# SKID RESISTANCE OF TAR ROAD SURFACES

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SYNOPSIS

The paper discusses the factors involved in skidding including some which are not under the control of the highway engineer It is pointed out that the chief factor in skidding, surface texture, can be controlled by the engineer How tar surfaces can be made non-skid is shown by the discussion of the types of aggregates and the reasons for selecting particular aggregates for particular uses

It is a well-known fact that automobile driving under certain conditions is often hazardous because of the danger of skidding That is, the force tending to push the car wheels out of their regular path has been great enough to overcome the frictional resistance between the tires and the road surface. Increasing the sideways force increases the chances of skidding and increasing the frictional resistance decreases them The sudden application of brakes causes a rapid increase in the sideways force and thus an increase in the tendency to skid.

Some things can be done by the road builder to decrease the sideways force although the most effective remedy, reduced speed, is entirely in the hands of the motorist High crowns tend to increase the sideways force and as flat a crown as possible should be used in all types of construction The only function of the crown is to shed the water off the surface of the road and, for most types of tight surfaces, one-quarter inch per foot is sufficient

Sharp curves increase the sideways force and the danger of skidding Curves should be laid out as flat as possible and should be elevated for the speed permitted over the road

Steep grades are a factor in skidding, since it is necessary to use brakes in descending, thus increasing the tendency to skid. Flat grades, therefore, are less dangerous than steep ones

The greatest opportunity in reducing skidding is in the increase of the frictional resistance between the tires and the road surface Here again, a part of the remedy is in the hands of the motorist Numerous tests have shown the danger of smooth, worn tires and pointed to the necessity for keeping the tires properly inflated

Weather conditions have a great influence on the skid resistance of all road surfaces Practically all tight surfaces are skid-safe when dry and, on the other hand, the texture of the surface has little effect on its skid-proof qualities when it is covered with snow or sleet. The highway maintenance crew can improve these surfaces by the addition of abrasive material such as sand or cinders, but the road builder can do little to help this condition. Fallen leaves are another cause of skidding which cannot be corrected by the highway constructor unless he removes the trees entirely

The highway engineer can, however, build surfaces which will be skid-safe for normal vehicle operation when the roads are wet To do this with tar is not a complicated operation and a few simple precautions will insure satisfactory results "Skid-safe" and "Non-skid" are of course, relative terms. With most cars it is possible to operate so as to build up the sideways force and overcome the frictional resistance of almost any road surface

All grades of tar are used in producing skid-safe surfaces There is little to choose between them, from the skid-safe standpoint Construction reasons dictate the choice of tar for a particular job

All construction and maintenance operations in which tars are used can be carried out so as to produce skid-safe surfaces

Surface treatments are used to renew a wearing surface worn away by traffic and to correct slippery conditions by building skid-safe surfaces The type of surface to be treated will determine the grade of tar to be used which will range from a light cold surface treating tar to a heavy hot surface treating tar Small sized cover will be used on the cold surface treating tars, either clean sand or small size stone or slag chips or small gravel Only sufficient cover should be used to prevent picking up under traffic. The exact amount will vary with the absorption of the tar by the original road surface, but will usually be from 10 to 20 pounds per square yard A sand paper finish will be produced which is non-skid

The hot surface treatments will require somewhat larger aggregate in order to produce a stable surface However, oversize aggregate such as an inch or more in size is neither necessary nor desirable The best results are obtained when the faces of the aggregate are exposed evenly on the surface, with the spaces between them tightly filled About ten pounds of covering material will be required for each one-tenth gallon of hot surface treatment tar The cover should be uniformly distributed over the surface Excess cover may cause skidding on the loose particles on the road surface Rolling will assist in producing a skid-safe road immediately

Hardness and toughness of the covering aggregate will have an influence on the skid resistance of the surface However, unless an aggregate breaks down into a slippery, slimy mud, the surface usually will not be slippery from that cause Aggregate which will produce a stable surface, which does not push out of shape under traffic, may provide a non-skid surface with tar

The covering aggregate should be graded from the bottom to the top size so as to produce a closed, tight surface The tar will penetrate into the aggregate particles and hold them tightly fixed in the road surface This high percentage of exposed aggregate faces provides the necessary frictional resistance to produce a skid-safe surface even though the individual aggregate particles may be of small size.

Tar Re-Tread surfaces are easily built non-skid. In the final application of the tar seal coat, the same precautions should be taken as in surface treatments. As a matter of fact, the operations are identical. Here again, small sized choke stone and small sized cover stone should be used. New York State 1-A stone ranging in size from one-eighth inch to one-quarter inch, square openings, has been very satisfactory.

The final finishing operations on penetration macadam are the same as those on tar re-tread. However, since the surface voids are larger, the next larger size of choke stone is used with the same size of covering aggregate on the seal coat. Open surfaces with large aggregate exposed are not necessary to produce a skid-safe tar penetration macadam. Fat spots are somewhat more easily formed in the penetration type than in the re-tread type due to the fact that the tar and stone are not mixed together as in the re-tread method. Uniform preparation of the original stone and uniform application of the tar binder will prevent them.

Plant mixed tar pavements are non-skid due to the penetrating properties of the tar binder used, assuming the pavement is properly proportioned without an excess of binder. This is true even for quite tight surfaces using a large percentage of sand or similar small aggregate. A sand paper finish is produced to which the tires cling tightly. If the tar concrete is stable, it will be non-skid.

Why is it possible to build non-skid surfaces with small sized aggregate and tar? Do these surfaces remain non-skid under traffic and, if so, why? Why are tight, close tar surfaces non-skid? Thousands of miles of road built under various conditions, in different parts of this country and abroad, have proven that tar roads built thus are essentially non-skid and remain so. The answer is in the inherent property of the tar itself, which causes it to penetrate into the road structure and also in some cases into the aggregate itself. This, unless an obvious excess of tar is used, prevents the tar from bleeding up and covering the exposed aggregate faces. Tars are not softened by drippings of oil from automobiles, which is another factor in the preservation of the non-skid texture. Again the tars are not easily emulsified without the addition of emulsifying agents, so that they will not be liquified and carried over the surface of the aggregate by traffic.

All types of tar maintenance and construction operations can be carried on so as to produce skid-safe surfaces with no additional cost, using the aggregates ordinarily available in the locality where the work is being done.

## DISCUSSION—SKID RESISTANCE

Prof. John S Crandell, *University of Illinois* I am wondering if we are not making this subject somewhat abstruse It appears that the only thing we need to do is to provide a sand paper finish and have no lubricant between the tires and the finish That is simple enough and we all know how to do it

Let us take up Mr Schlesinger's point first By cleaning off the surface of the brick a sand paper finish can be secured, but a sand paper finish can also be obtained with filler How? By simply mixing sand with the asphalt or the tar There are miles and miles of good brick pavement that were laid that way There is a pavement in Urbana, Ohio, laid in 1916 with just such a filler and I stopped last summer and asked the Chief of Police if they had had any trouble with skidding on that pavement and he said—No

Now for the sand paper finish on the other types Sometimes we find that asphalt pavements do become slippery Can we make them non-slippery after they have been built? Not very well There is a possibility, I think, of making a better sand paper finish by applying a little kerosene to the surface followed by sand I also suggest for use in dangerous cases that a sand mastic be made up with cut-back or emulsion—and scattered over the surface at irregular intervals Although a little rough surface would result there would be patches of thin non-skid surface so that when a wheel tends to slip it hits one of those spots and does not skid That was done years ago to keep the horses from skidding

Mr Martin spoke about chips on the surface This provides a good surface but sometimes the chips will not stay where they are put This brings up the subject of adhesion The chips move because the bitumen does not adhere to them A good test for adhesion is greatly needed

Major Besson who was formerly here in Washington once told me "My opinion is that every pavement in this city of Washington is perfectly skid proof and skid safe, if it is clean " Uncleanliness caused by snow and ice, leaves, dirt, the grinding up of aggregates, etc , make a surface which is dangerous when wet, simply because they place lubricant between the wheel and the surface Hence let us keep the pavements clean

Mr E O Rhodes, *Koppers Products Company* Last year, when Professor R A Moyer presented his paper entitled "Skidding Characteristics of Road Surfaces" at the December 1933 meeting of the Highway Research Board, attention was called to the fact that he should have included detailed information concerning each of the surfaces tested, giving for each bituminous surface the type of binder, method of construction or treatment, age and surface condition at time of test

Fortunately, such detailed information now has been provided in Bulletin 120, dated August 8, 1934, from Iowa State College and the reasons for some of the results and conclusions presented by Professor Moyer in his report as published by the Highway Research Board become more understandable

To illustrate the fact that there are important differences between Professor Moyer's reports as originally presented to the Highway Research Board, as published in the Proceedings of that organization and as presented in Bulletin 120 from Iowa State College the following statements are quoted:

As presented at Highway Research Board Meeting and published in 1933 Proceedings.

> "The coefficients obtained on the *high type asphaltic surfaces* were consistently higher than the coefficients on any of the other types of surfaces tested This was especially true for the sheet asphalt, rock asphalt, and asphaltic concrete surfaces "

As published in Bulletin 120, Iowa State College:

> "The coefficients obtained on the *high type bituminous surfaces* were consistently higher than the coefficients on any other surfaces tested This was especially true for the sheet asphalt, rock asphalt, asphaltic concrete, *and tar macadam surfaces* "

This is mentioned because in his paper entitled "Best Practice In The Achievement of Non-Skid Asphalt Surfaces" presented at this meeting, Mr B E Gray referred to Professor Moyer's report in the following manner "Probably the most striking feature of Professor Moyer's *first report* were the results of tests on asphalt surfaces The highest coefficient of friction (resistance to skidding) for all surfaces tested were obtained on high type asphaltic surfaces "

In each edition of his report Professor Moyer contrasts the high coefficients of the high type asphaltic surfaces with the dangerously low coefficients of an asphalt penetration macadam surface and a fine aggregate type asphalt plank He points out that the high type asphaltic surfaces had a "sand paper" finish which the other asphaltic surfaces did not possess From this Mr Gray has concluded that "such results clearly indicated that it is not the material, per-se, which makes for either a non-skid road or a slippery road but rather the way in which the material is employed It was apparent that the "sand paper" finish on certain surfaces was largely responsible for their resistance to skidding " On this basis he proceeds to outline methods for obtaining a "sand paper" finish on asphaltic surfaces

It appears obvious that Mr. Gray referred only to Professor Moyer's "first report" because his latest one contains information that does not agree with Mr. Gray's conclusions

It is highly significant that the four high type asphaltic surfaces that had such high coefficients of friction and "sand paper" finishes contained native asphalts in every case According to Bulletin 120 (Iowa State College) asphaltic concrete surface (A-1) contained fluxed Bermudez asphalt, rock asphalt surface (A-2) contained natural asphalt, bitulithic surface (A-3) contained fluxed Bermudez asphalt, and sheet asphalt surface (A-4) contained fluxed Trinidad asphalt The other asphaltic surfaces tested contained petroleum asphalts, had lower coefficients of friction and did not have "sand paper" finishes Certainly, this would seem to indicate that the different kind of asphalt used in the high type pavements contributed to the surface condition and to the high coefficient of friction

That variations in the character of the asphalt may cause wide variations in the skid-resistance of a road surface is brought out clearly in Mr Schlesinger's paper by Mr Walter G Rueckel He points out that the exuding of filler from one brick road caused a decrease of thirty per cent in the coefficient of friction in one year's time He then goes on to state that in tests made with different asphalts, natural lake asphalt did not exude, and asphalt fillers produced from an asphaltic base oil exuded less than an asphalt produced from a semi-asphaltic base oil He even goes so far as to suggest blends of asphalts to decrease the exuding characteristics and implies that by so doing the skid-resistance can be increased.

The report presented to the Highway Research Board in 1933 by Professors Stinson and Roberts contributes some measurements of coefficient of friction which, by comparison with data presented by Professor Moyer again indicate the differences that may occur when different varieties of asphalt are used Following are some comparisons of this nature.

| Investigator | Surface Tested | Type of Binder | Coef of Friction 30 m p h non-skid tires, sliding |
|---|---|---|---|
| Moyer | A-1 Asphaltic Concrete | Fluxed native asphalt (Bermudez) Penetration 50 to 65, 25°C 100 g 5 s | 0 6 |
| Stinson and Roberts | T-5-40 Asphaltic Concrete | Petroleum asphalt Penetration 50–60 25°C, 100 g 5s | 0 42 |
| Moyer | A-4 Sheet Asphalt | Fluxed native asphalt (Trinidad) Penetration 55–65, 25°C, 100 g 5s | 0 64 |
| Stinson and Roberts | T-50-D-16 Sheet Asphalt | Petroleum Asphalt Penetration 50–60 25°C, 100 g 5s | 0 41 |

Recognizing the fact that the equipment used by Stinson and Roberts was not exactly the same as that used by Professor Moyer, although similar in principle, another comparison is given for smooth concrete.

| Investigator | Surface Tested | Coefficient of Friction 30 m p h non-skid tires, slidings |
|---|---|---|
| Moyer | Smooth concrete | 0 45 |
| Stinson and Roberts | Smooth concrete | 0 40 |

These tests on the same type of surface agree sufficiently well to indicate that the comparisons cited above for different kinds of asphalt are significant

Obviously, it is not safe to conclude, as Mr Gray has done, that "it is not the material per-se which makes for either a non-skid road or a slippery road but rather the way in which the material is employed "

PROF R A MOYER, *Iowa State College* Mr Rhodes criticised my interpretation of the results of the tests on the asphalt and tar surfaces, because I did not include the tar macadam surface in the class of surfaces with the highest coefficients in my first report but did include it in this classification as reported in the bulletin published later An examination of the test results will show that the coefficients obtained on the tar surfaces were not so high as those obtained on the high type asphaltic surfaces Furthermore, we did not have as complete test data on the tar surfaces as on the asphalt surfaces Therefore, in my first paper, I did not feel justified in making the broader generalization reported in the bulletin. The conclusion in the bulletin was based on further tests on various road surfaces, on a more critical study of all the test results, and upon theories established as a result of intensive studies of surface textures of the various surfaces examined under a low powered microscope

While it is true that all of the high type asphaltic pavements which we tested contained native asphalts, that is not sufficient proof that similar pavements containing petroleum asphalts would have lower coefficients In fact, in all of our tests, the results indicated that only in the pavements where the asphalt content was so high as to cause the surface to bleed or to be glazed with excess asphalt were the coefficients dangerously low The coefficients obtained on the asphalt retread (A-5), road oil mix (A-6), and Iowa oiled gravel (A-7), were all notably high, and all of them contained petroleum asphalts The coefficients for the Iowa oiled gravel were very nearly the same as those obtained on the tar macadam The oil used in this surface was a highly cracked residual oil which Mr. Rhodes implies could not possibly provide a non-slippery surface when wet The tests proved conclusively that high coefficients were possible and the photograph of this surface, enlarged four times as shown in Fig 22, Bulletin 120, presents evidence which indicates why these coefficients were possible on a surface containing so low a grade of petroleum asphalt

It is my opinion that if the proper amount and grade of asphalt or tar are used together with sufficient fine sand or gritty particles, high coefficients may be assured with practically all types of bituminous materials which are now in common use and which are known to provide stable road surfaces

Mr. C A. Hogentogler in his paper, "Soil Science Relating to Flexible Type Road Surfaces"[1] raises an interesting point in regard to the cause of low coefficients of friction on wet surfaces:

"Skidding of motor cars in wet weather is due to moisture films adsorbed so strongly either to the tires or the pavement that the rubber is separated from the rid ng surface by films sufficiently thick to have the mobility of free water

"Research on means for eliminating this serious traffic hazard should include search for chemical treatments which could so electrolyze the tires or the pavement surface that the thickness of the separating films would be reduced below that required for lubrication, in other words, to within the range of thickness where the films have properties more like solids than like liquids "

Pettijohn, 1919, found about five millionths of an inch for the maximum thickness of a water film on pearls made from one type of glass and 10 millionths of an inch for pearls made from another type With river sand the estimated thickness varied from 20 millionths with 10 mesh sand to 5 millionths of an inch with 60 mesh sand

It is significant that our tests support the above contentions in regard to the effect of film thickness on various types of road surfaces Our highest coefficients were obtained on sandpaper-like surfaces. The sand in the rock asphalt surface was largely of a 50- to 60-mesh size which is the size reported in Mr Hagentogler's paper as providing low film thickness Our tests indicated that if the particle size of the aggregate increased, or if the surface was polished or flat as in the case of the steel traffic plates, the film thickness was likewise increased and the lubricating effect of the water became more evident Also, the film thickness on soft and absorbent surfaces such as on wood plank was greater than on hard impervious sandpaper like surfaces

It is significant that the materials with the lower values of hardness also have the greatest absorption capacity It is on the soft absorbent surfaces that thicker film thicknesses can be expected and where the lubricating effect of the water will be most noticeable It is also on the soft type of aggregate that the film thickness of bituminous material will be greatest and most difficult to wear off. The advantage of using fine hard impervious sand or gritty rock particles cemented in place by a weaker and less permanent cement to secure a high resistance to skidding on a road surface is, therefore, not only borne out by test but is the logical result which may be explained on the basis of a knowledge of the properties of these materials

[1] Proceedings Highway Research Board, Vol 14 part II