

AN EVALUATION OF PAVEMENT WEAR CAUSED  
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The Perma-T-Gripper (PTG) tire stud, manufactured by the Townsend Company is physically different from conventional studs in two ways. First, conventional studs use a solid core of tungsten carbide whereas the PTG uses a core consisting of tungsten carbide fragments bound together in a copper matrix. Second, the core of a conventional stud extends the entire length of the device while the PTG core extends about one-half the length. Those two physical differences cause PTG studs to wear pavements at a rate much less than conventional studs. The question is, how much less is that wear rate?

The only tests directly comparing pavement wear caused by PTG and conventional studs were made at Washington State University in 1972 (Phase I) and 1973 (Phase II) (1). Wear tests were made on a circular track, almost 40 ft in diameter using tires traveling at a speed of about 20 mph. Because of anomalies in the data, only the wear rates from Phase I for the asphalt pavements and the Wirand concrete are considered here. Phase II involved some relatively uncommon surfacings and results were quite erratic. Some results of the Phase I tests were also ignored because of inconsistency. Phase I wear rates showed the PTG to compare with conventional studs as follows:

Wirand Concrete - PTG wear rate was 36 percent of conventional studs.  
Asphalt Pavements - PTG wear rate was 34 percent of conventional studs.

Those wear rates, of course, exceed the maximum (i.e., 25 percent of the wear rate of conventional stud) allowed by Michigan rules. What, then, are the arguments that the PTG stud does not exceed the allowable wear rate?

1. PTG studs currently use a core of lower density than those used during the WSU tests. The lower density studs would wear down faster and thus have even less protrusion than the older ones. Less protrusion, of course, would mean a lower rate of pavement wear. According to information from Townsend Company and from METCOMP Associates, a consulting firm in Bethlehem, Pennsylvania, the density of PTG studs has been reduced by about 25 percent (from 8 gm/cc to 6 gm/cc) since the WSU test. Unfortunately, even though we know pavement wear should be reduced through this change in density, the reduction cannot be quantified at this stage.

2. Measurements during the WSU tests showed PTG studs to average about 62 percent less protrusion than the conventional studs (0.036 in. vs. 0.096 in.). What happens when these differences in protrusion are examined using results of the American Oil Company (AMOCO) (2) tests where PTG studs were not tested. A 0.040 in. conventional stud protrusion was used by AMOCO for establishing wear rates on pavement surfaces that were

tested. If the proportional difference in protrusion averaged for the WSU tests held during the AMOCO tests, the protrusion of PTG studs would be about 0.015. Extrapolating from the AMOCO graphs showing terminal stages of pavement wear, the PTG, is estimated to wear concrete pavements at a rate of 21 percent of conventional studs for "high type" asphalt, 23 percent for "regular type" asphalt and 26 percent for concrete pavements.

Why should comparative wear rates be taken from extrapolations of AMOCO tests instead of merely using the direct comparisons made at WSU? The WSU tests showed Controlled Protrusion (CP) studs to wear pavements at a rate almost equivalent to conventional studs. In contrast the AMOCO tests showed CP studs to wear pavements at a rate from 30 to 50 percent less than conventional studs. Possibly the disagreement in results is due to an interaction of speed and some feature of the stud or perhaps the conventional stud had been modified between the time of the two tests. Whatever the cause may have been, the inconsistencies between the two tests warrant an examination of stud wear rates based upon basic research done by other agencies.

The following paragraphs discuss factors affecting pavement wear by studs and how such factors apply to comparative wear of PTG studs.

#### Pavement Wear Permitted by Rules

Michigan's allowable pavement wear rate was established using results from tests made in 1970 and 1971 by American Oil Company. The AMOCO tests were made at a speed of 35 mph on a circular wear track, 14 ft in diameter. Pavement wear rate was found to be a function of stud protrusion and stud protrusion is a variable which changes during the service life of the studs. During the tests, correlations between stud protrusion and wear rates of each type pavement were developed. In order to facilitate comparisons, these correlations were then used to transform wear rates for different pavements to those for a constant 0.040 in. protrusion.

Pavement wear data based upon exposure to studs with 0.040 in. protrusion were used to estimate pavement repair costs in Michigan. Subsequently, these same data were used to establish a rate of pavement wear which would be tolerable under Michigan's rules.

#### Effects of Test Speed

Tests (3, 4) have shown that pavement wear rate for a rolling studded tire is a function of tire speed. Pavement wear increases at an increasing rate as vehicle speed increases. Since tests made on the WSU track were made at speeds of only 20 mph, stud wear rates would probably be greater on typical highways than during the WSU studies. Speeds during the AMOCO tests were 35 mph. Because of the small diameter track (14 ft) at AMOCO

a large slip angle would be experienced by tires and wear rates would be higher than at equivalent speed on a tangent length of pavement.

### Effects of Stud Weight

Pavement wear rate has also been shown to increase with increasing stud weight (3, 4). Conventional tire studs weigh about 2.7 grams while the PTG stud weighs about 2.0 grams. The difference in weight is because the PTG stud has a core extending only about half the length of the stud while conventional stud cores extend full length. Unfortunately, PTG studs used during the WSU tests had cores extending full length and weighing 2.7 grams, the same as conventional studs. Thus, the lighter weight PTG currently being manufactured should show measurably less wear than the ones used at WSU. The amount of reduction in wear cannot be estimated using available data.

### Effect of Stud Protrusion

It seems to be unanimous among researchers (1, 2, 3, 4) that stud protrusion is a major factor affecting pavement wear. The Vienna study showed that by reducing stud protrusion from 3 mm (0.118 in.) to 1 mm (0.039 in.) pavement wear was reduced to 1/7 of the original value. Equations relating stud protrusion to pavement wear rate were developed by AMOCO using data from their tests. Even though the AMOCO tests were made on a track only 14 ft in diameter, it appears that relationships shown between studs of different protrusions would be valid -- at least at the 35 mph test speed used during the study.

The preceding argument which was presented by Townsend Company appears reasonable if an interaction between test speed and stud protrusion is assumed.

As mentioned earlier, during the approximately 25,000 mile duration of WSU Phase I tests PTG studs averaged 62 percent less protrusion than conventional studs; conventional studs averaged 0.096 in. protrusion and PTG averaged 0.036. Tests made by the Nevada Auto Test Center (5) in 1971 provided protrusion data as follows:

Stud Type	Stud Protrusion (in.) (Mean Average For All Studs)	
	New	After 4,000 mi
PTG	0.010	0.020
Conventional	0.020	0.100

Thus, the Nevada tests showed that after 4,000 miles wear the PTG studs had about 80 percent less protrusion than conventional studs.

According to Cantz (3), average protrusions of conventional studs was 0.065 in. as measured in parking lots in western Pennsylvania in 1970-71. According to representatives of Townsend Company, PTG studs, measured after 5,000 miles, showed protrusions averaging slightly less than 0.020 in. From the foregoing comparisons, it appears that the 62 percent lower protrusion of PTG studs compared to conventional studs is not an unreasonable estimate. Therefore, the use by Townsend Company of the AMOCO results relating protrusion to pavement wear and the consequent conclusions appear reasonable.

### Tire Construction

Because radial tires, as compared to bias-ply tires, generate less squirm and consequently less slip between stud and pavement, different rates of pavement wear would be expected for similar studs which are mounted in the two different types of tires. On a 14 ft diameter test track, Cantz (3), found no difference in pavement wear caused by radial and bias-ply tires which were identically studded. That finding is not surprising; since wheel test speeds were only 15 mph and the slip caused by the short turning radius of the track would be great compared to slip caused by tire squirm, experimental error would mask any effects due to tire construction. In contrast, tests made in Vienna (4) on a track designed to eliminate cornering slip and at various speeds up to one exceeding 60 mph, pavement wear caused by radial tires was only half that caused by bias-ply tires. Under actual conditions, this would mean that radial tires would be effective in reducing pavement wear except at intersections where braking and short radius turns were common.

### Performance on Ice

Two tests have been made comparing traction on ice of tires equipped with PTG and conventional studs (5, 6). Both tests showed the traction of PTG studs on ice to be superior to that of conventional studs. That result was surprising even to the manufacturer of PTG studs since it has been widely accepted that traction on ice was a direct function of stud protrusion. In my opinion, in spite of its relatively low protrusion, the PTG showed superior traction because of its sacrificial nature. It consists of many small particles with sharp edges and before any edge polishes, it is dislodged from the matrix and another particle is exposed.

### Conclusions

There is almost no question that PTG studs wear pavements at a rate much less than conventional studs. Although the evidence is not direct, it appears that under most conditions, PTG studs would wear pavements at a rate that lies about on the border of that allowed by Michigan's rules. If PTG studs were used only in radial tires, they would almost certainly comply with Michigan's rules.

## REFERENCES

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