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Interim Report

**Data Bank for
Recycled Bituminous
Concrete Pavements**

**D. Y. Lee
Principal Investigator**

July 1982

DAH-YINN LEE

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DOT-FH-11-9576

**Submitted to the
Federal Highway Administration
Washington, D.C. 20590**

**Department of Civil Engineering
Engineering Research Institute
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INTERIM REPORT
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Task C - Distribution of questionnaire and analysis
of responses

Task D - Laboratory testing

Tasks A to C (36 months) commenced on April 1, 1979. Task D was initiated on August 1, 1980 for a period of 24 months. A six-month extension of the project was approved on April 15, 1982, making the total duration of this research project of 48 months and the termination date of March 31, 1983.

This Interim Report describes the research accomplished during Task A and Task B, and, although not required by the contract, updates the status of questionnaire distribution and retrieval in Task C as of June 30, 1982. Since FHWA computer programmers are still in the process of developing the software package, the description of software cannot be included in this report. A three-part document comprising the functional requirements, data requirements and instructions for key entry of data was submitted September 1980. Also, since the execution of the project, 19 Bimonthly Reports have been submitted.

From the very beginning of the project frequent and close liaison has been maintained with Mr. Peter Kopac, Contract Manager through bimonthly reports, letters, telephone, personal visits to Ames by the FHWA personnel and meetings during the principal investigator's annual visit to Washington, D.C. for the TRB meetings.

TASK A - DEVELOPMENT OF A QUESTIONNAIRE AND A PLAN TO
OBTAIN RESPONSES TO THE QUESTIONNAIRE

A.1. Literature Review: To assist in questionnaire development and recycling project identification and to collect information on documented research studies as supplement source of data for the data bank, extended literature search and collection started as soon as the project commenced. The computerized bibliography on recycled bituminous pavements has been created and updated periodically.

The number of articles in the file totals 371. The distribution of number of articles by year, a reflection of the extent of asphalt pavement activities, is as follows:

1952 - 1	1977 - 34
1962 - 2	1978 - 59
1972 - 1	1979 - 70
1973 - 2	1980 - 93
1974 - 6	1981 - 63
1975 - 15	1982 - 17
1976 - 8	

A copy of the most recent bibliography list is appended as Appendix A.

A.2. Recycling Project Identification: Identification of completed bituminous concrete recycling projects was accomplished through four avenues:

- (1) Review of literature and the principal and co-principal investigators' personal knowledge through contacts with highway agencies.

- (2) The FHWA regional offices were contacted, through the Office of Research, FHWA, for assistance in assembling a listing of recycling projects and individuals to be contacted for additional information on individual recycling projects.
- (3) Letters were sent to the Asphalt Institute, the National Asphalt Pavement Association, and the Editors of Rural and Urban Roads, Better Roads, Civil Engineering, Roads and Streets, Engineering News-Record, Construction Methods and Equipment, and Constructor requesting their assistance in running articles in their respective publications for information on recycling projects. As a result of our request several magazines have published articles requesting information on recycling projects. These include Rural and Urban Roads, Public Works, Better Roads, and Engineering News-Records. Samples of the letter and these publications are attached as Appendix B and C respectively.
- (4) Inquiries were sent to major recycling equipment manufacturers such as Barber-Greene, Boeing Construction Equipment Company, CMI Corporation, Cutler Recycling, Inc., Iowa Manufacturing Company, Koehring, etc., and to major recycling contractors including Everds Brothers, Inc., Las Vegas Paving Corporation, Midwest Asphalt, Rohlin Construction Company, and Warren Brothers, etc., for asphalt recycling projects and contacts in which they have been involved. A sample of the returns is attached as Appendix D. As a result of this effort, lists were received from 12 equipment and modified manufacturers and from contractors.

- (5) Letters with short questionnaires were sent to state asphalt paving associations of all 50 states. Samples of the letter and questionnaire are attached as Appendix E.

Although it was intended to collect information on all three types of recycling projects, the emphasis has been given to hot recycling projects for the following reasons:

- By definition the term "bituminous concrete" denotes a high-type dense-graded bituminous mixture made of hot mineral aggregates plant-mixed with hot asphalt cement or other bituminous materials.
- Information most needed such as cost, energy, and performance as related to the mixture characteristics and construction procedure has been on recently developed hot mix recycling.
- Useful (accurate, complete and representative) information such as in-place characteristics of recycled mixtures, construction details and performance evaluation are more easily documented and likely to be available for hot mix recycling projects than for either surface or cold recycling projects.

It was also decided that while we will accept information on air-field and foreign recycling projects, we will not pursue with as much vigor as with hot recycling projects completed in the United States.

Identification of projects completed prior to 1980 began April 1979 and was completed by January 1980. The final number of projects identified was 264.

The questionnaire distribution list was computerized. This list includes codes for state and FHWA region as well as names, addresses and telephone numbers of persons to whom the questionnaire will be sent. The list includes 314 names, of these 154 were later sent one or more questionnaires. Identification of projects completed during 1980-81 began in June 1980 and completed May 1982. The total number of recycling projects completed during this period and identified was 274. The questionnaire distribution list for post-1980 projects contains 257 names, of these, 106 were later sent one or more questionnaires (Appendices F & G).

A.3. Preliminary Questionnaire: Considerable time and effort was spent on preliminary questionnaire development. The major guideline in the questionnaire construction was to generate data pertinent to the development of a cross-referencing system to achieve the following objectives:

- (1) To include all major bituminous concrete recycling projects in the United States.
- (2) To relate performance of these recycled pavements to materials characteristics and recycling process.
- (3) To provide rapid access to data and information, of either broad or detailed nature, on recycled pavement projects.

Special consideration was given so the questionnaire can be conveniently completed by the respondent in order to facilitate obtaining data and information from the proper authorities and in such a form that the information and data can be efficiently translated for information storage and access.

The first draft of the preliminary questionnaire was completed in early June 1979. Copies of the draft questionnaire were sent to Mr. Richard Henely, Kossuth County, Iowa, Mr. Wade Betensen of Utah DOT, Mr. Welden Chattin of Texas DOT, Mr. Robert Doty of Caltran, and Mr. Bud Brakey of Colorado DOT for comments.

The preliminary questionnaire was then revised, based on discussions with and comments from the above individuals and forwarded to Mr. Kopac on August 8, 1979 for FHWA review. It was recognized by the team as well as the reviewers, that the preliminary questionnaire as submitted was lengthy, complicated and extremely time consuming to accurately complete all details. However, the primary criterion used to decide whether each questionnaire item should be retained is "Is this information pertinent to the materials - process - performance correlation?" and not whether the information requested is available.

A.4. Pre-test of Preliminary Questionnaire: Detailed and useful comments on the preliminary questionnaire were received from Mr. Peter Kopac in early September 1979. After partial modification of the preliminary questionnaire by incorporating comments from Mr. Kopac, the research team visited Mr. Richard Ingberg and Mr. Roger Olson of MinnDOT at St. Paul and Mr. Richard Henely of Kossuth Co., Iowa in September-October 1979 for the purpose of conducting an oral "walk-through" of the questionnaire. They were asked to identify, in their opinions: (a) question items that are ambiguous; (b) question items that are not pertinent; (c) items important but not contained in our

preliminary questionnaire; and (d) approximate time required to complete the questionnaire. Two additional oral "walk-through" pretests of the preliminary questionnaire were conducted with Mr. Frank R. McCullagh of the Arizona DOT and with Mr. C. S. Hughes of Virginia Highway and Transportation Research Council and Mr. Joe Love of Virginia Department of Highway and Transportation, during October-November 1979.

A.5. Final Questionnaire: The preliminary questionnaire was modified based on results of pretests with personnels of Cal Tran, Kossuth Co., Iowa, Arizona DOT, Minnesota DOT and Virginia Department of Highway and Transportation and Research Council as well as comments from FHWA, in December 1979. The final draft questionnaire, together with Questionnaire Distribution and Execution Plan, was submitted to Mr. Peter Kopac, Contract Manager, on January 2, 1980 for FHWA review and clearance.

Comments and approval of the final draft questionnaire submitted to Mr. Peter Kopac on January 2, 1980 were received on February 22, 1980. Authorization to proceed with final preparation of questionnaire was given by Mr. Kopac on February 25, 1980.

Mock-up copies of the questionnaire were produced the last week of March 1980 and sent to Mr. Kopac the first week of April 1980 for final approval. Four hundred copies of each of the following material were printed in the second week of May 1980:

- Formal questionnaires (alternate white and ivory parts with cover page), 22 sheets. (Appendix I)
- Working copy of questionnaire (blue), 20 sheets.

- Guides (yellow), 5 sheets. (Appendix J)
- Cover letters (white), 1 sheet. (Appendix K)
- 12½ x 9½ in. envelopes for sending questionnaire packages.
- 12½ x 9½ in. business return envelopes (postage paid).
- Business return postcards (postage paid).
- Post-card reminders. (Appendix L)

Forty copies of questionnaires were subsequently sent to Mr. Kopac for distribution within FHWA and, Region 15 and NEEP 22. Distribution of questionnaires started in May 1980 for projects completed by December 31, 1979.

Soon after the questionnaires were returned and data coding and keypunching operations began, the need for some corrections and modifications of the questionnaire was noted. This was defined and discussed with FHWA personnel. A revised version of the questionnaire was delivered to Mr. Peter Kopac in January 1982. Approval to print and distribute the revised questionnaires was received on March 31, 1982. Three hundred copies of the revised questionnaires were printed and about 250 were distributed (with blue working copies) in April - May 1982. A copy of the revised questionnaire is attached as Appendix M. A copy of the cover letter for post-1980 projects is attached as Appendix N. A copy of the cover letter for pavement performance update (with part 4 of the questionnaire) is attached as Appendix O.

TASK B - DEVELOPMENT OF A HARDWARE/SOFTWARE SYSTEM
FOR THE DATA BANK

Concurrently with Task A, work to develop a hardware/software system for the data bank also began. In designing the system, utmost considerations were given to achieving the following objectives:

- (1) The system shall permit access of data and information from the data bank for two broad purposes:
 - To provide an inventory of projects with aspects in common such as total tonnage, number of projects using a particular plant, process, or material, etc., and
 - To provide a cross-reference to correlate performance of recycled pavements with a particular process or material or to correlate materials with process or method, etc.
- (2) The system shall be capable of adding or deleting categories and be capable of continually accepting changes and improvements in recycling technology. It shall also have the capabilities to incorporate revised questionnaires for updating performance.

After careful data definition and extensive review of currently available software systems it was determined that the most efficient data management system to be used in the project is the SAS (Statistical Analysis System) system. The use of this system would significantly reduce programming requirements, program maintenance and documentation. A proposal to design the project computer system around "SAS" was submitted on July 30, 1979. Permission to design the data bank around the SAS system was granted on August 14, 1979.

While the questionnaire was being approved, system work proceeded in two areas: (1) defining the characteristics and lengths of data items and (2) defining the form and contents of output reports. Several questionnaires were completed in-house based on review of recycled projects. A number of excellent questions which may be asked of the Data Bank after it becomes operative were supplied by FHWA in April 1980. These, together with questions generated by project staff, were incorporated in the software design so the data bank can generate more useful output reports.

Work on the Functional Description and Data Requirements documents began as soon as the questionnaire was approved in February 1980, completed in September 1980 and was submitted to FHWA on October 21, 1980. This document consisted of three parts: I. Functional Requirements Document (35 pp.), II. Data Requirement Document (3 pp.) and III. Instructions for Keyentry of Data (11 pp.). Written comments on the documents by Mr. Bill Mellott of FHWA dated December 11, 1980 was received December 30, 1980. Point-by-point responses to these comments were prepared by Dr. W. J. Kennedy on January 9, 1981 and transmitted to Mr. Kopac on January 13, 1981. On January 28, 1981, Mr. Kopac notified the principal investigator that Messrs. David Wood and Bill Mellott of FHWA were satisfied with Dr. Kennedy's written responses. Apparently programming of the computer software system began at FHWA shortly thereafter.

In addition to the Functional Description and Data Requirements documents, a completed questionnaire for a hypothetical recycling project

and a copy of questionnaire showing the expected reasonable types and ranges of data were also forwarded to Mr. David Wood on October 29, 1981 and March 17, 1982 respectively. Although a number of telephone conversations had taken place between Iowa State University and FHWA to clarify points discussed in the documents, the feeling here is that FHWA data processing personnel do fully understand the requirements and have been making good progress in design and programming activities.

As stated earlier, the software description will be prepared by the FHWA personnel when they have completed the design and programming of the software system.

TASK C - DISTRIBUTION OF QUESTIONNAIRE AND ANALYSIS OF RESPONSES

Mailing of questionnaires for pre-1980 projects started in May 1980 and was completed July 30, 1980. Mailing of questionnaires was preceded by letters from FHWA's Offices of Research and Development to Regional Offices and to agencies other than State Highway Departments, and followed by postcard reminders and personal telephone calls by the principal investigator and Mr. C. L. Huisman of Iowa DOT, co-investigator. In addition, copies of cover letter to each respondent were sent separately to the respondent's agency head to keep him or her informed of the agency's participation and to acknowledge the respondent's contribution in time and effort. Mailing of questionnaires for post-1980 projects started in January 1982 and was completed by June 30, 1982. Updating questionnaires (part 4) were mailed in May 1982 to 31 agencies on 48 projects. Each

questionnaire package contained the following:

- Cover letter (Appendices K and L)
- Guide (Appendix J)
- Postage-paid return
- Business envelope(s) (12 ½ x 9 ½ in.)
- Postage-paid postcard (for use if additional questionnaires are needed)
- For each project:
 - one copy (white/ivory) formal questionnaire with address label fixed on page 1 (Appendices I and K)
 - one copy (blue) working copy of questionnaire partially completed.
 - one copy (yellow) part 4

A summary of questionnaire distribution and retrieval activities as of June 30, 1982 is shown in the following table:

SUMMARY OF QUESTIONNAIRE DISTRIBUTION AND RETRIEVAL

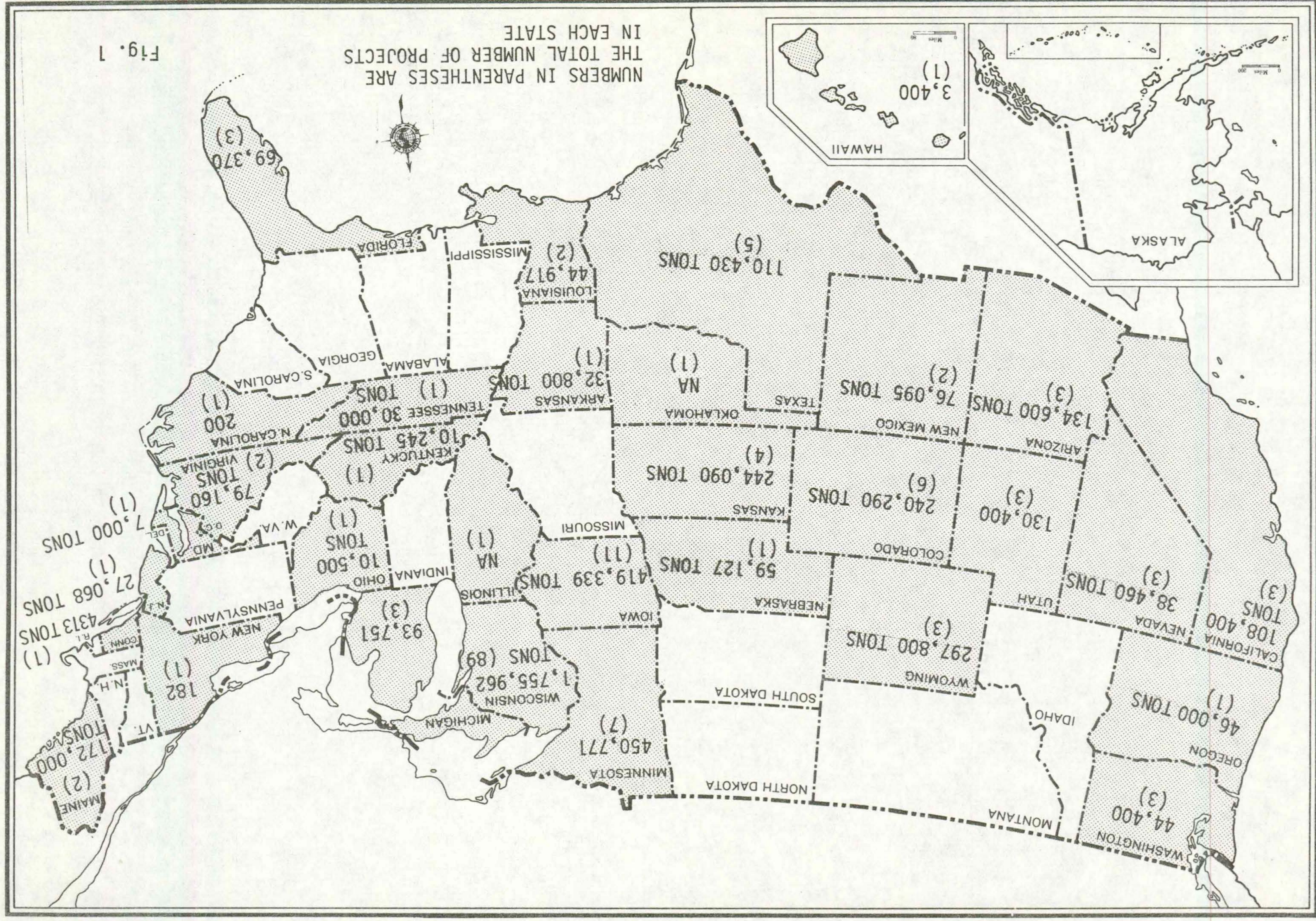
	<u>Pre-1980</u>	<u>Post-1980</u>	<u>Total</u>
Total Agencies on the Distribution List	314	257	-
Number Questionnaires Sent	264	274	538
Number Agencies Rec'd Questionnaires	154	106	260
Number Agencies Responded	75	24	99
Number Projects From Respondents	102	21	123
Number Projects Completed by ISU	51	95	146
Total Number Projects	153	116	269
Number Projects Key punched	153	107	260
Number Projects on Tape	153	14	167
Number Projects Sent to FHWA	153	14	167
Number Update (Performance) Questionnaires Sent	43	5	48
Number Agencies Rec'd Update Questionnaires	27	5	31
Number Update Questionnaires Returned	6	2	8

Although the computer data bank is not operational since programming of the software is still in progress, some manual analysis of the collected data had been performed. The results of analysis of the characteristics of hot mix recycling projects completed by December 31, 1979 were presented at the 1982 Annual Meeting of Transportation Research Board (Session 96). Some of the characteristics of all recycling projects (completed through 1981) collected as of June 30, 1982 are given in Figures 1-7. A list of projects and their identification numbers in the data file as of June 30, 1982 is appended as Appendix P.

RECOMMENDATIONS

Based on work completed in Tasks A and B, and experiences gained during Task C, the following are recommended:

1. The data bank project should be continued for at least another 5 years and should be the focal point of all other research activities involving asphalt recycling.
2. The most painless, accurate and cost-effective way to obtain complete questionnaire returns is for FHWA to make the completion of a questionnaire as a part of contractual agreements which state where Federal funds are used before the recycling project is started.
3. Laboratory testing and performance evaluation update should be continued, preferably following the same methods and procedures used and on the projects selected in Task D of this contract. It is felt that the projects selected for testing in this project are representative of hot recycling projects in the United States in terms of geographical locations, weather conditions, types of facilities and recycling methods.
4. The programmers and personnels responsible for maintaining the data bank system should recognize the need and possibilities of data being added, deleted and corrected, and the possibility of the questionnaire being further revised.
5. Mechanisms should be set up to include data from other FHWA research projects e.g., Texas A&M, Resources International, Inc., etc., where testing of recycled field samples are involved.



NUMBERS IN PARENTHESES ARE THE TOTAL NUMBER OF PROJECTS IN EACH STATE

Fig. 1

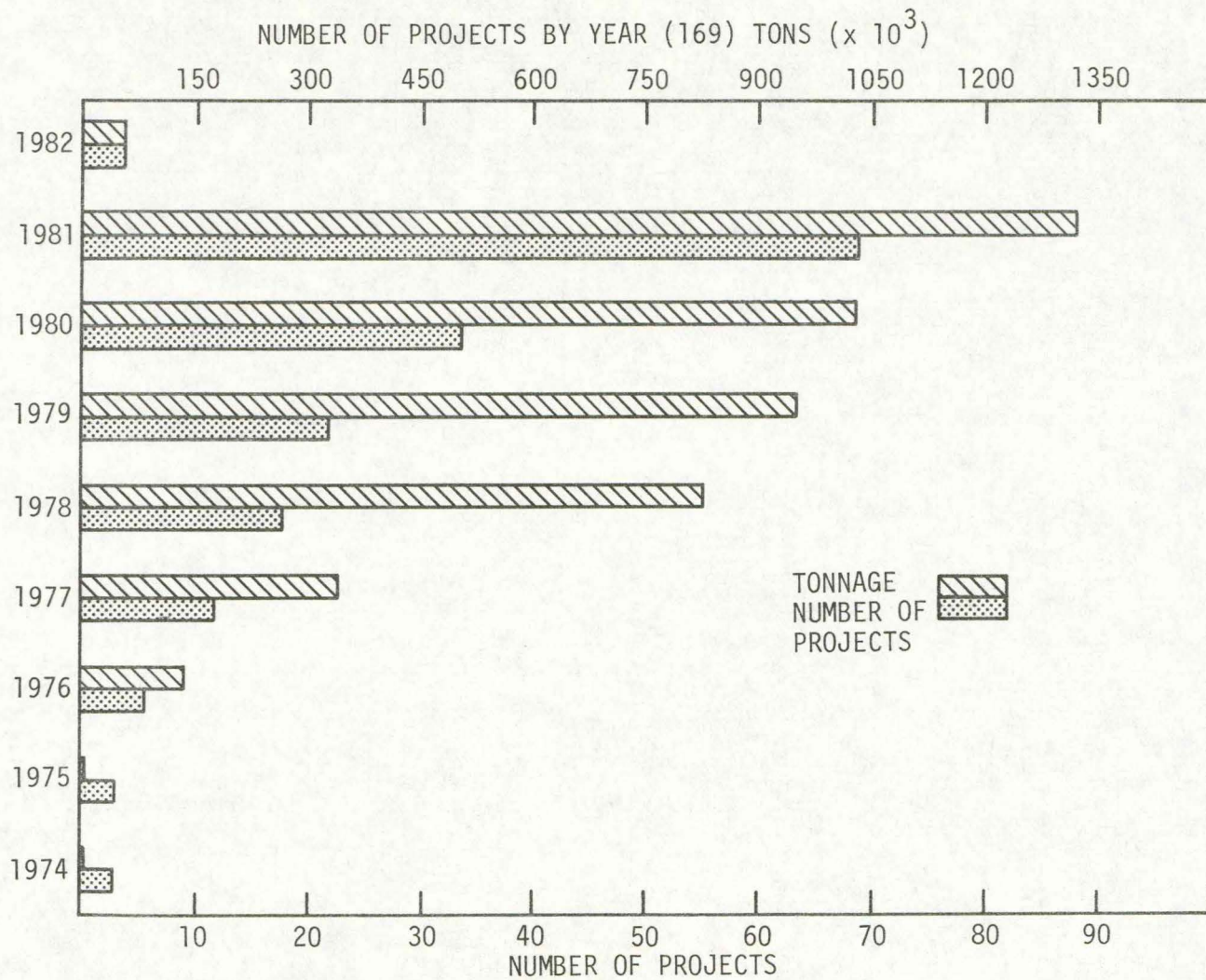


Fig. 2

TYPE AND LENGTH OF RECYCLED FACILITY

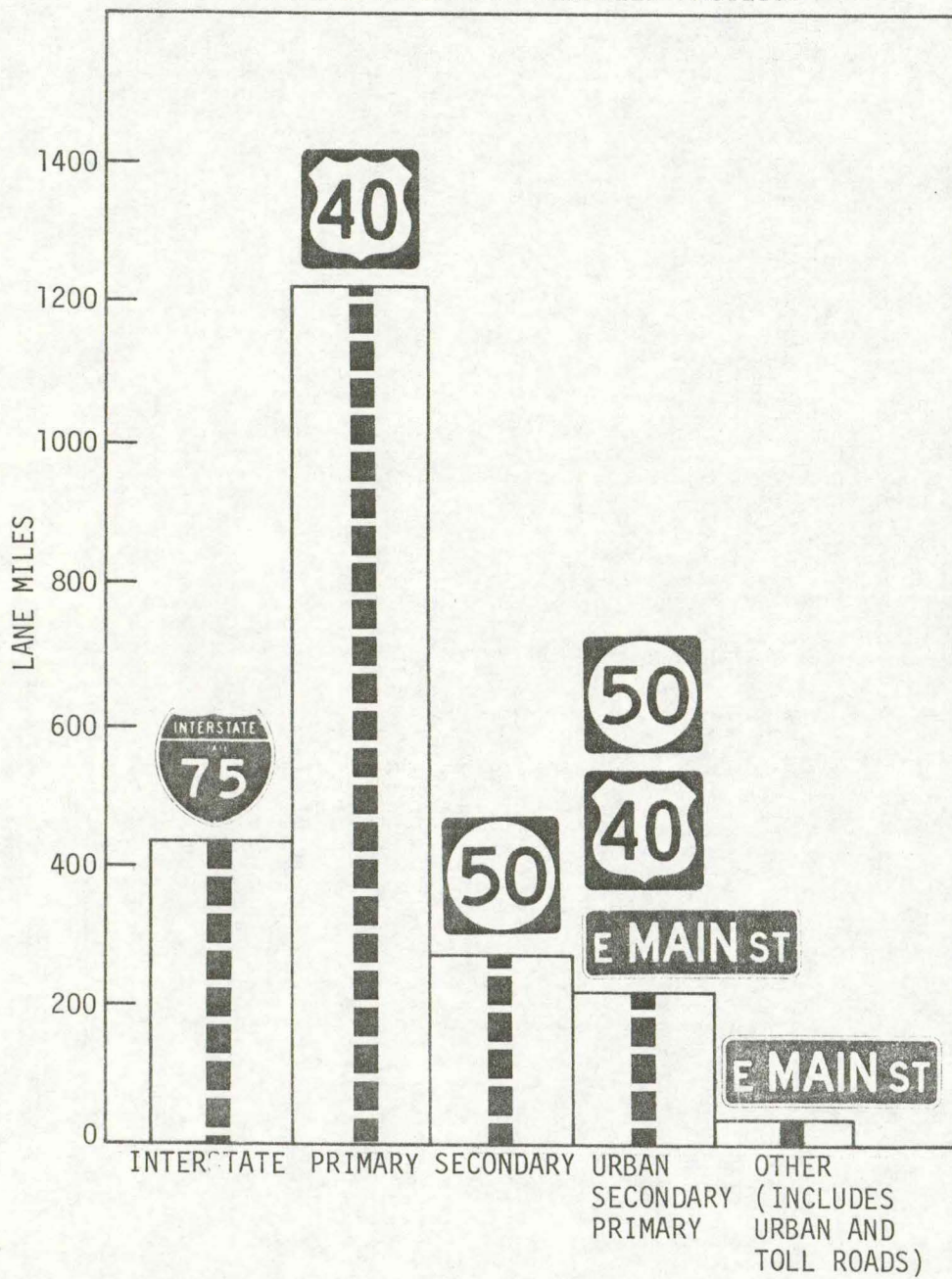


Fig. 3

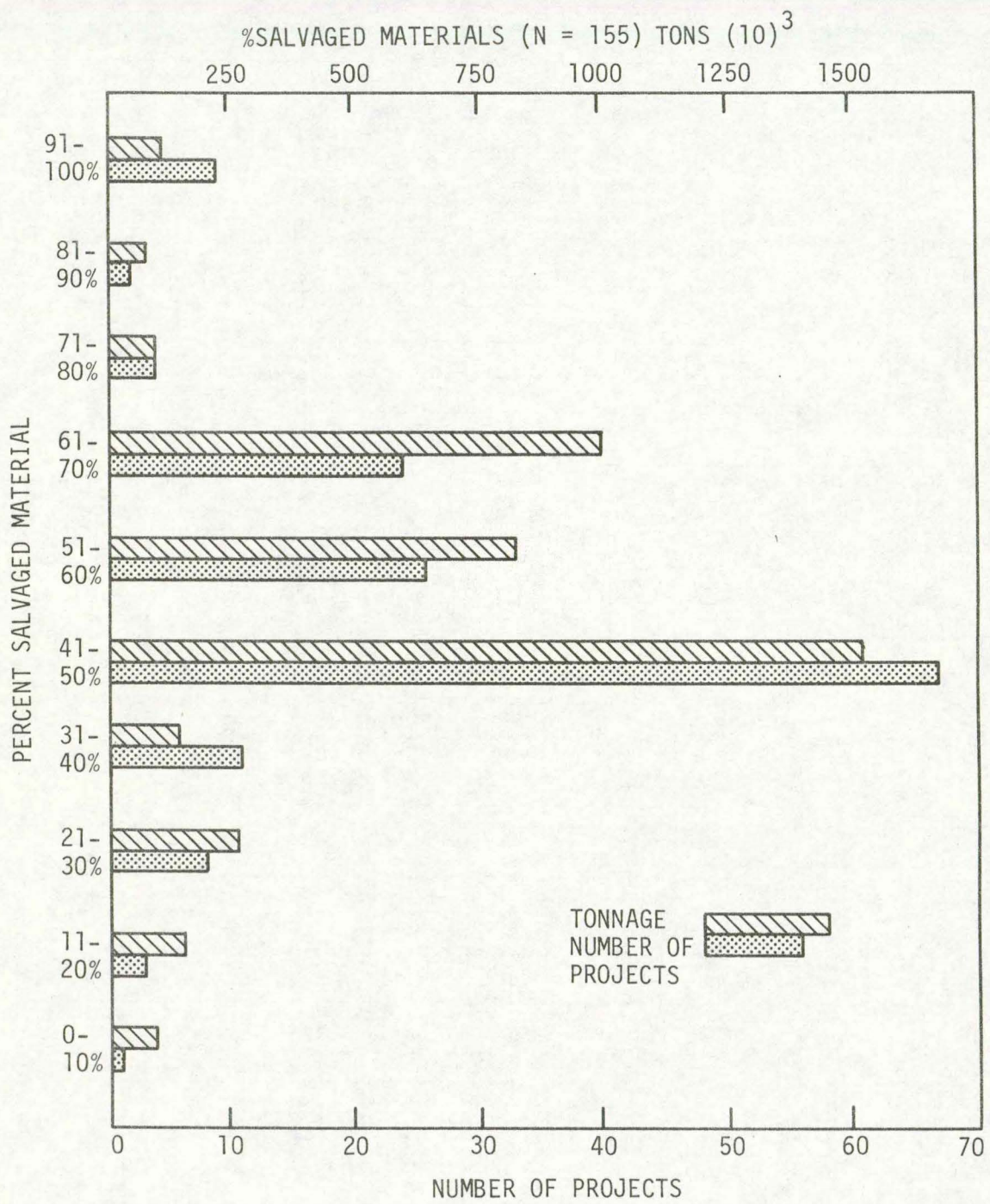


Fig. 4

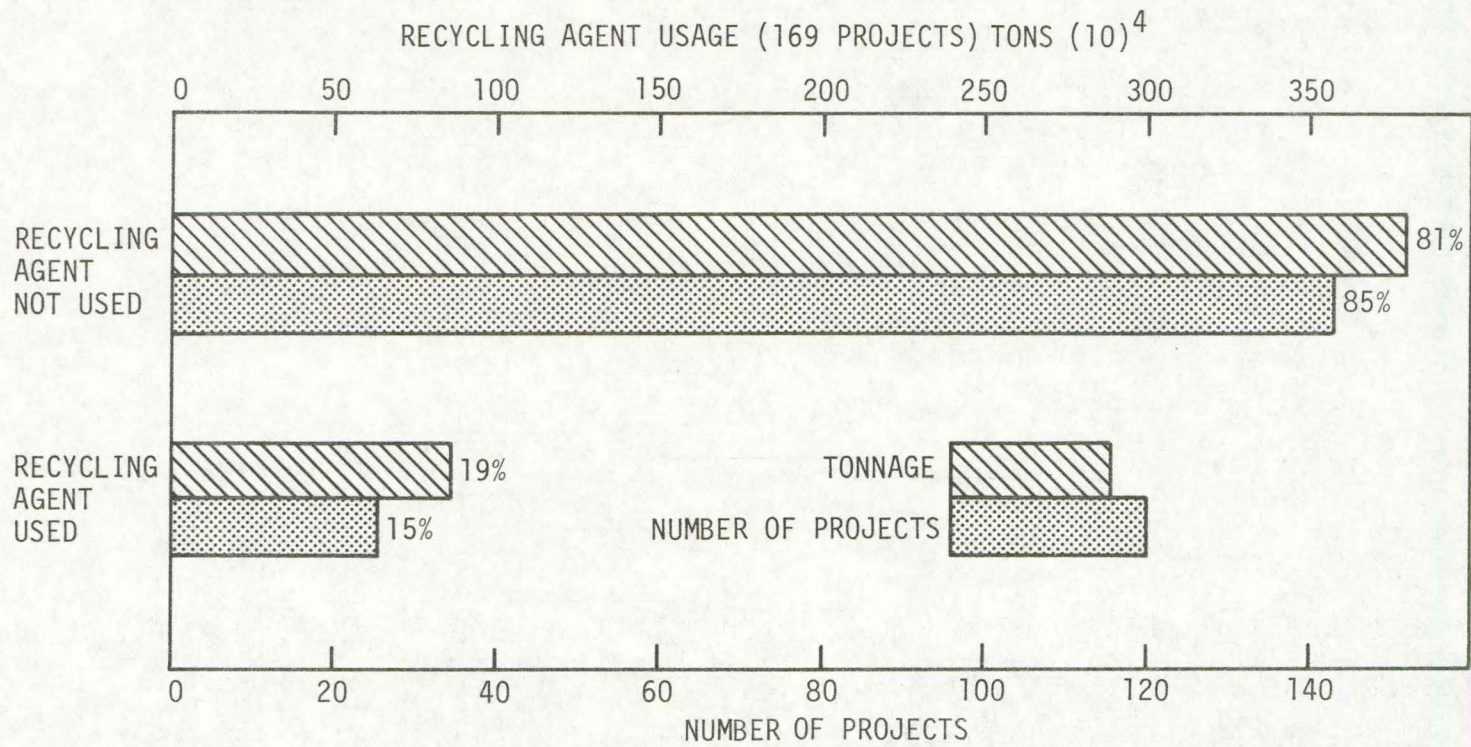


Fig. 5

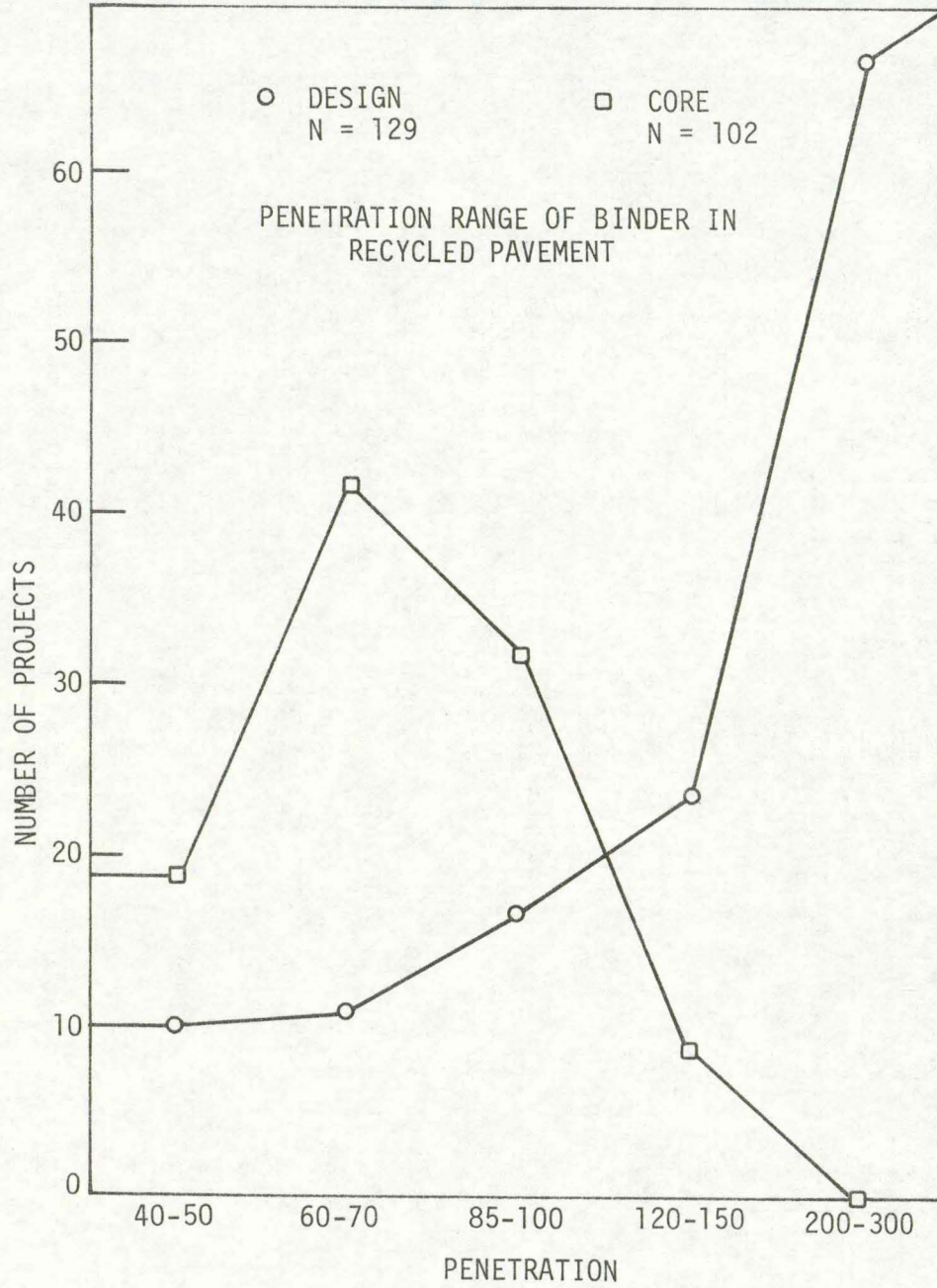


Fig. 6

VISCOSITY RANGE OF BINDER IN RECYCLED PAVEMENT

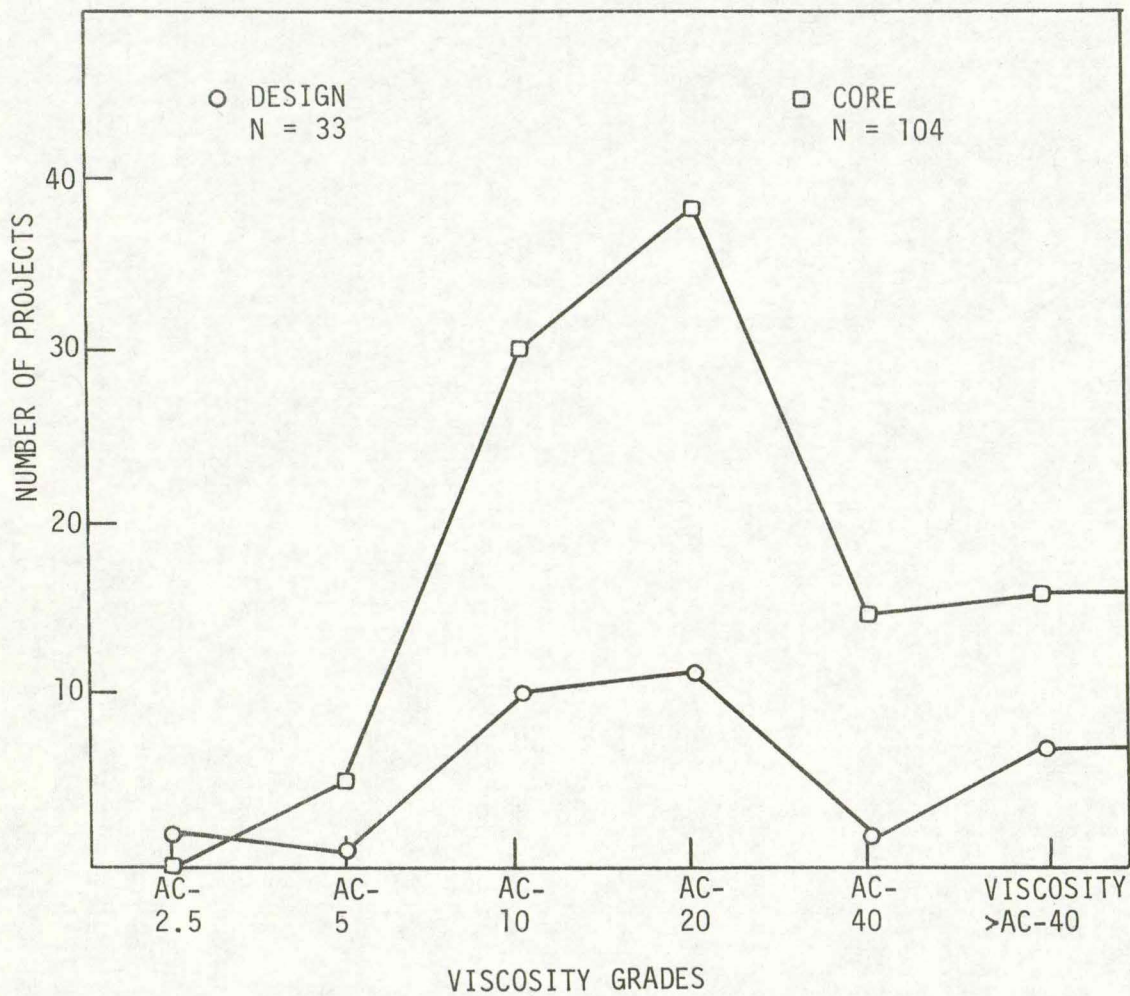


Fig. 7

APPENDIX A: Bibliography - Recycled
Bituminous Pavements

APPENDIX B: Sample Cover Letter
to Publishers

APPENDIX C: Samples of Published Requests
for Asphalt Recycling Data

APPENDIX D: Sample Questionnaire to Equipment
Manufacturers and Contractors (1979)

APPENDIX E: Sample Questionnaire to State
Asphalt Paving Associations (1982)

APPENDIX F: Distribution List (Pre-1980 Projects)

APPENDIX G: Distribution List (Post 1980 Projects)

APPENDIX H: FHWA Letter to Highway Agencies

APPENDIX I: Questionnaire (1980)

APPENDIX J: Guide to the Questionnaire

APPENDIX K: Questionnaire Cover Letter (1980)

APPENDIX L: Postcard Reminder

APPENDIX M: Revised Questionnaire (1982)

APPENDIX N: Questionnaire Cover Letter (1982)

APPENDIX 0: Cover Letter for Performance
Update Data (Part 4)

APPENDIX P: Project Listing

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