2. The amount of expansion is directly related to the top size of the aggregate. Reduce the size of the reactive rock.

3. The amount of expansion is directly related to alkali content of the cement. Use low alkali cement and use lower than 0.06 percent Na_2O equivalent, if available.

4. The use of fly ash, GGBF slag, silica fume or blended hydraulic cement does not appear to be effective in controlling ACR.

ABRASION RESISTANCE

Introduction

Abrasion resistance is defined by the ACI committee on terminology as "ability of a surface to resist being worn away by rubbing and friction" [29]. Abrasion of pavements may result from vehicular traffic on highways and warehouse floors. The use of studded tires or chains may accelerate the wear of concrete road surfaces by attrition, scraping, and percussion.

Materials related factors which may reduce the resistance of concrete to abrasive action should be considered in design and construction of pavements. Frequently the failure of concrete to resist abrasion can be traced to cumulative effects such as inadequate compressive strength, excessive air content, soft or resistant aggregates, inadequate bond strength of the aggregate, improper cuing or finishing, or overmanipulation of fresh concrete surface. Reducing the wear resistance of concrete involves the surficical hardened cement paste, which initially resists abrasive forces. As the paste is worn away, coarse aggregate ultimately is exposed. As the pavements wear, adequate friction resistance may be lost, which is necessary to reduce the hazard of vehicle skidding under wet conditions.

Compressive Strength

Whitte and Backstrom [30], as researchers before and after them, consider the compressive strength the most important factor responsible for the abrasion resistance of concrete. Studies indicated 34 MPa concrete develops twice as much resistance to abrasion as 20 MPa concrete [31]. ACI 201.2R [6] recommends that in no case should concrete compressive strength be less than 27.4 MPa and that strength level be attained by a low water-cement ratio and the lowest consistency for proper placing and consolidation.

Aggregate Selection

Next in importance is the quality of the fine and coarse aggregates. Smith [32] concluded no correlation exists between concrete abrasion resistance and coarse aggregate test results by ASTM Test Method C 131 [11]. However, Concrete resistance can increase by using hard, dense aggregate, such as traprock, granite, or silica.

Testing

There are three ASTM test methods that may be used for testing for abrasion resistance; one is recommended for use in evaluating pavement concrete. ASTM C 779 [11] has three procedures: procedure A is a revolving disk machine which operates by sliding and scuffing of steel disks in conjunction with abrasive grit; procedure B is a dressing-wheel machine which operates by impact and sliding of a steel dressing wheel; procedure C is a ball-bearing machine which operates by high-contact stresses, impact and sliding friction from steel balls. ASTM STP 169 B [33] recommends the ASTM C 779 [11] for pavement concrete as follows: procedure A for light to medium traffic, procedure B for heavy tire and steel wheel traffic, and procedure C for heavy steel and track vehicles.

Skid Resistance

The problem of friction resistance to skidding has been studied for many years. ASTM [33] has over twenty specifications, test methods and practices which focus on how to measure traveled surface characteristics.

ACI 201.2R [6] discusses the skid resistance of concrete pavements as depending on the surface texture. Two types of texture are involved; the macro-texture (large scale) resulting from irregularities "built in" at the time of construction; and micro-texture (small scale) resulting from hardness and type of fine aggregate used in the concrete. ACI 221R [18] discusses the properties of various aggregates to polishing and frictional resistance.

Construction Practices

With a given concrete mixture, compressive strength at the surface can be improved by;

Avoiding segregation,

Eliminating bleeding,

Properly timed finishing, and

Proper curing.

SUMMARY

Concrete pavements can be designed and constructed for long-term performance without deteriorating provided the materials selection, traffic predictions, and maintenance all conform to adequate standards. Evaluation of concrete materials during the project design will provide information for specification requirements and construction practices to assure concrete pavements will perform in service. Concrete materials engineering is necessary to negate concrete durability problems.

The air-void system for the concrete materials specified must be adequate for resistance to freezing and thawing of the paste. The aggregates must be evaluated to determine that they are non-frost susceptible.

If the aggregates available for the project are potentially alkali-silica or alkali-carbonate reactive, the specifications must include provisions to negate reactivity in service.

Deicing chemical usage has to be known to prevent scaling or recognize an external source of alkalies which may contribute to alkali reactivity.

The compressive strength of the concrete and the aggregate quality and properties have to be adequate to provide abrasion resistant concrete.

Testing and good construction practices must be followed to assure long-term pavement performance without concrete durability problems.

The construction of quality concrete highways and the process that assures achievement of such quality have to be the concern of all involved in the process. Quality assurance is too important to be left to those responsible for the acceptance of the product. Quality is really the business of everyone associated with design, construction, operation, and maintenance of the concrete pavement.

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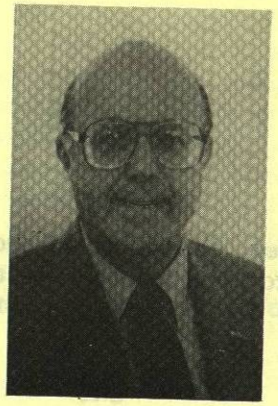

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