EVALUATION OF CATCH BASIN GRATES

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This investigation is the result of complaints by bicycling interests, concerning the possible danger of crossing existing sinusoidal grates while riding bicycles equipped with the new narrow tires.

Background Information

The sinusoidal grate was developed more than ten years ago, in response to problems with previous grates due to drainage inefficiency. In August 1962, the East Jordan Iron Works conducted a series of tests that demonstrated the superior performance of the sinusoidal grate, and led to its acceptance by the Michigan Department of State Highways. A report covering the tests and results was issued by the Research Laboratory in the fall of 1962. The report shows some of the alternate designs that were evaluated at the time and states in part:

> "The grates with large openings were considered objectionable because of the hazard they present to children on bicycles. The sinusoidal grate presents no problem in this respect as can be seen clearly in [the] Figure. The bicycle shown is the English type with narrow tires."

During the past ten years, bicycles have increased in popularity and the tire width has been decreased on some models, resulting in complaints from bicyclists as noted above.

Recently, the Research Laboratory conducted tests on the currently used sinusoidal type grating to determine the effect that these grates have on bicycle control when traversed by the very narrow-tire bicycle types currently produced. This was presented in Research Report No. R-834. This series of tests conducted at various speeds over the sinusoidal type grating indicated that while the currently manufactured narrow bicycle tires would at times partially penetrate the grating opening, there was no problem of loss of control or steering ability.

The East Jordan Iron Works, being aware of the recent discussion concerning this matter, cast two experimental gratings which were modifications of the sinusoidal type, to see if the narrow bicycle tire penetration could be reduced or eliminated. These are:

Modified Sinusoidal Type A - This maintained the sinusoidal longitudinal bars but the edges were rounded with a 3/8-in. radius and three cross-braces were added. The cross-braces were recessed about 1/2-in. below the top of the grating at about 5-in. centers (Fig. 1).

<u>Modified Sinusoidal Type B</u> - This maintained the sinusoidal longitudinal bars but added rounded protrusions 1/2-in. in diameter to the sides of the sinusoidal bars, four on one side and two on the other side of each bar, and one recessed cross-brace at the center of the grating (Fig. 2).

In addition, the currently used sinusoidal grating (Fig. 3) and the rectangular grating (Fig. 4) were tested. However, it is obvious that any added cross-bars or supports in the grate will have some adverse effect on its drainage characteristics. Therefore, the Research Laboratory was asked to conduct experiments comparing the modified grates with previous models, for drainage characteristics and possibility of penetration by narrow-tired bicycles.

<u>Bicycle Tests</u>

The various gratings were installed in an existing catch basin. The same Raleigh bicycle used in Report No. R-834, with 27 by 1-1/4-in. tires (actual width 1.128 in.), was ridden over each grating a number of times at various speeds and angles to determine whether the tire would penetrate the gratings and the effect on bicycle steering. Prior to conducting the tests an inquiry was made at a local bicycle shop concerning the availability of the 27 by 1-in. tire, the narrowest now available. The narrower tire and wheel were available at $90.00 for each assembly. They assured us that 27 by 1-1/4-in. tires or larger, were used on 95 percent of the racing or multi-speed types of bicycles.

Conducting these tests (as well as the previous ones) with the 27 by 1-1/4-in. tire seemed to be the most reasonable procedure, since the narrower tires are rarely used even on racing bicycles. The tests indicated that riding over the rectangular grating with the narrow-tired bicycle had the least effect on ride and no effect on steering. The modified sinusoidal grating Type A has a slight effect on ride similar to a slightly rough surface condition and no appreciable effect on steering. The sinusoidal grating had slightly more effect on ride and steering. However, as observed in Report No. R-834, the effect on steering even with a relaxed condition of the bicycle rider's hands on the handle-bars required no steering correction. The modified sinusoidal grating Type B had the most noticeable effect. When the narrow-tire penetrated the grating opening, the 1/2-in. diameter protrusions on the side of the sinusoidal bars tended to cause the tire to bind in the opening and thus the effect of the bicycle momentum did not as readily overcome the tire penetration. It would appear that for this type of modification to be successful a larger diameter protrusion or closer spacing of protrusions would be required to completely prevent the penetration of the tire into the grate opening. However, this was more of a question of tire damage than safety since it did not appreciably effect control of the bicycle.

The grate modified with cross bars (Type A) effectively prevented the bicycle tire from penetrating and, because of considerations of wheel diameter, would be expected to do the same with a narrower tire.

Drainage Tests

A wooden frame was built to contain the various grates, in a simulated gutter section approximately 16 ft long. Transverse slope of the gutter was set at the standard 1-in. per ft and grade was set at 2 or 5 percent, by use of a surveyor's level. An existing container was modified to incorporate a valve with adjustable opening. After some experimentation the tests were conducted with the 12-in. wide valve opened 2 in. (24 sq-in. opening). In this position, one barrel of water flowed out in slightly less than 10 seconds, giving an average flow rate of roughly 350 gal/min. Figure 5 shows the apparatus in operation.

Once grade was set, approximately 1 bbl of water was placed in the container and the container positioned over the gutter. The valve was then opened, allowing the water to flow down the gutter. Water that passed through the grate was collected in one drum while the overflow and by-pass water flowed to a second drum. The depth of water in each drum was measured and recorded. Three tests were made for each grate and grade. Results of the tests are shown in Table 1, where the tabulated values are averages of the three runs for each test condition.

TABLE 1
RESULTS OF DRAINAGE TESTS
(Average of three trials)

Grate identification	Grade, percent	Water through grate, percent	Relative efficiency compared to Grate 1, percent
1. Conventional sinusoidal	2	94.0	100.0
	5	92.0	100.0
2. Modified sinusoidal; Type A	2	88.0	94.0
	5	81.0	88.0
3. Modified sinusoidal; Type B	2	91.0	97.0
	5	86.0	93.0
4. Conventional rectangular	2	77.0	82.0
	5	69.0	75.0

Figure 6 shows the various grates under test at 2 percent grade. Turbulence caused by cross bars and studs is evident, and adds to the overflow as indicated in the table. Some splashing is evident in the photos, but the amount of water loss was quite small proportionately. Results for the three trials agreed closely in each series of tests.

Conclusions

Comparison of the "rideability" of the modified sinusoidal grates with the conventional sinusoidal grate indicates that the Type A modification with cross bars is better for the 27 by 1-1/4-in. tire tested, and would be suitable as well for narrower tires. Type B with studs is not as satisfactory with the 27 by 1-1/4-in. tire, and would be worse for narrower tires.

The drainage tests indicate a loss of approximately 6 and 12 percent efficiency at grades of 2 and 5 percent, respectively for the Type A Modifications, while the Type B has losses of about 3 and 7 percent, respectively. Both modified sinusoids are significantly better than the conventional rectangular grate.

Recommendations

It is suggested that the Department should consider inclusion of the Type A alternate with a stipulation that it should be used in the future in areas such as secondary roads, subdivisions, etc., where cyclists could be expected to use the facility; and where our Specifications and Standards may be used by local governments.

We also recommend that the conventional sinusoidal grate be specified as before for freeway construction, since bicycles are prohibited and the superior drainage characteristics are required.

Figure 1. Modified Sinusoidal Type A Grating showing that the narrow bicycle tire rides on the cross-bracing and does not penetrate the grating opening.

Figure 2. Modified Sinusoidal Type B Grating showing that the narrow bicycle tire still penetrates the grating opening and the protrusions on the side of the sinusoidal bar grip the tire sidewall.

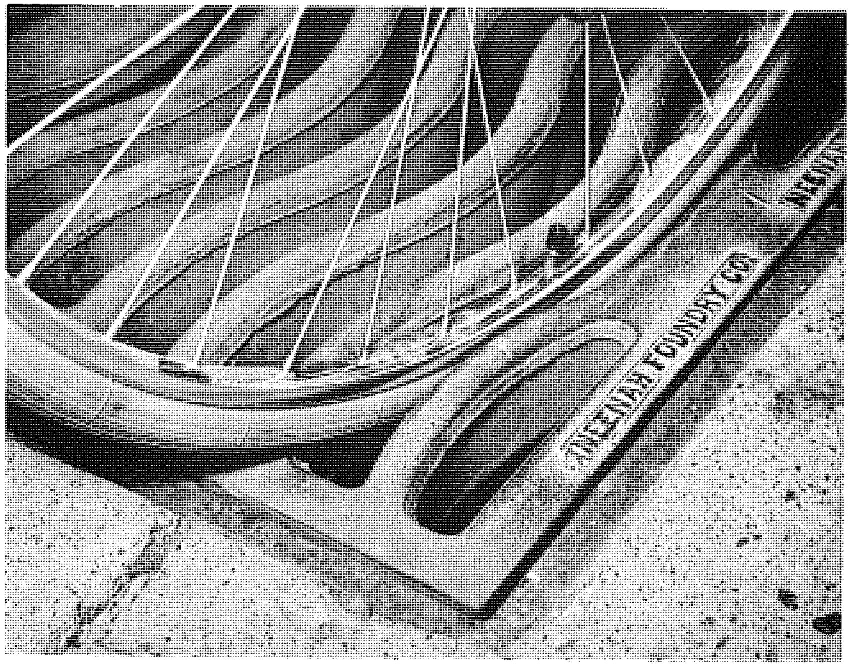


Figure 3. Sinusoidal Type Grating showing narrow bicycle tire penetrating grate opening.

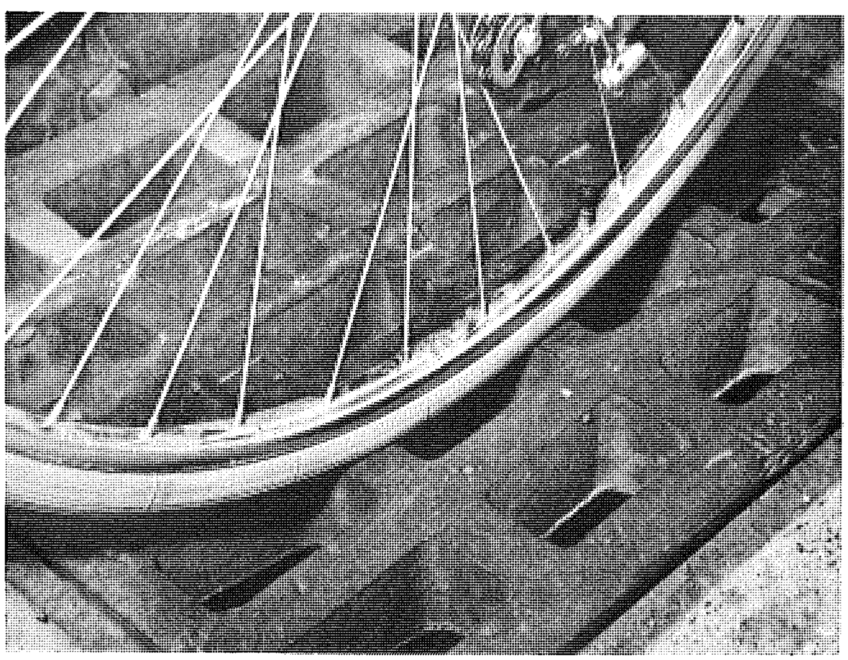


Figure 4. Rectangular Type Grating showing no penetration of narrow bicycle tire into grating.

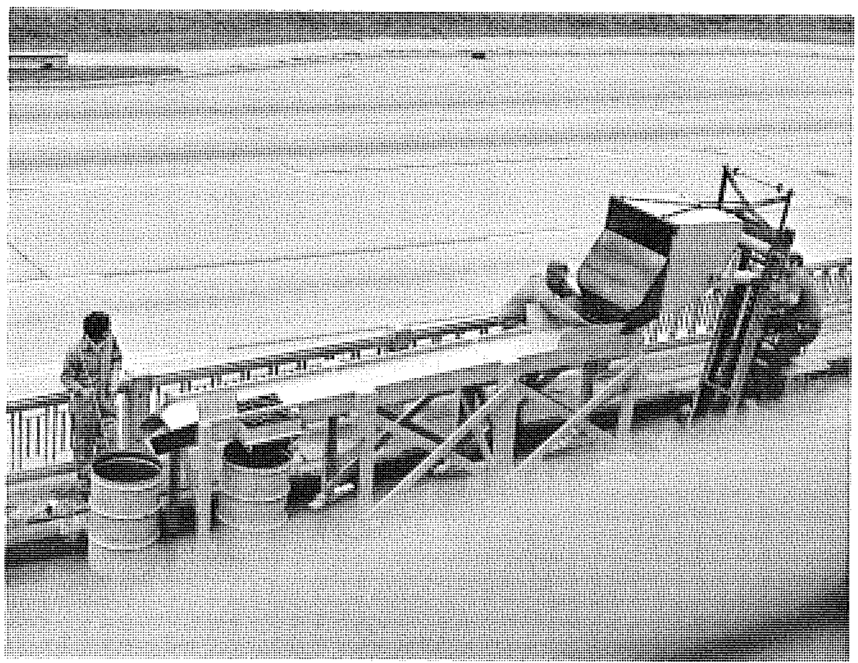
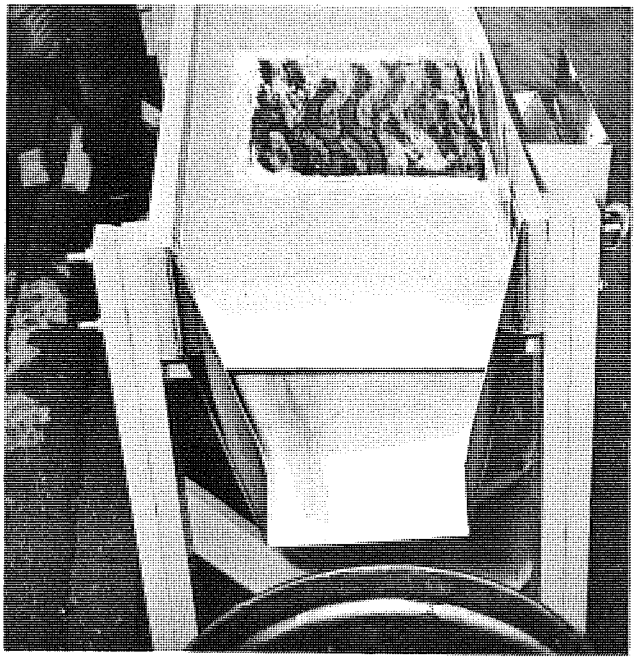
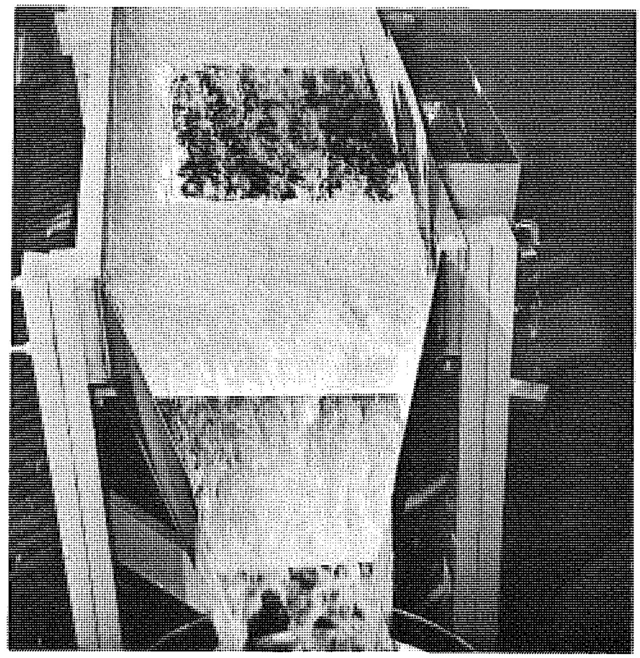


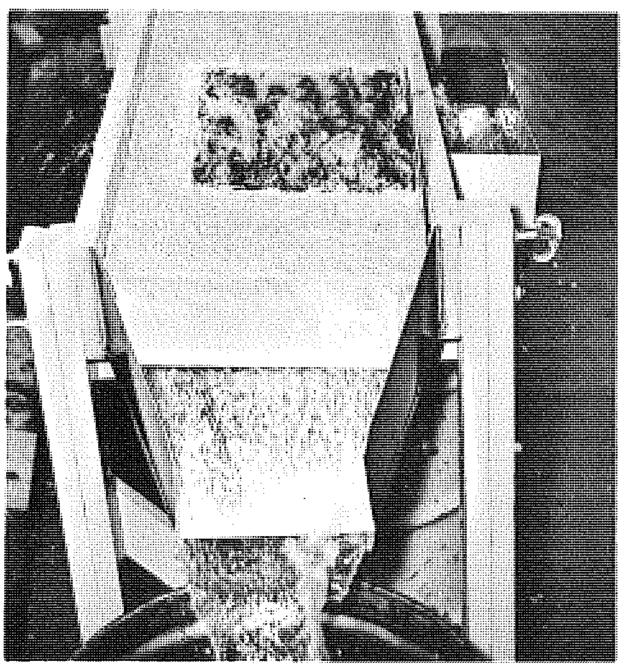
Figure 5. Simulated gutter section for drainage testing of grates.



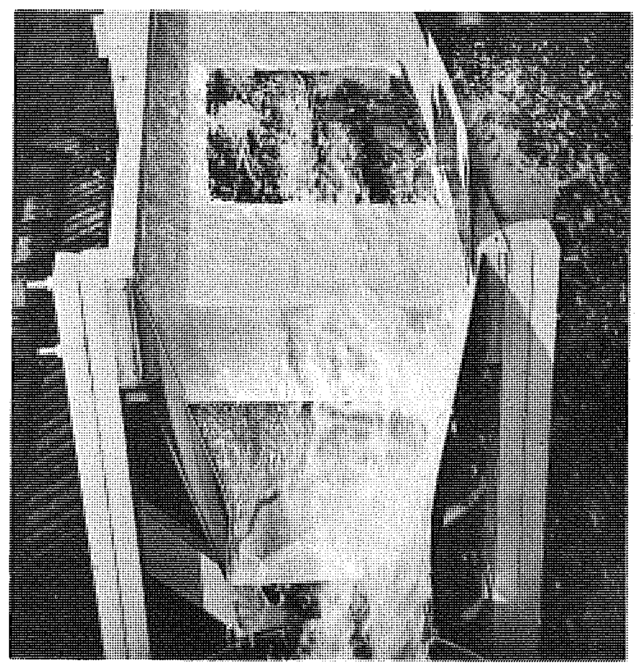
a) Conventional Sinusoidal grate



b) Modified Sinusoidal Type A



c) Modified Sinusoidal Type B



d) Conventional Rectangular

Figure 6. Grates under test, (2 percent grade).