Commonwealth of Kentucky

Department of Highways

# Proposed Working Plan

for

# A STUDY OF THE PROPERTIES OF COARSE AGGREGATES

by

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## INTRODUCTION

Among the numerous materials used in the construction of highways probably none is more important or perplexing than coarse aggregate. Through past research and experience a group of procedures and specifications for selecting aggregates suitable for pavements has been developed. These acceptance tests deal almost entirely with physical properties such as gradation, soundness, absorption, abrasion, etc. However, recent data accumulated by field observations and surveys (1), (7), (8)* have indicated that some materials passing the specifications have undesirable properties which cause difficulties over a long period of time. Consequently, research directed toward a more thorough investigation of aggregates has become importunate.

## PURPOSE

Since standard acceptance tests have not served to eliminate all troublesome aggregates, it is purposed that a study be made to develop a means for recognizing and eliminating those aggregates which are ultimately detrimental. In addition, it is suggested that for those aggregates found to give inferior performance, a method may be developed by which the detrimental actions can be controlled and the aggregate then incorporated into concrete without producing failures. The suggested investigation will require a considerable amount of time, but progress reports at certain intervals will be a means of recording developments as they appear.

*Numbers in parenthesis refer to bibliography at end of report.

## SCOPE

This investigation will not be confined to any particular class or type of aggregate; rather, it will include all types of natural and prepared materials now used as coarse aggregates in this state. The analysis will be based primarily on results obtained in performance surveys and classifications will be made on a petrographic as well as engineering basis. Comparisons will be made with materials of known properties which prevail in states other than Kentucky in order that data accumulated elsewhere may be used to an advantage.

It is recognized that failures in concrete pavement could be due to such variables as sand, cement, and water; however, the major problem appears to be in the coarse aggregate. Therefore, other variables will not be considered in this study, except as they have tended to influence the performance of the coarse aggregates.

In addition to the main thesis of this study, several adjunctive lines of investigation may be included with a minimum of effort. Some of these are: adhesion or stripping of bituminous materials from aggregates, anti-stripping agents, and the relative costs of materials in different sections of the state based on locality and transportation.

## MATERIALS

Materials pertinent to this project may be divided into the usual major and minor groups with a possibility of further subdivision based on properties such as mineral composition and

perhaps origin. By a preliminary arrangement these are as follows:

Stone:
1. Limestone
2. Sandstone

Gravel:
1. River Gravel
2. Bank or Pit Gravel

Slag:

## PROCEDURES

The procedure for investigating aggregates in this study will be divided into four general categories:

(1) Correlation between aggregates and field performance.

(2) Tests for physical properties.

(3) Study devoted to the composition of the material both mineralogically and chemically.

(4) Experiments to determine feasibility of using the poorer type aggregates.

The first of these will include a classification of good, intermediate, poor, or indeterminate aggregate as indicated by performance. It is believed that certain aggregate will clearly stand out as good or bad, while the majority will be intermediate or indeterminate. Once the aggregates giving good and bad performance have been determined it should be possible to discover the reason for failures.

Tests for physical properties on all aggregates will include those now contained in our specifications supplemented by others which are thought to be pertinent to the problem. These

tests are:

1. Abrasion - to determine the resistance of aggregates to wear or abrasion. Two methods - Los Angeles; Deval.
2. Toughness - a measure of the resistance to fracture under impact loads.
3. Specific Gravity - as determined by several methods.
4. Absorption - to determine the amount and depth of penetration of water by:
    1. Twenty-four hour soaking in water - amount (1).
    2. Dye penetration to determine depth and rate of absorption.
5. Soundness - a measure of resistance to disintegration through tests with sodium sulfate, magnesium sulfate, and freezing and thawing.
6. Gradation - on representative samples of uncrushed materials.
7. Unit Weight - for combinations of materials.
8. Durability
    1. Freezing and thawing and immersion and drying tests on samples of aggregate and possibly concrete with representative samples of aggregate.
    2. Reduction of "E" and flexural strength of concrete made from the various aggregates.

3. A check for any change of the physical characteristics of the aggregates upon completion of a given number of cycles of freezing and thawing and immersion and drying.

9. Thermal (6)

1. Coefficient of Expansion - on aggregate (3).
2. Specific Heat - on aggregate and possibly representative samples of concrete.

10. Exposure - arbitrary procedures consisting of groups of previously described tests on aggregate immediately after being taken from the source and at certain times after exposure comparable to stock-piling.

Ultimately, the procedure for determining the acceptance of aggregates may fall within the group of physical tests. However, it is probable that such a procedure cannot be conclusively evaluated or established without a correlation based on the composition of the material. For that reason, the solution may be dependent upon tests within the third step of the procedure. Since mineralogical analysis are somewhat new to highway aggregate studies, only a preliminary estimate of procedures mainly based on literature can be recorded at this time. At this stage it is thought that determinations relative to limestone aggregates, for example, would be devoted to the quantity of insoluble residue supplemented by analysis of the type of mineral represented in this residue. If those two determinations

should not reveal the fundamental causes of variable performances then a third step designed to show the arrangement of impurities (principally clays) is proposed. The last of the three is most complicated and time consuming, therefore, if the solution is dependent upon this procedure it will probably be necessary to develop a simplified test that approximates those for arrangement of minerals in order that specifications will be feasible. Chemical and mineralogical tests for aggregates other than limestone will, through necessity, be formulated as work progresses.

As to step four of the procedure, there is a minimum of data available on increasing the durability of aggregates or concrete. However, upon determining the cause of failure of certain aggregates it is believed that the incorporation into concrete of at least the intermediate performing aggregates will be forthcoming.

## EQUIPMENT

Most of the equipment known to be required for a study of this nature is now available in the Highway Materials Research Laboratory. Consequently, on the basis of present knowledge the cost of the experiment will lie mainly in the time spent by Laboratory personnel. On the other hand, if spectroscopic analysis for mineral distribution should be required probably the most practicable arrangement would be one whereby a person trained for this analysis and possessing necessary equipment

could be utilized on a fixed fee basis. Equipment and men of this nature are available in two or three locations on the University campus.

## CONCLUSIONS

1. That coarse aggregates are the probable source of many of the failures on concrete pavements. This does not exclude the possible effects of fine aggregates, which are proposed for study in a later project.

2. That a study of coarse aggregates is desirable, in which the following will be considered:

   a. Correlation of pavement performance and aggregates.

   b. Tests of physical properties of aggregates.

   c. Study of composition of the material both mineralogically and chemically.

   d. Experiments on feasibility of using intermediate to poor aggregates in concrete.

3. That the study will be long, but frequent progress reports will record developments as they appear.

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