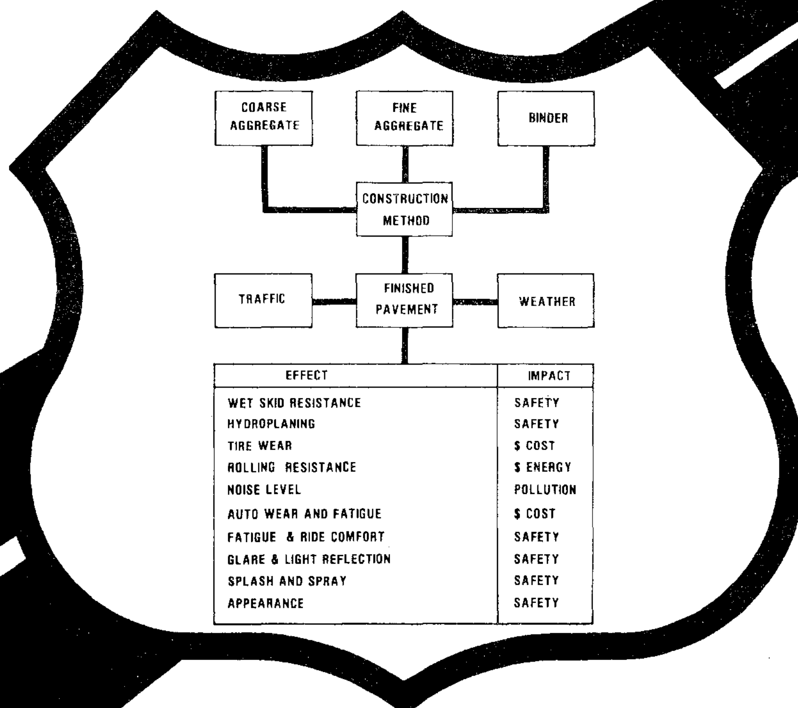
Report No. FHWA-RD-79-107

ALTERNATIVES FOR THE OPTIMIZATION OF AGGREGATE AND PAVEMENT PROPERTIES RELATED TO FRICTION AND WEAR RESISTANCE

Executive Summary
October 1978
Final Report



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Prepared for
FEDERAL HIGHWAY ADMINISTRATION
Offices of Research & Development
Materials Division
Washington, D.C. 20590

FOREWORD

This Executive Summary should be of interest to management, research, and operations personnel concerned with the properties and performance of aggregates and pavement surfaces as related to friction and wear resistance. The report summarizes in a general manner the major findings of an extensive review of the literature by an interdisciplinary team of researchers at The Pennsylvania State University. In addition to skid resistance, the report addresses such tire-pavement interactions as noise generation, tire wear, rolling resistance, and other performance characteristics. A full account of the findings is available in Report No. FHWA-RD-78-209.

This report is being distributed in sufficient numbers to provide a minimum of one copy to each regional and division office, and two copies to each State highway agency. Additional copies for the public are available from the National Technical Information Service (NTIS), U.S. Department of Commerce, 5285 Port Royal Road, Springfield, Virginia 22161.

Charles F. Scheffey
Director, Office of Research

NOTICE

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA-RD-79-107		

4. Title and Subtitle Alternatives for the Optimization of Aggregate and Pavement Properties Related to Friction and Wear Resistance - Executive Summary	5. Report Date October 1978
	6. Performing Organization Code PTI
7. Author(s) S. H. Dahir and J. M. Rice	8. Performing Organization Report No. PTI 7704
9. Performing Organization Name and Address The Pennsylvania State University Pennsylvania Transportation Institute University Park, Pennsylvania 16802	10. Work Unit No. (TRAIS) FCP No. 34G2-011
	11. Contract or Grant No. DOT-FH-11-8814
12. Sponsoring Agency Name and Address U.S. Department of Transportation Federal Highway Administration Offices of Research and Development Washington, D.C. 20590	13. Type of Report and Period Covered Final Report 1975 - 1978
	14. Sponsoring Agency Code M-0564

15. Supplementary Notes

The principal investigators were S. H. Dahir and J. J. Henry. Other contributers at The Pennsylvania State University were D. A. Anderson, P. A. Kopac, J. W. Lawther, W. E. Meyer, D. M. Roy, and J.C. Wambold. FHWA Contract Manager James M. Rice (HRS-22)

16. Abstract

This report summarizes the major findings of a detailed, comprehensive report which has received only a limited distribution. The full report, FHWA-RD-78-209, is available upon request.

An interdisciplinary team of researchers has conducted an in-depth review of the literature, supplemented with expert opinions, research experience, and limited tests, to develop a state-of-the-art on the topics of (a) properties of aggregates, (b) pavement texture and skid resistance, (c) tire-pavement noise, (d) tire wear, (e) light reflection and glare, (f) splash and spray, (g) rolling resistance and fuel consumption, and (h) optimal aggregates and pavement surfacing systems. A cost-benefit analysis is also summarized.

The information on aggregates and their contribution to pavement texture, coarse and fine, is being used in on-going FHWA staff and contract research studies to investigate currently and potentially available ceramic and impregnation materials and processes for the manufacture or treatment of aggregates to provide extremely durable and skid-resistant pavement surfaces.

17. Key Words	18. Distribution Statement
Aggregates, Microtexture, Macrotexture, Skid Resistance, Pavement Wear, Noise, Tire Wear, Rolling Resistance, Splash, Spray, Glare, Economic Analysis	No restrictions. This document is available through the National Technical Information Service, Springfield, Virginia 22161.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	30	A03-A01

Form DOT F 1700.7 (8-72)

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U. S. DEPARTMENT OF TRANSPORTATION

FEDERAL HIGHWAY ADMINISTRATION

SUBJECT Report FHWA-RD-79-107, "Alternatives for the Optimization of Aggregate and Pavement Properties Related to Friction and Wear Resistance - Executive Summary"	FHWA BULLETIN November 15, 1979

Distributed with this Bulletin is the subject report which will be of interest to management, research, and operations personnel concerned with properties and performance of aggregates and pavement surfaces as related to friction and wear resistance. The report summarizes the major findings of an extensive review of the literature by an interdisciplinary team of researchers at The Pennsylvania State University. In addition to skid resistance, the report addresses such tire-pavement interactions as noise generation, tire wear, rolling resistance, and other performance characteristics. A full account of the findings is available in Report No. FHWA-RD-78-209.

Sufficient copies of the summary report are being distributed to provide a minimum of one copy to each regional office, one copy to each division office, and two copies to each State highway agency. Direct distribution is being made to the region and division offices.

For official use, additional copies of this report, as well as the comprehensive report, may be requested from Mr. Richard E. Hay, Chief, Materials Division, FHWA, HRS-20, Washington, D.C. 20590. These requests will be filled while the limited supply lasts. (See attached Report Request Form.) Additional copies for the public are available from the NTIS, Department of Commerce, 5285 Port Royal Road, Springfield, Virginia 22161.

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Alternatives for the Optimization of Aggregate and Pavement Properties Related to Friction and Wear Resistance

Abstract and Report Request Form

An interdisciplinary team of researchers has conducted an in-depth review of the literature, supplemented with expert opinions, research experience, and limited tests, to develop a state-of-the-art on the topics of (a) properties of aggregates, (b) pavement texture and skid resistance, (c) tire-pavement noise, (d) tire wear, (e) light reflection and glare, (f) splash and spray, (g) rolling resistance and fuel consumption, and (h) optimal aggregates and pavement surfacing systems. A cost-benefit analysis is also summarized.

The information on the aggregates and their contribution to pavement texture, coarse and fine, is being used in on-going FHWA staff and contract research studies to investigate currently and potentially available ceramic and impregnation materials and processes for the manufacture or treatment of aggregates to provide extremely durable and skid-resistant pavement surfaces.

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PROLOGUE

In 1975, the Federal Highway Administration awarded a contract to The Pennsylvania State University for a study to investigate alternatives for the optimization of aggregate and pavement properties related to friction and wear resistance. As a result of an extensive literature review and limited laboratory and field studies, a 295-page report was prepared and submitted to FHWA for review and subsequent publication as FHWA-RD-78-209. The results obtained in the study are summarized in this document.

OBJECTIVES

The specific objectives of the study were:

1. To determine optimal aggregate properties and pavement surface characteristics needed to provide and retain desirable functional performance requirements and to establish warrants for use of optimal pavement surfacing systems.

2. To explore the range of candidate aggregates and pavement surfacing strategies to meet requirements.

3. To conduct economic analyses, and make recommendations and plans for future action.

SCOPE OF WORK

The scope of work primarely involved the use of existing sources of information, published and unpublished, plus consultations with experts in the several technologies involved. The emphasis in this study was on the intrinsic properties of aggregates for pavement surfacing systems to optimize the modification of existing aggregates and the synthesis of new aggregates.

Approach

Six tasks and several subtasks were delineated as guidelines in meeting the objectives of the study. The six tasks were:

Task A - Quantification of Optimal Properties of Pavement Surfaces and Aggregates

Task B - Critieria for Use of Optimal Pavement Surfaces

Task C - Aggregate Selection and Evaluation

Task D - Technical Evaluation of Pavement Surfacing Systems

Task E - Economic Evaluation of Alternative Aggregates and Pavement Surfacing Systems

Task F - Synthesis of Results and Recommendations

BACKGROUND

For the purposes of skid resistance and wear resistance, a pavement surface system is only as good as the materials it is made from and the method of incorporating these materials to form the system. Normally, aggregates constitute 70 to 95 percent by weight of the surface material. For this reason, the study reported here is concerned with (a) the identification and evaluation of existing and proposed polish-resistant and wear-resistant aggregate and pavement surface systems, and (b) the development of recommendations for material systems that will meet surface performance requirements of skid resistance and wear resistance while taking into consideration other performance properties including tire wear, noise level, rolling resistance, glare and light reflection, splash and spray and other functional surface characteristic associated with traffic, geometric, and environmental conditions. The role of aggregates on surface properties and the subsequent penalties and benefits are shown in figure 1. Broad relationships between surface materials, design and construction, and surface performance are summarized in the block diagram, figure 2.

SUMMARY OF RESULTS

Aggregate Role and Most Important Properties

The role of the aggregate is to provide, throughout the life of the pavement surface, a microtexture (fine asperities) that will maintain the necessary level of friction for the prevailing conditions, thus eliminating or reducing unsafe skidding on wet surfaces. In bituminous surfaces, the aggregate must also provide and maintain a macrotexture (coarse asperities) that will facilitate the fast removal of water from the tire-pavement contact area, thereby inhibiting the build-up of a thick water film that could separate the tire from the pavement surface and lead to hydroplaning.

The most important properties that affect aggregate performance are:

1. Hardness of the constituent minerals. Hardness combined with strong grain consolidation or bonding provides resistance to wear. Stiffler (1) found mineral hardness to be the most important property contributing to wear resistance (figure 3).

2. Differential hardness of constituent minerals. Research performed independently in North Carolina (2) and in Maryland (3) indicates that, within each particle of naturally occurring aggregate, a proportion of hard to soft minerals in the range of 40 to 70 percent produces the highest resistance to polishing (loss of microtexture) due to different rates of wear (figure 4). For the hard minerals, the shape, size, and distribution of grains or crystals within each particle influences the resistance to polishing. Angular and medium to large grains outperform rounded and small grains (figure 5).

3. Shape, size, gradation, and differential hardness of aggregate particles. In a bituminous pavement surface these properties influence the coarseness and drainage-effectiveness of the macrotexture, along with embedment of coarse particles or erosion of binder matrix. Research has shown that high macrotexture can be achieved in a dense bituminous surface with coarse angular particles (6 to 12 mm) having different rates of wear (4). In open-graded mixes, it is recommended that 80 to 90 percent of the aggregate be in the range of 3/8 inches to No. 8 sieves (9.5 to 2.36 mm) (5). Sample gradations of proven good designs are shown in table 1.

4. Texture of portland cement concrete (PCC). The hardness and angularity of the mortar sand in PCC are considered important properties for providing microtexture. The coarse macrotexture is achieved through mechanical texturing of plastic mortar. For PCC surfaces with heavy traffic, the coarse aggregate in the top of the surface should meet wear-resistance and polish-resistance requirements similar to those needed for bituminous surfaces.

Aggregate properties that may alleviate noise generation, tire wear, light reflection, and other performance requirements are discussed under the respective performance requirements.

Synthetic Aggregates

Where polish-resistant and wear-resistant natural aggregates are not available or not adequate for the requirements at critical highway sites, synthetic aggregates are promising, including calcined bauxite, fired bricks, non-blated sintered slags, sintered materials with controlled bloating, fused waste materials with controlled bloating, and some beneficiated marginal aggregates (6). These materials develop their polish-resistance and wear-resistance in various ways; therefore, each has to be designed and specified accordingly. Since many of the potentially acceptable synthetic aggregates are energy and capital intensive, development of new aggregates from waste should, when possible, be considered as part of the primary process rather than a reclaiming afterthought. Suggested target values for highly polish-resistant and wear-resistant aggregates are shown in table 2.

Pavement Texture and Skid Resistance

It is generally known that strong relationships exist between surface texture and skid resistance. As indicated, it is customary to divide texture into microtexture and macrotexture. Profiling techinques used on six test surfaces at The Pennsylvania State University measured the root mean square height (RMSH) for cutoff frequencies from 400 to 16,300 cycles per metre. The frequency values were correlated with the skid number extrapolated to zero speed (SN_o) which is a function of the microtexture. Results of the correlation are shown in figure 6 which indicates that microtexture may be considered as asperities smaller that 0.5 mm, corresponding to a cutoff frequency of 2,000 cycles per metre.

A significant achievement was the development of a procedure for predicting field skid numbers (SN) from laboratory data. The skid number (SN) can be predicted for a speed V mph (1 mph = 1.6 km/hr) from the root mean square height of the macrotexture (RMSH) in milli-inches (1 milli-inch = 25.4 microns) and the British Portable Number (BPN) as follows:

$$SN_V = (1.38\ BPN - 31)e^{-.038V\ RMSH^{-.52}}$$

An alternative prediction can be obtained by relating skid number to BPN and Sandpatch Mean Texture Depth (MD) in milli-inches (1 milli-inch = 25.4 microns):

$$SN_V = (1.38\ BPN - 31)e^{-.06V\ MD^{-.52}}$$

In designing aggregates for good skid resistance at high speeds, it is important to provide large values of root mean square height of macrotexture or mean texture depth. For aggregates which polish to a given level of root mean square height of microtexture or BPN, it is possible to determine the macrotexture that is required to provide the desired level of skid resistance at the design speed (figure 7).

Tire Noise

Despite the lack of adequate models to describe the mechanism of noise generation, some rather tentative but plausible inferences may be drawn as to the selection and the use of tires and surface textures for quieter pavements. Research has shown that tire noise generation on pavement surfaces is largely dependent on the tire tread and design. For example, the noise behavior of snow tires and cross band tires on conventional pavements is less favorable than ordinary traditional tire designs. However, surface texture does influence tire-surface noise. Improved noise performance has been obtained with open-graded surface mixtures when compared to conventional dense-graded bituminous mixtures. Open-graded mixtures using designs similar to those described in NCHRP Synthesis 49 (5) lead to lower noise levels. Pressurization of texture cavities which results in monopole air pumping is less likely to occur on open-graded than on dense-graded surfaces. Furthermore, open-graded textures are not associated with annoying tread frequency noise "tonals" which may occur with textured PCC surfaces. These findings lead to the important conclusion that the objectives of designing surfaces with adequate skid resistance and reduced noise levels are not diametrically opposed.

Tire Wear

On conventional surfaces, tire wear appears to be largely a function of tire design and construction as may be concluded from figure 8 (7), but these characteristics are outside the scope of the current study. Other important factors include pavement texture, which depends largely on aggregate shape, size, and hardness. Related factors include environmental condition of the surface (wet or dry, warm or cold, clean or contaminated), roadway geometry (grades, tangents, curves) and traveling speed. Experiments on tire wear and skid resistance relative to pavement texture were discussed by Lees and Williams (8) and Lees et al. (4). The indications were that tire wear and skid resistance both increase rapidly with increasing microtexture above 5 microns, which is the size required to penetrate water films that are normally 2 to 3 microns thick. When the microtexture approaches 100 microns, the rate of increase in friction tends to level off due to reduced contact area whereas the rate of tire wear keeps on increasing as shown in figure 9. Accordingly, Lees suggests that surface microtexture should ideally be in the range of 10 to 100 microns. These findings are in agreement with Sabey (9) and Lowne (10) that macrotexture does not, in general, influence the rate of tire wear (figure 10) (9).

Light Reflection and Glare

These are prinicipally related to night visibility, particularly on wet surfaces. Informative work on this problem was reported in a paper by Fredsted (11) which discusses some experiments performed on Denmark's highways. He reported that diffuse preferential light reflection was a function of aggregate color and surface texture.

Textures that penetrated the water film on the surface improved visibility, and 30 percent light-colored coarse aggregate in a darker mass produced sufficient contrast to assist the driver in perceiving the roadway to a safe distance (50 to 100 metres). This treatment would be most effective if the light-colored aggregate protrudes 0.6 mm or more above the darker aggregate.

Glare was substantially improved by having a good surface macrotexture and color contrast, provided that surface drainage was also maintained.

Splash and Spray

Maycock (12) defined splash as the large droplets thrown off the tire, and spray as the envelope of very fine droplets which are carried in the turbulent air stream around the vehicle. Performing experiments on "fine cold asphalt" surfaces, he found splash associated with large water depths and low speeds. Spray was associated with shallow water depth and high speed. At 9 m (30 feet) behind a commercial vehicle, spray was very small below 48 km (30 mph) but increased substantially with increasing speed. Experiments with bituminous surfaces described as pervious, slightly pervious, and impervious showed that at 96 km (60 mph) the amounts of spray produced on the impervious and slightly pervious surfaces were significant but little in difference compared to the lack of spray on the pervious surface. Later, Brown (13) confirmed Maycock's conclusion that open-textured surfaces reduce splash and spray. He reported that six experimental surfaces were still effective in reducing spray 2 years after being laid and after having 2.75 million commercial vehicles pass over them.

Rolling Resistance and Fuel Consumption

Generally, tire rolling resistance constitutes about 10 percent of fuel consumption. This rolling resistance is caused by (a) sidewall hysteresis, the largest contributor, responsible for up to 95 percent; (b) contact friction and slippage between tire and road surface causing 5 to 10 percent of loss; and (c) tire windage drag accounting for only 1.5 to 3 percent. Pavement texture and aggregates affect frictional losses; however, the effect on rolling resistance is less than 10 percent, or less than 1 percent of total losses.

Optimal Aggregates for Different Pavement Sites

Relative to surface performance requirements, particularly skid resistance, pavement sites may be grouped into four categories (14). General descriptions with suggestions for approporiate aggregates are as follows:

1. Easy, defined as generally straight sections on lightly-traveled roads and streets. In this category almost any conventional aggregate may be used in a variety of surfacing systems.

2. Average, defined as generally straight sections without sharp curves on heavily traveled city streets and main rural roads. In this category at least medium grade aggregate should be used, e.g., granite, gneiss, some slates and shales, and carbonate agregates with high sand-size hard silicious content (over 25 percent).

3. Difficult, defined as heavily-traveled approaches to intersections or ramps, sharp curves on high speed roads, and long steep grades. In this category high-type conventional surfacing systems should be used. Aggregates should be of high quality, natural or synthetic, e.g., wear-resistant and polish-resistant sandstone, graywacke, some slags and other synthetic materials.

4. Very difficult, which includes approaches to traffic signals on high-speed roads and approaches to traffic signals with pedestrian crossings on main urban streets. The best surfacing systems and aggregates should be used in this category, including hard, silicious aggregates in textured PCC, epoxy asphalt-calcined bauxite treatments, and bituminous mixtures utilizing sandstone, graywacke, or other aggregates of proven performance such as synthetic and blended materials.

Pavement Surfacing Systems

Of the surfacing systems considered, those that have been most commonly and successfully used to date, and may be improved as the quality of aggregate and binder improve, are the following:

1. Open-Graded Asphalt Concrete, high quality aggregates, binder and mix design.

2. Dense-Graded Aphalt Concrete, high quality aggregates (blended, if necessary), binder and mix design.

3. Epoxy-Asphalt Seal Coat, high quality aggregate.

4. Portland Cement Concrete, silicious sand, high strength mix design, textured with tines or combs.

5. Sawed transverse or longiudinal grooving of PCC surfaces

Systems 1 through 3 may be applied to newly constructed surfaces or to remedy worn and/or polished surfaces of either bituminous or PCC pavements, whereas system 4 is recommended for new pavements and system 5 is recommended as a remedial treatment primarily for PCC surfaces.

Cost Benefit Analysis

1. Tentatively, the benefit (negative) associated with tire wear has a relatively large magnitude. This is because tire wear costs, although small when considering a single vehicle, are considerable when accumulated for all vehicles.

2. The benefits associated with accidents and noise have a large magnitude in some cases. Accident and noise costs may be considerable on an individual basis, but accidents only affect the people who are involved, and noise only affects a few resisdents under certain conditions.

3. The benefit associated with maintenance operations appears to be a secondary one. Most resurfacing systems appear to require relatively the same amount of maintenance (true, at least, for conventional systems).

4. System costs vary more widely than system benefits. The cost of a system may be the only consideration necessary in making a decision. A high cost is a large disadvantage because the total benefits would have to be tremendous in order to balance the costs. Total benefits are not usually large because the individual benefits often cancel each other out (i.e, if accident benefits are positive, the noise and tire wear benefits may be negative).

5. The overall benefit-cost model is not highly sensitive to changes in assumed unit costs. In other words, varying the unit costs will not have a great effect on the final recommendations.

CONCLUSIONS

Equations are presented for predicting the frictional resistance or skid number of a pavement from independent measurements of the coarse and fine texture of the surface. The hardness of mineral particles is a determinant of wear resistance, while a differential in hardness provides polish resistance. Target values of aggregate properties are presented for developing new aggregates. Guidelines are summarized for the selection of aggregates and surfacing systems to meet the performance requirements of different roadway situations.

The trade-offs with other tire-pavement interactions are provided. Good skid-resistance of pavements can be achieved simultaneously with minimizing noise generation, light reflection and glare, and splash and spray. Pavement texture has a minor effect on rolling resistance and fuel consumption, but tire wear increases with the abrasiveness of the pavement surface.

An economic analysis developed a benefit-cost model which is applicable for general situations to establish the most economical resurfacing systems.

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RELATED PAPERS

1. Anderson, D. A., and Henry, J. J., "Alternative Synthetic Aggregates for Skid-Resistant Surface Courses," paper presented at 57th Annual Meeting, TRB, 1979.

2. Anderston, D. A., Dahir, S. H., and Henry, J. J., "The Selection of Aggregates for Skid Resistant Pavements," paper presented at 54th Annual Meeting, AAPT, 1979.

3. Dahir, S. H., "Petrographic Insights into Aggregate Wear and Polish Susceptibility," paper presented at 56th Annual Meeting, TRB, 1978.

4. Dahir, S. H., "A Review of Aggregate Selection Criteria for Improved Wear Resistance and Skid Resistance of Bituminous Surfaces," Journal of Testing and Evaluation, ASTM, 1979, (to be published).

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Table 1. Typical Aggregate Gradations

Percent Passing Sieve No. (U.S. Standard)	Size (mm)	Grading: Dense[a] (Pa. ID-2A)	Open[b] (FHWA)	Fine[a] (Pa. FJ-1)	One-Size[a] (Pa. Seal Coat)
1/2"	12.5	100	100	-	100
3/8"	9.5	80-100	95-100	100	75-100
No. 4	4.75	45-80	30-50	90-100	10-30
No. 8	2.36	30-60	5-15	60-100	0-10
No. 16	1.18	20-45	-	40-80	
No. 30	0.60	10-35	-	20-60	
No. 50	0.30	5-25	-	10-40	
No. 100	0.15	4-14	-	7-25	
No. 200	0.075	3-10	2-5	3-15	

[a] Pennsylvania Department of Transportation, Specifications, Form 408, 1976.

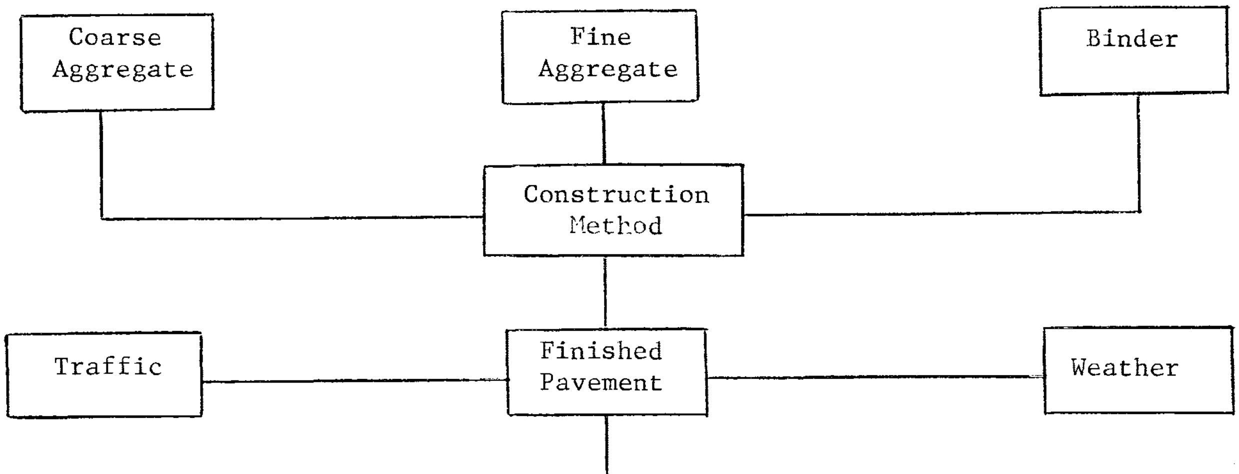
[b] Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects, FP-74, U.S. Department of Transportation, Federal Highway Administration, 1974.

Table 2. Target Values for Polish-Resistant and Wear-Resistant Synthetic Aggregates

Property	Value Range
Mohs Hardness of Hard Fraction	8-9
Mohs Hardness of Soft Fraction	6-7
Differential Hardness, min.	2-3
Percent of Hard Fraction	
Natural Aggregate	50-70
Artificial Aggregate	20-40
Hard Grain or Crystal Size	150-300 μm; Avg. 200
Hard Grain or Crystal Shape	Angular Tips (≤90°)
Percent Porosity (Vesicularity)	25-35
Pore Size, Optimum	125 μm
Aggregate Particle Size Range	3-13 mm
Aggregate Particle Shape	Conical, Angular (≤90°)
Los Angeles Abrasion, Percent	≤20
Aggregate Abrasion Value, Percent[a]	≤8
Aggregate Impact Value, Percent[a]	≤20
Polished Stone Value, BPN[b]	≥75

[a] According to British Standards Institution, BS 812:75

[b] According to BS 812:75 or ASTM D 3319-74T and E 303 (using auxiliary scale)



Effect	Impact
Wet Skid Resistance	Safety
Hydroplaning	Safety
Tire Wear	$ Cost
Rolling Resistance	$ Energy
Fuel Economy	$ Energy
Noise Level	Pollution
Auto Wear & Fatigue	$ Cost
Fatigue & Ride Comfort	Safety
Glare & Light Reflection	Safety
Appearance (color, etc.)	Safety
Splash and Spray	Safety

Figure 1. Role of Aggregates on Surface Properties and the Subsequent Penalties and Benefits of the Surface Properties

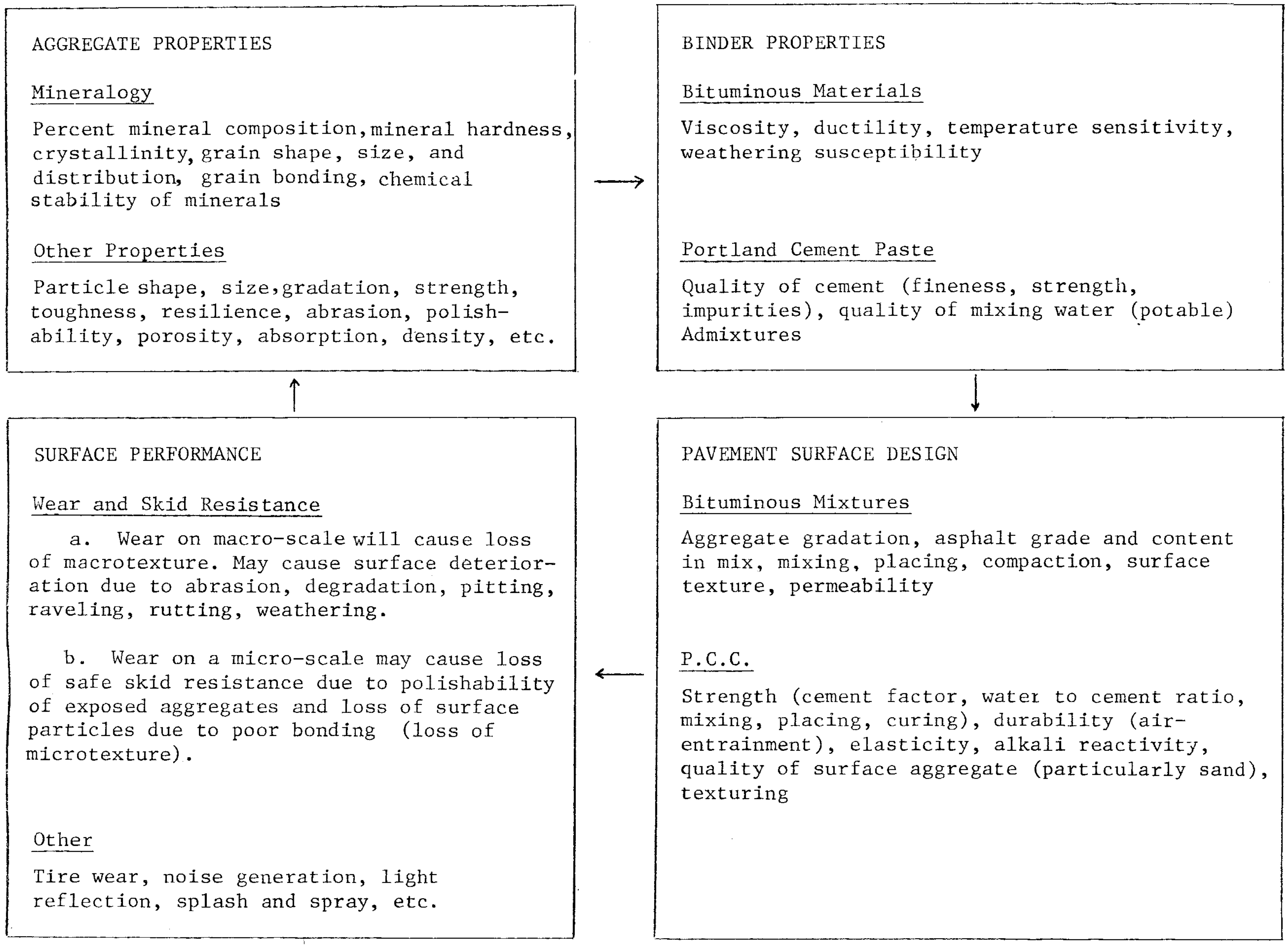
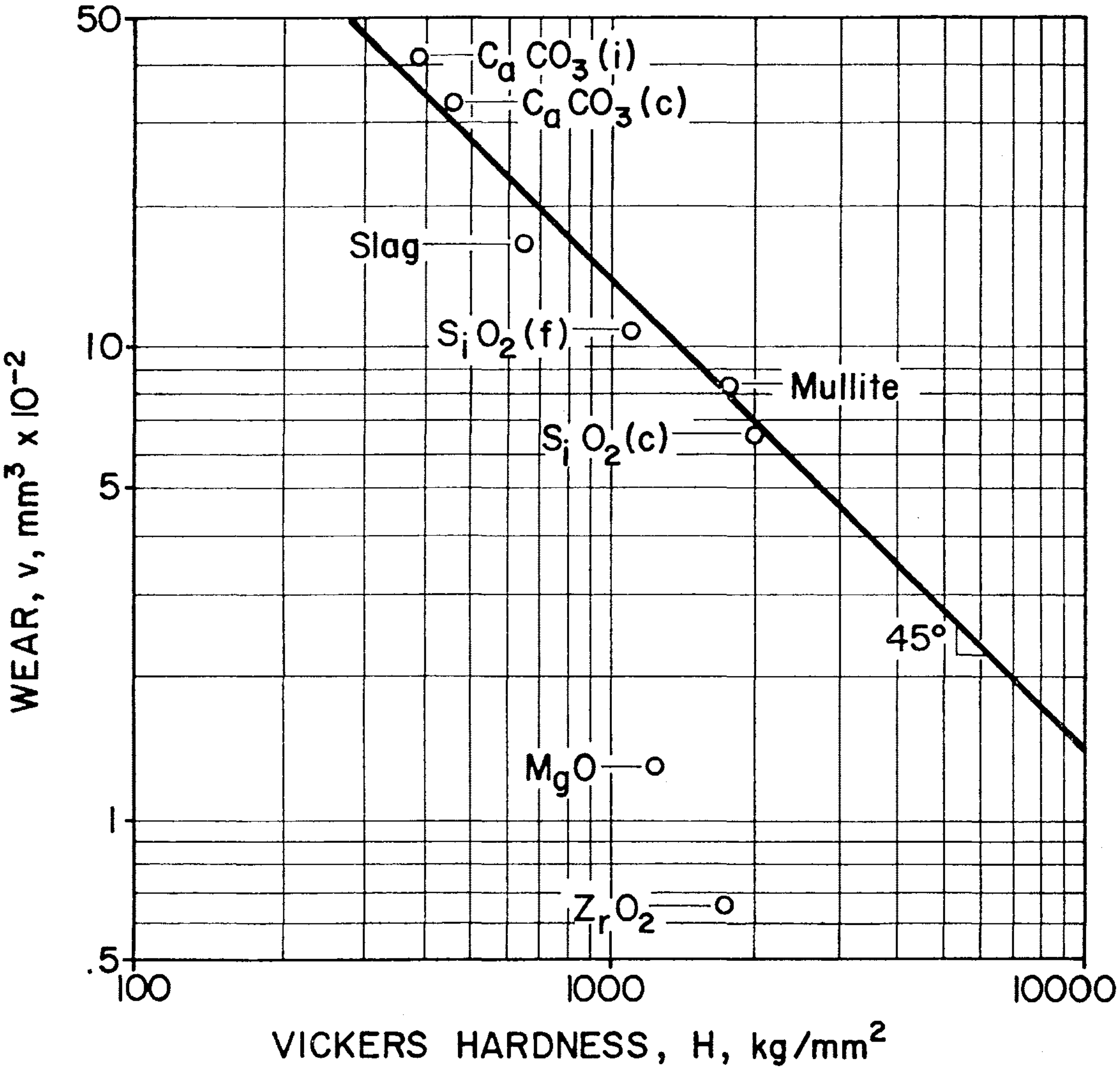


Figure 2. Relationships between Surface Materials and/or Design and Surface Performance



(c = crystalline, f = fused, i = impure)

Figure 3. Log Wear as a Function of Log Hardness for Minerals Softer than SiO_2 Abrasive

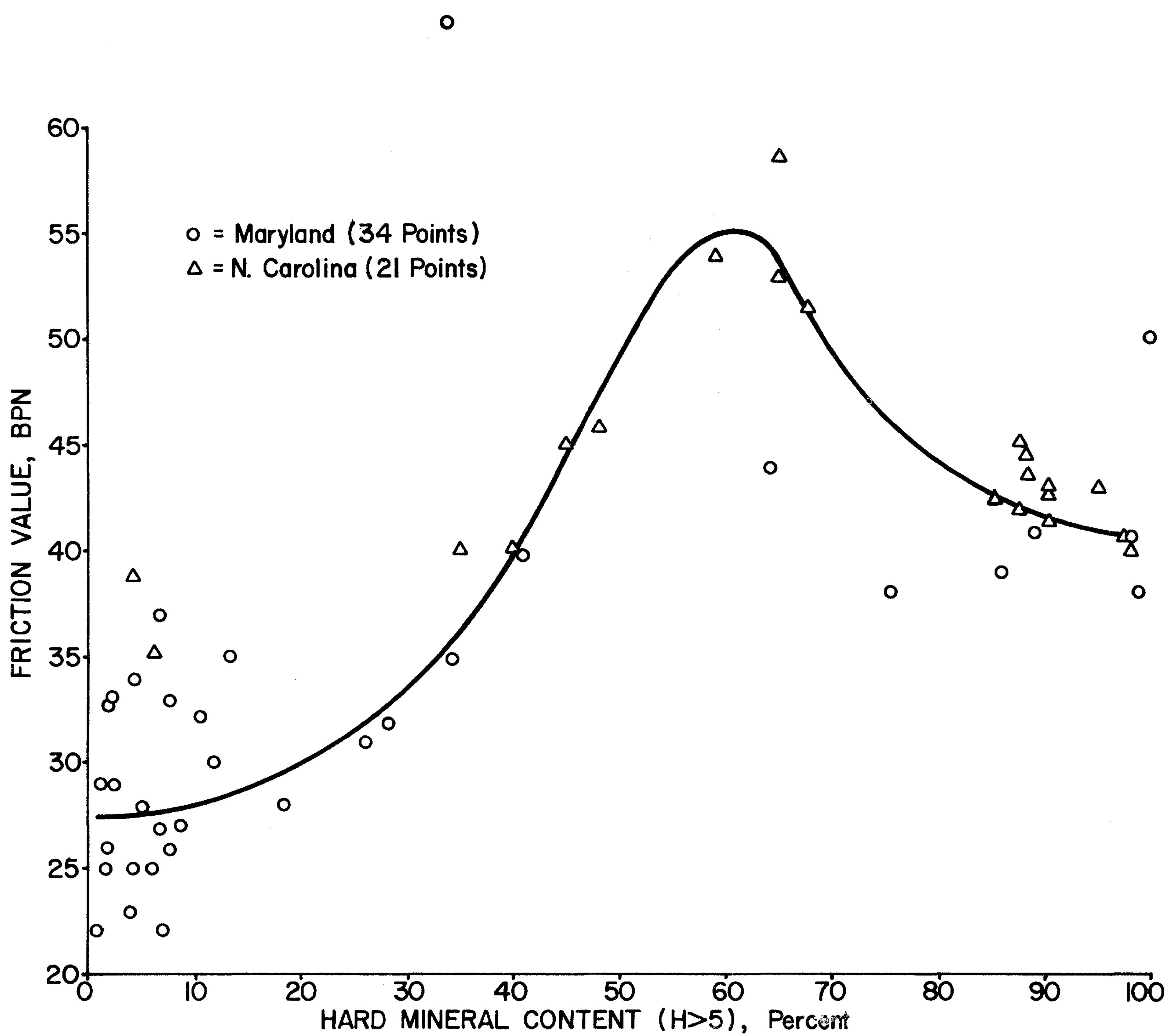
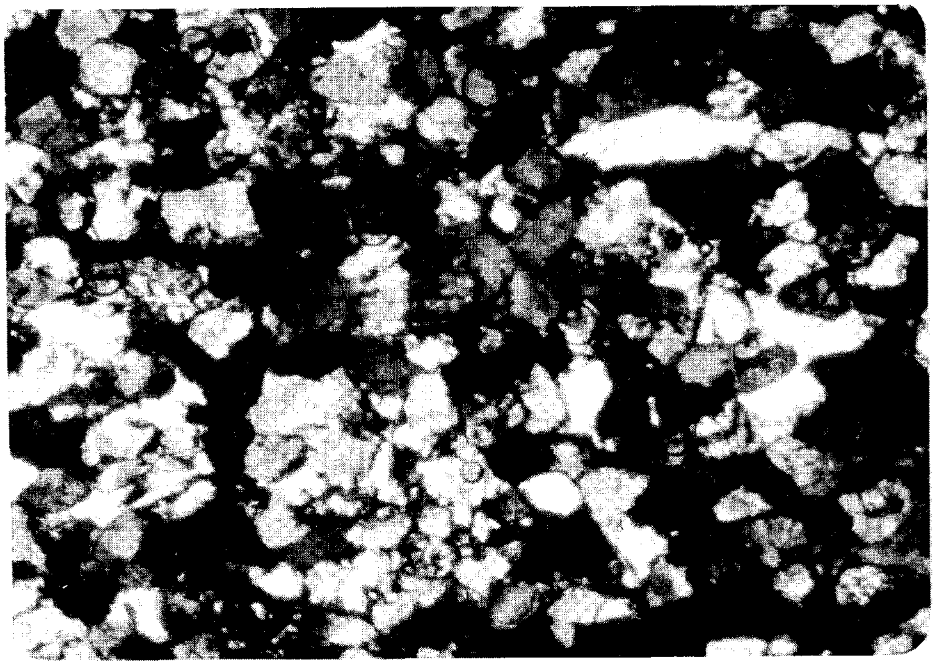
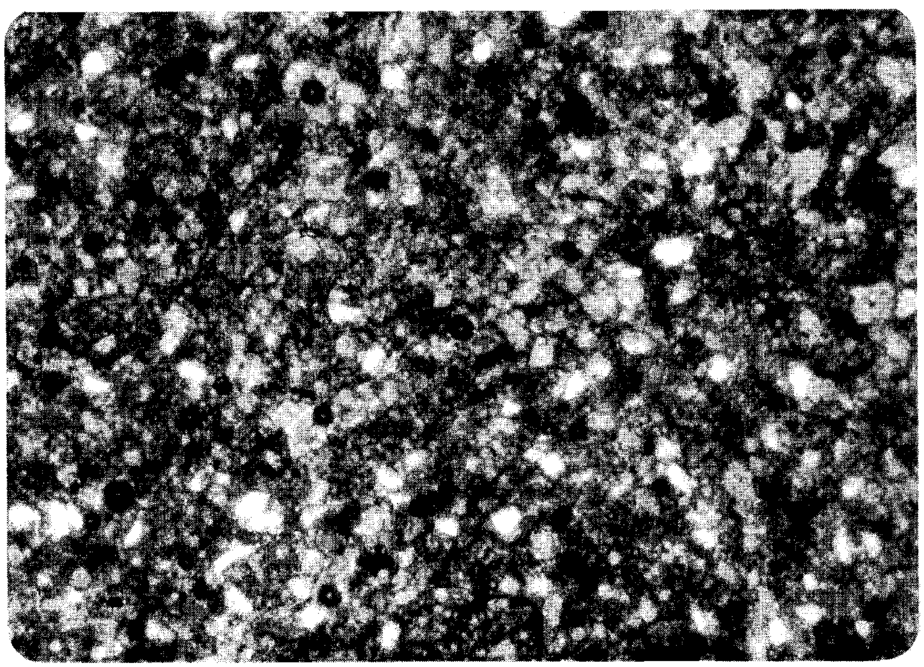


Figure 4. BPN Friction Values (ASTM E 303) Versus Hard Mineral Content



Angular, medium to large grains in sandstone



Rounded to subrounded small grains in limestone

Figure 5. Comparison of hard, angular medium to large grains in sandstone with soft, subrounded, small grains in dolomitic limestone (62.5x)

Cutoff Frequency x 100	4	5	6.3	8	10	12.5	16.3	20	25	31.5	40	50	63	80	100	125	163
Correlation Coefficient	.440	.607	.559	.530	.666	.797	.875	.872	.820	.731	.602	.346	.221	.118	.055	.000	.032

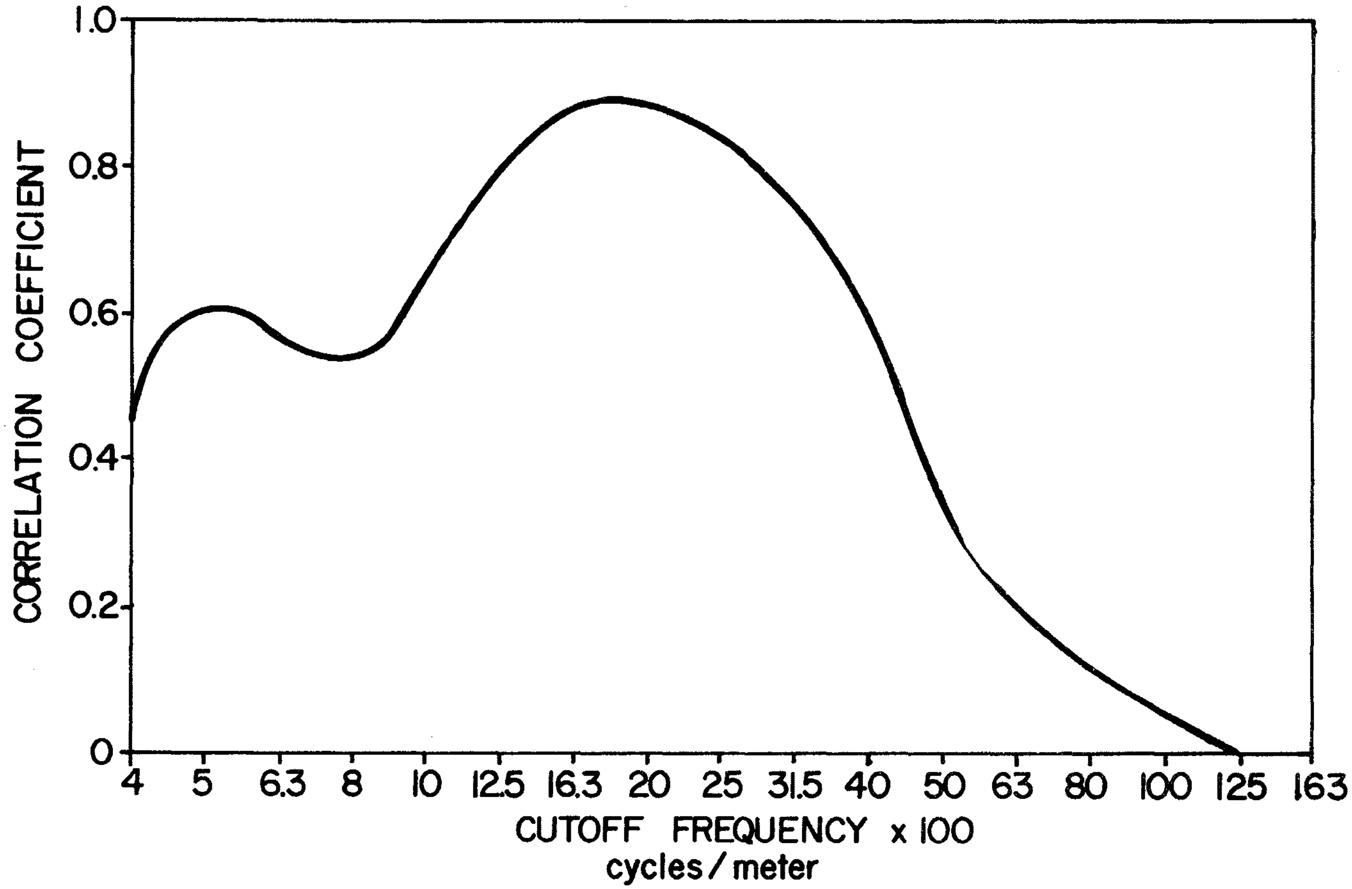


Figure 6. The Correlation Coefficient between Zero-Intercept Skid Number and Root Mean Square Texture Height at Different Cutoff Frequencies

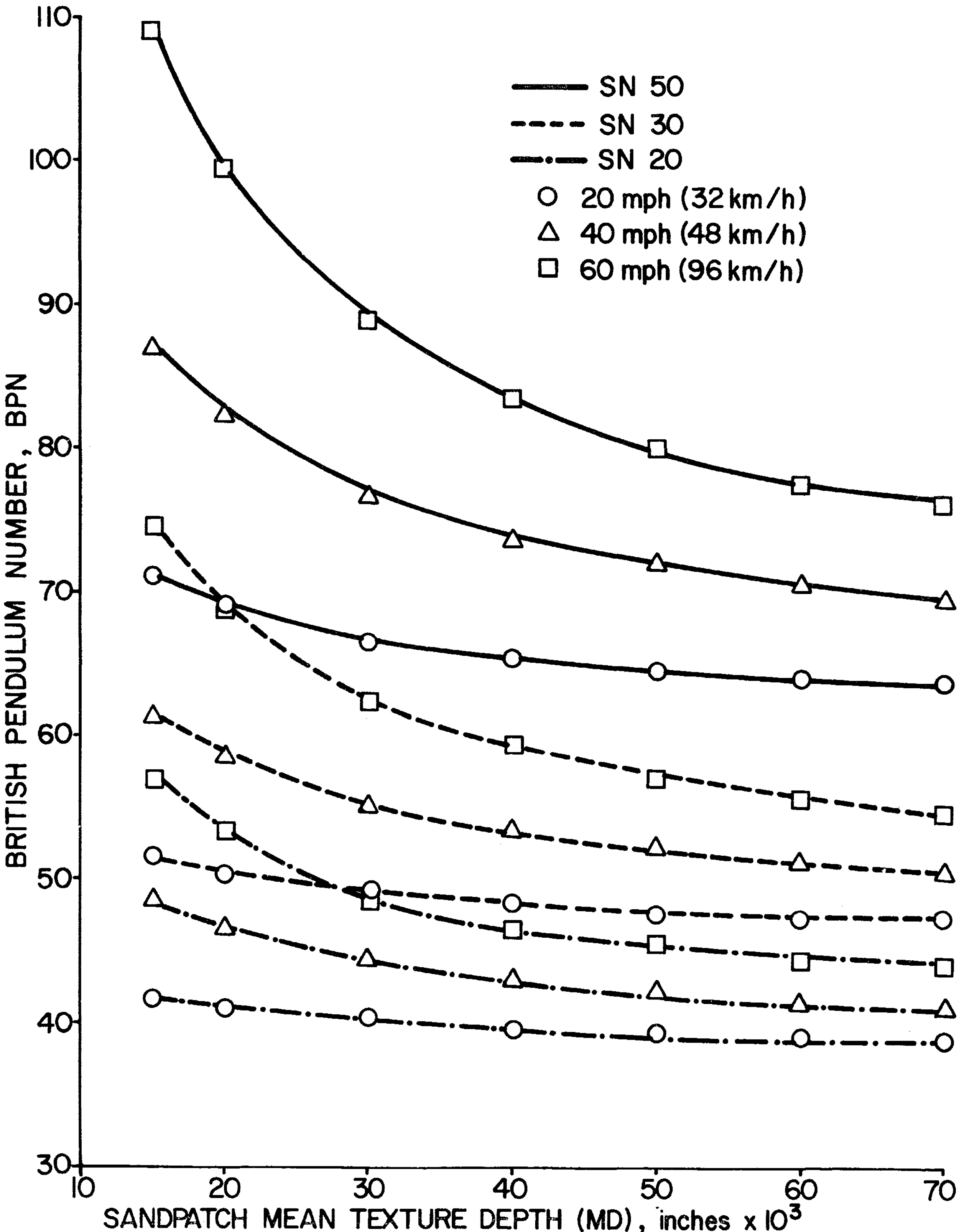
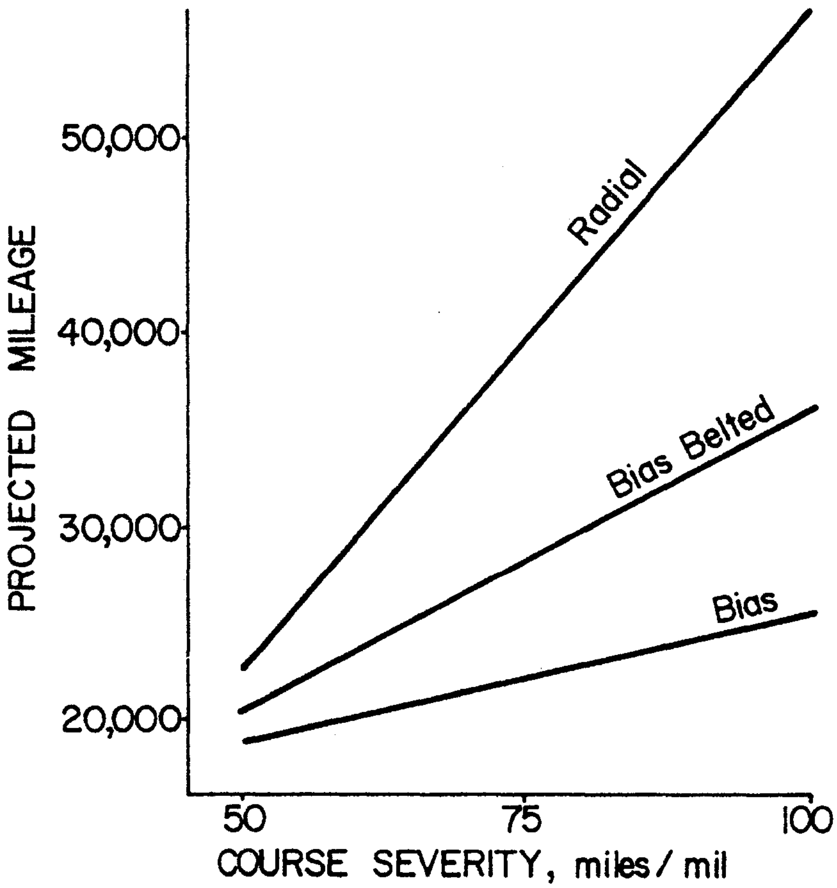


Figure 7. Relation of BPN and Macrotexture with Speed and Skid Number



1 mile = 1.61 km

1 mile/mil = 1.61 km/0.025 mm

Figure 8. Idealized plot of effects of course severity on projected mileage by tire construction (increasing abscissa indicates decreasing severity)

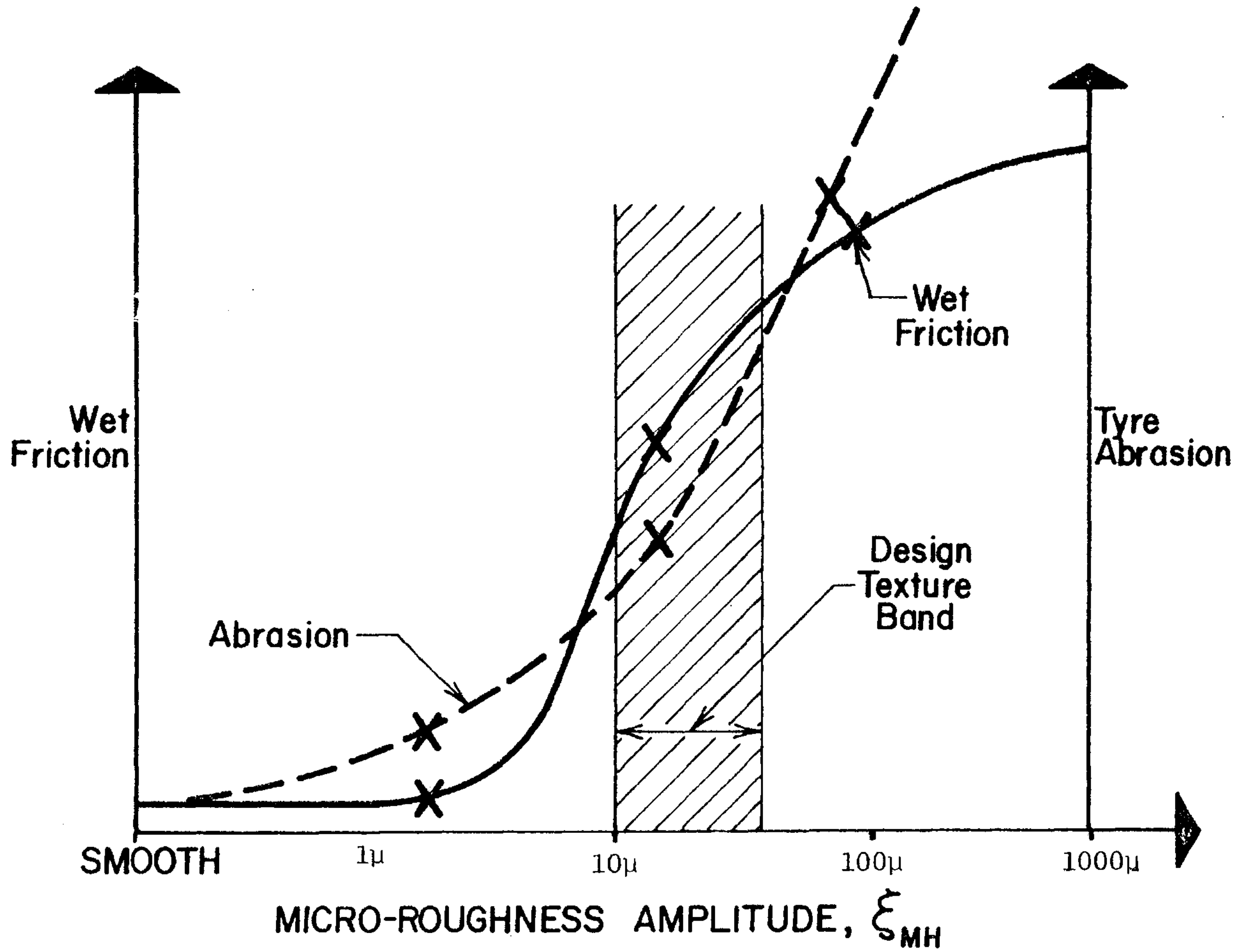


Figure 9. Wet Friction and Tire Abrasion vs. Surface Micro-Roughness

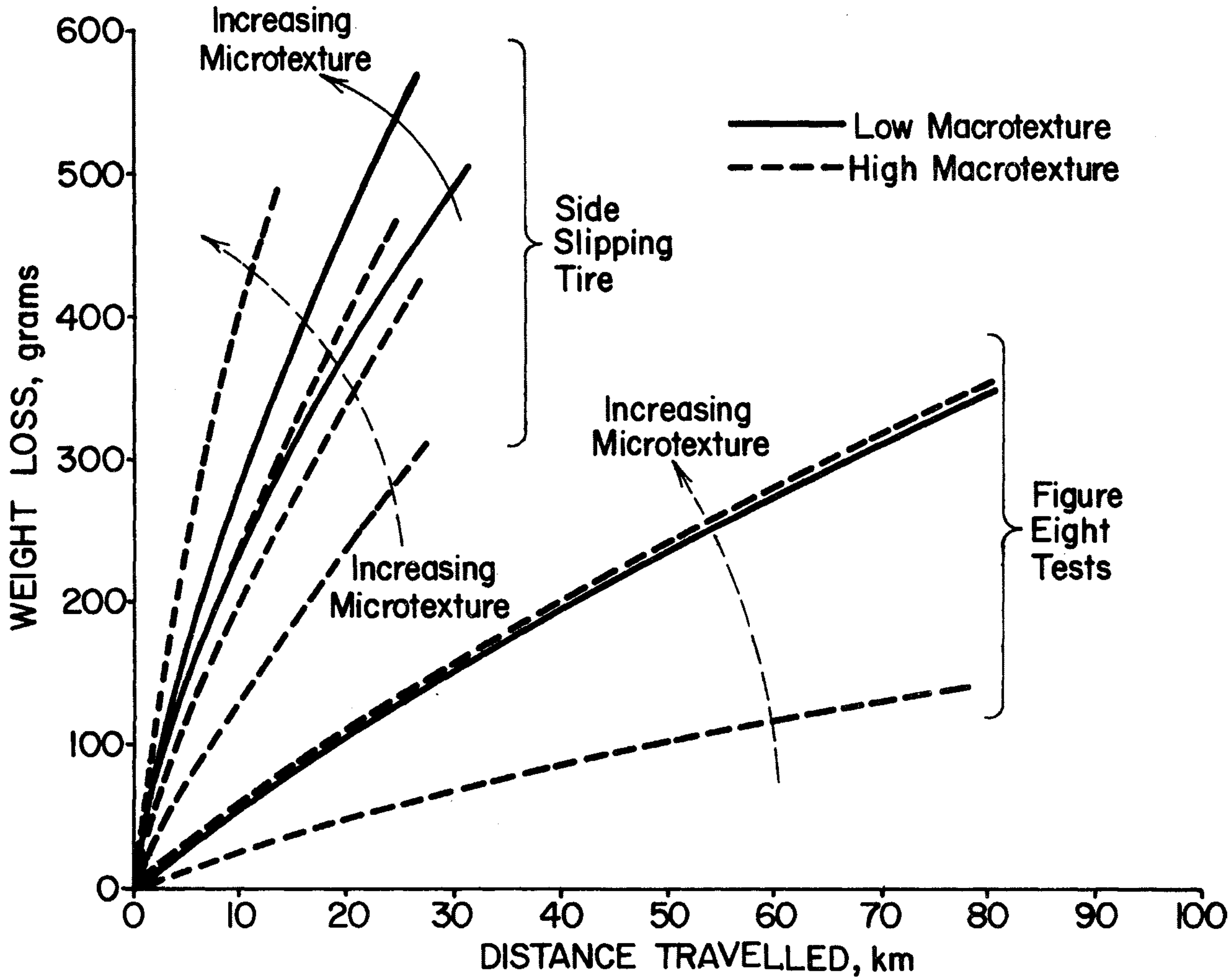


Figure 10. Wear of Tires on Surfaces of Different Texture (Tests Dry)

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FEDERALLY COORDINATED PROGRAM OF HIGHWAY RESEARCH AND DEVELOPMENT (FCP)

The Offices of Research and Development of the Federal Highway Administration are responsible for a broad program of research with resources including its own staff, contract programs, and a Federal-Aid program which is conducted by or through the State highway departments and which also finances the National Cooperative Highway Research Program managed by the Transportation Research Board. The Federally Coordinated Program of Highway Research and Development (FCP) is a carefully selected group of projects aimed at urgent, national problems, which concentrates these resources on these problems to obtain timely solutions. Virtually all of the available funds and staff resources are a part of the FCP, together with as much of the Federal-aid research funds of the States and the NCHRP resources as the States agree to devote to these projects.*

FCP Category Descriptions

1. Improved Highway Design and Operation for Safety

Safety R&D addresses problems connected with the responsibilities of the Federal Highway Administration under the Highway Safety Act and includes investigation of appropriate design standards, roadside hardware, signing, and physical and scientific data for the formulation of improved safety regulations.

2. Reduction of Traffic Congestion and Improved Operational Efficiency

Traffic R&D is concerned with increasing the operational efficiency of existing highways by advancing technology, by improving designs for existing as well as new facilities, and by keeping the demand-capacity relationship in better balance through traffic management techniques such as bus and carpool preferential treatment, motorist information, and rerouting of traffic.

* The complete 7-volume official statement of the FCP is available from the National Technical Information Service (NTIS), Springfield, Virginia 22161 (Order No. PB 242057, price $45 postpaid). Single copies of the introductory volume are obtainable without charge from Program Analysis (HRD-2), Offices of Research and Development, Federal Highway Administration, Washington, D.C. 20590.

3. Environmental Considerations in Highway Design, Location, Construction, and Operation

Environmental R&D is directed toward identifying and evaluating highway elements which affect the quality of the human environment. The ultimate goals are reduction of adverse highway and traffic impacts, and protection and enhancement of the environment.

4. Improved Materials Utilization and Durability

Materials R&D is concerned with expanding the knowledge of materials properties and technology to fully utilize available naturally occurring materials, to develop extender or substitute materials for materials in short supply, and to devise procedures for converting industrial and other wastes into useful highway products. These activities are all directed toward the common goals of lowering the cost of highway construction and extending the period of maintenance-free operation.

5. Improved Design to Reduce Costs, Extend Life Expectancy, and Insure Structural Safety

Structural R&D is concerned with furthering the latest technological advances in structural designs, fabrication processes, and construction techniques, to provide safe, efficient highways at reasonable cost.

6. Prototype Development and Implementation of Research

This category is concerned with developing and transferring research and technology into practice, or, as it has been commonly identified, "technology transfer."

7. Improved Technology for Highway Maintenance

Maintenance R&D objectives include the development and application of new technology to improve management, to augment the utilization of resources, and to increase operational efficiency and safety in the maintenance of highway facilities.