

# Report on Roller-Compacted Concrete Pavements

Reported by ACI Committee 325

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*This report covers the present state of the art for roller-compacted concrete pavements. It contains information on applications, material properties, mix proportioning, design, construction, and quality control procedures. Roller-compacted concrete use for pavements is relatively recent and the technology is still evolving. The pavement consists of a relatively stiff mixture of aggregate, cementitious materials, and water, that is compacted by rollers and hardened into concrete.*

**Keywords:** Aggregates; cements; compaction; concrete construction; concrete durability; concrete pavements; consolidation; curing; construction joints; density; mixing; placing; Portland cement; roller compacted concrete, strength.

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**CHAPTER 1—INTRODUCTION**

This state-of-the-art report contains information on applications, material properties, mix proportioning, design, construction, and quality control procedures for roller compacted concrete pavements (RCCP). Roller compacted concrete (RCC) use for pavements is relatively recent and the technology is still evolving. Over the last ten years several major pavement projects have been constructed in North America using RCC and the performance of these pavements has generally been favorable. Roller compacted concrete pavements are also gaining acceptance in several European countries and Australia.

The advantages of using RCC include cost savings as a result of the construction method and the increased placement speed of the pavement. RCC pavements do not use dowels, steel reinforcement, or forms. This also results in significant savings when compared to the cost of conventionally constructed concrete pavements.

Roller compacted concrete is used in two general areas of engineered construction: dams and pavements. In this document, RCC will be discussed only in the context of its use in

pavements. RCC for mass concrete is discussed in ACI 207.5R.

Roller compacted concrete for pavements can be described as follows:

A relatively stiff mixture of aggregate [maximum size usually not larger than  $\frac{3}{4}$  in. (19 mm)], cementitious materials and water, that is compacted by vibratory rollers and hardened into concrete. When RCC is used as a surface course, a minimum compressive strength of 4000 psi (27.6 MPa) is generally specified.

The materials for RCC are blended in a mixing plant into a heterogeneous mass which has a consistency similar to damp gravel or zero slump concrete. It is placed in layers usually not greater than 10 in. (254 mm) compacted thickness, usually by an asphalt concrete paving machine. The layers are compacted with steel wheel vibratory rollers, with final compaction sometimes provided by rubber tire rollers. The pavement is cured with water or other means to provide a hard, durable surface. RCC pavements are usually designed to carry traffic directly on the finished surface. A wearing course is not normally used, although a hot mix asphalt overlay has been added, in some cases, for smoothness or rehabilitation. Transverse and longitudinal contraction joints for crack control are not usually constructed in RCC pavements.

RCCP has been used for a wide variety of applications. These include log sorting yards, lumber storage, forestry and mining haul roads, container intermodal yards, military vehicle roads and parking areas, bulk commodity (coal, wood chips) storage areas, truck and automobile parking, and to a lesser extent, municipal streets, secondary highways, and aircraft parking ramps.

**CHAPTER 2—BACKGROUND**

The first RCC pavement in North America was identified by the Seattle office of the U.S. Army Corps of Engineers. The project was a runway at Yakima, Washington, constructed around 1942. A form of roller compacted concrete paving was reported in Sweden as early as the 1930s.<sup>1</sup>

The first RCC pavement in Canada was built in 1976 at a log sorting yard at Caycuse on Vancouver Island, British Columbia. The decision to build RCC was the outgrowth of a pavement design which called for a 14 in. (356 mm) thick cement stabilized aggregate base and 2 in. (51 mm) asphalt concrete surface. As an alternative to the asphalt concrete surface, the owners decided to increase the cement content of the top 6 in. (152 mm) of cement stabilized material to 13 percent by weight to improve wear and freeze/thaw resistance. Cement content in the 8 in. (203 mm) base layer was set at 8 percent. The final result was a 4 acre (1.6 hectares) log sorting yard with an exposed, cement stabilized crushed gravel operating surface. No bonding grout was used between the two cement stabilized layers. Special effort was made by the contractor to complete both layers on the same day. Some minor delamination occurred after a few years of log stacker traffic. This observation led to the recommendation for a limitation on the maximum time between lifts. The

Caycuse Log Sorting yard has been in continuous use since 1976. The area of RCC pavement was doubled to 9 acres (3.6 hectares) in a 1978 expansion. A thin asphalt overlay was applied in 1987 as a minimum cost maintenance operation to improve pavement smoothness.

Following the success of the paving at Caycuse, three more RCC dry-land log sorting yards were built on Queen Charlotte Islands off the coast of British Columbia during 1976 to 1978. These pavements continue to perform well with little maintenance. By 1980 nearly 20 acres (8 hectares) of log sorting yards constructed with RCC were in operation in British Columbia. The next milestone in Canadian RCC pavement history came when a decision was made to build 12 miles (19.3 kilometers) of 7 in. (179 mm) thick RCC pavement for a coal mine haul road at Tumbler Ridge in British Columbia. A 4 acre (1.6 hectares) coal storage area was also built with a 9-in.-thick (229 mm) roller compacted concrete. The haul road was surfaced with bituminous concrete while the storage area remains as an exposed RCC pavement. This region of British Columbia undergoes severe winter conditions, with frost penetration to a depth of 8 ft (2.4 m). No distress from the severe winter climate is evident at the coal storage area, although some failures have occurred in the loaded wheel paths of the haul road.

While these developments were going on in Canada, there was growing interest in RCC by various organizations in the United States where RCC for dams was being evaluated in several test projects. During the early 1980s, engineers at the United States Army Corps of Engineers started studying the use of RCC for pavement construction at military facilities. A small test road for tracked vehicles, 9 in. to 13 in. (229 mm to 330 mm) thick, 470 yd<sup>2</sup> (392 m<sup>2</sup>) was built at Ft. Stewart, Georgia, in 1983, and a tank test road 10 in. to 13 in. (254 mm to 330 mm), 590 yd<sup>2</sup> (493 m<sup>2</sup>), was constructed at Ft. Gordon, Georgia, in the same year. RCC test road construction by the Corps of Engineers continued in 1984 when 1870 yd<sup>2</sup> (1564 m<sup>2</sup>) of 8.5 in. (216 mm) thick pavement was built for a tank trail at Ft. Lewis, Washington.

In 1984, the question of freeze/thaw durability of RCC remained to be addressed. The Corps of Engineers constructed a full scale test pavement at the Cold Regions Research Engineering Laboratory in Hanover, New Hampshire, where a complete range of climatic conditions could be simulated. The test program was successful, and in a memorandum to all field offices, dated Jan. 25, 1985, the use of RCC paving for "horizontal construction" was encouraged, where appropriate, for all facilities administered by the Corps of Engineers.<sup>2</sup>

The first full scale RCC pavement designed and built by the Corps of Engineers was a tactical equipment hardstand at Ft. Hood, Texas, in 1984.<sup>3</sup> The area of the project was 18,150 yd<sup>2</sup> (15,175 m<sup>2</sup>). A 10 in. (254 mm) thick slab was specified and a flexural strength of 800 psi (5.5 MPa) was achieved. This project provided the Corps of Engineers with valuable information about maximum aggregate size, single versus multiple lift construction methods, compaction procedures, curing and sampling of RCC material. During 1986, the Corps of Engineers built a tracked vehicle hardstand at Ft.

Lewis, Washington. The area of the pavement was 26,000 yd<sup>2</sup> (21,753 m<sup>2</sup>) with a thickness of 8.5 in. (216 mm).

The interest in RCC heavy duty pavement began to expand beyond the logging and mining industries by the mid-1980s. The Burlington Northern Railroad selected RCC for 53,000 yd<sup>2</sup> (44,313 m<sup>2</sup>) of paving at a new intermodal facility at Houston, Texas in 1985,<sup>4</sup> and 128,000 yd<sup>2</sup> (107,021 m<sup>2</sup>) of intermodal yard paving at Denver, Colorado, in 1986. In 1985 the Port of Tacoma, Washington, constructed two areas of RCC pavement totalling 17 acres (6.9 hectares).<sup>5,6</sup> Also, large areas of RCC pavement were constructed at the Conley and Moran Marine Terminals in Boston between 1986 and 1988.

The largest RCC pavement projects undertaken to date include the more than 650,000 yd<sup>2</sup> (543,464 m<sup>2</sup>) of 8 and 10 in.-(203 and 254 mm) thick RCC pavement placed at the General Motors Saturn automobile plant near Spring Hill, Tennessee, and 89 acres (36 hectares) of 10 in.-(254 mm) thick RCC pavement placed at Ft. Drum, NY. Both were constructed in 1988-89 and were used as parking areas and roads.

Apart from the reported use of RCC at Yakima, Washington, in 1942, the only example of an airport installation is at the Portland International Airport in 1985.<sup>7,8</sup> The 14-in. (356 mm) RCC pavement with an area of 9 acres (3.6 hectares) is used for overflow short term aircraft storage.

There has been a growing interest in the use of RCC paving for low to moderate traffic streets, and secondary highways. Municipal street pavements have been built in Portland, Oregon; Regina, Saskatchewan; and Mackenzie, British Columbia.

Fig. 2.1 to 2.4 illustrate typical RCC pavement practices. Fig. 2.5 illustrates typical RCC pavement surface at Ft. Drum, New York, and Fig. 2.6 shows a close-up of the pavement surface adjacent to a sawed longitudinal construction joint. Fig. 2.7 shows a close-up of an acceptable RCC pavement surface at Ft. Bliss, Texas, and Fig. 2.8 shows a close-up of an excellent RCC pavement surface.

## CHAPTER 3—MATERIALS

### 3.1—General

Pavement design strength, durability requirements, and intended application all influence the selection of materials for use in RCC pavement mixtures. The basic materials used to produce RCC include water, cementitious materials (cement and fly ash), and fine and coarse aggregates. Generally, the cost of materials selected for use in RCC pavements is almost the same as the cost of materials used in conventional portland cement concrete. However, some material savings may be possible due to the lower cement contents normally needed in RCC pavement mixtures to achieve strengths equivalent to those of conventional concrete.

### 3.2—Aggregates

The aggregates comprise approximately 75 to 85 percent of the volume of an RCC pavement mixture and can significantly affect both the fresh and hardened concrete



Fig. 2.1—RCC placement using modified asphalt pavers



Fig. 2.2—Vibratory roller compaction

properties. Proper selection of suitable aggregates will result in greater economy in construction and longer serviceability of RCC pavements. In freshly mixed RCC, aggregate properties affect the workability of a mixture and its potential to segregate and the ease with which it will properly consolidate under a vibratory roller. The strength, modulus of elasticity, thermal properties, and durability of the hardened concrete are also affected by the aggregate properties.

Aggregates used in RCC pavement mixtures contain both fine [finer than the 4.75 mm (No.4) sieve] and coarse frac-

tions, although the fractions may be preblended and stockpiled as a single aggregate on large projects. The coarse aggregate usually consists of crushed or uncrushed gravel, crushed stone, or a combination thereof. The fine aggregate may consist of natural sand, manufactured sand, or a combination of the two.

For high quality RCC, both the coarse and fine aggregate fractions should be composed of hard, durable particles and the quality of each should be evaluated by standard physical property tests such as those listed in ASTM C 33. If lower



Fig. 2.3—Rubber-tired roller compaction



Fig. 2.4—Fog curing of freshly placed RCC pavement

quality RCC is acceptable, then aggregates which do not meet established grading and quality requirements may be satisfactory as long as design criteria are met. RCC containing uncrushed gravel generally requires less water to attain a given consistency than that containing crushed gravel or stone. RCC containing crushed gravel or stone may require more effort to compact, and is less likely to segregate. It is also more stable during compaction and usually provides a higher flexural strength.

RCC mixtures are typically not as cohesive as conventional concrete and therefore, aggregate segregation is an important concern. Greater economy may be realized by using the largest practical nominal maximum size aggregate (NMSA). Increasing the NMSA reduces the void content of the aggregate and thereby reduces the paste requirement of a mixture. However, in order to minimize segregation during handling and placing of RCC and to provide a relatively smooth pavement surface texture, the NMSA should not exceed  $\frac{3}{4}$  in. (19



*Fig. 2.5—RCC pavement — Ft. Drum, New York*

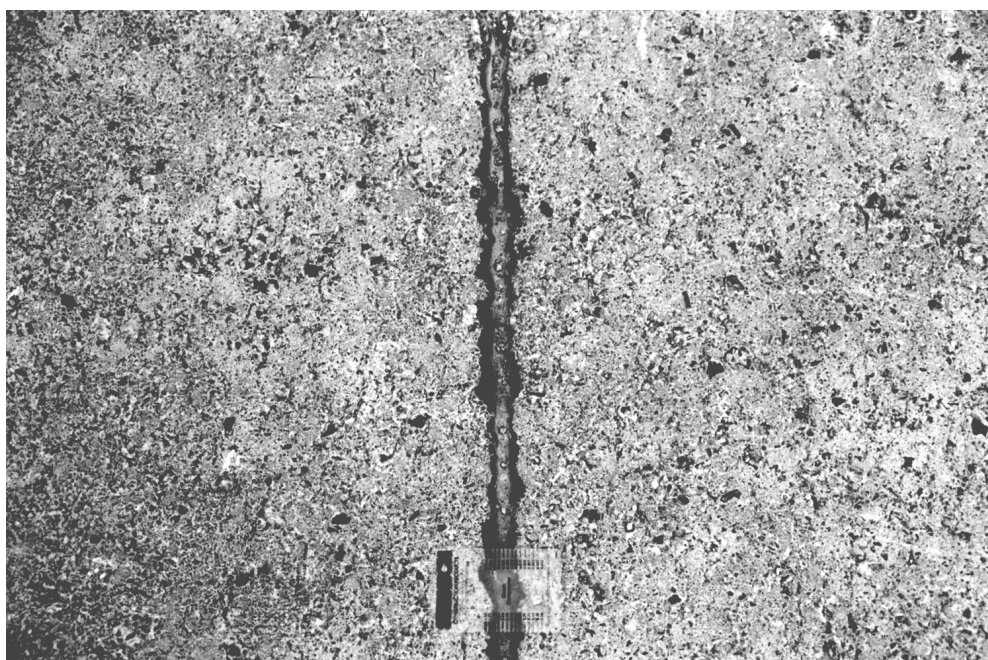


*Fig. 2.6—RCC pavement surface texture — Ft. Drum, New York*

mm). If the coarse and fine aggregate fractions are preblended and stockpiled as a single size group, segregation may make grading control difficult. Careful attention must be given to stockpile formation and subsequent handling of single-size group aggregate.

The range of aggregate gradings used in RCC pavement mixtures has included standard graded concrete aggregates having normal size separations to pit- or bank-run aggregate with little or no size separation. If longitudinal and transverse pavement smoothness are of importance, the coarse

and fine aggregates should be combined such that a well-graded aggregate blend is produced which approaches a maximum-density grading.

Grading limits that have been used to produce satisfactory RCC pavement mixtures are shown in Fig. 3.2. The use of aggregate fractions finer than the 75 micrometers (No. 200) sieve, if nonplastic, may be a beneficial means to reduce fine aggregate voids. However, their effect on the fresh and hardened RCC properties should be evaluated in the optimum proportioning study.

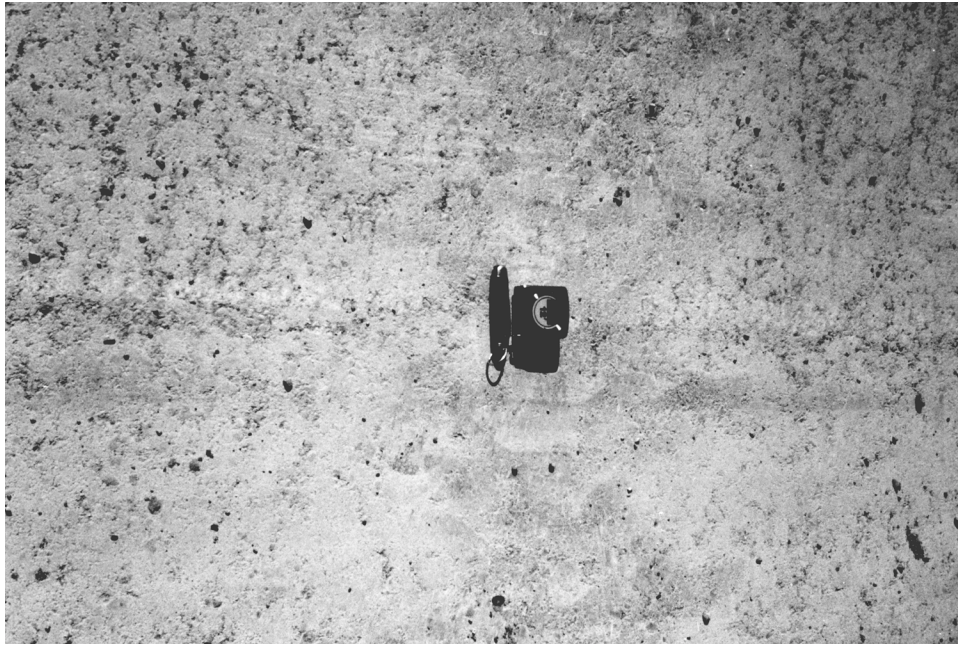


*Fig. 2.7—Acceptable RCC pavement surface — Ft. Bliss, Texas*



*Fig. 2.8—Excellent RCC pavement surface — Ft. Bliss, Texas*

### 3.3—Cementitious materials

Cementitious materials used in RCC pavement mixtures include portland cement or blended hydraulic cement, and may include pozzolan, or a ground granulated blast furnace slag. The selection of cement type should be based in part upon the design strength and the age at which this strength is required. In addition, applicable limits on chemical composition required for exposure conditions and alkali reactivity should follow standard concrete practice. A detailed discussion on the selection and use of hydraulic cements may be

found in ACI 225R. Many of the RCC pavements constructed to date have been constructed using Type I or II Portland cement and Class F or Class C fly ash.

The use of fly ash in RCC is an effective means of providing additional fine material needed to assure adequate compaction, particularly in those RCC mixtures that contain standard graded concrete fine aggregate. Fly ash contents generally range from 15 to 20 percent of the total volume of cementitious material. The selection of any pozzolan to use in RCC should be based on its conformance with applicable

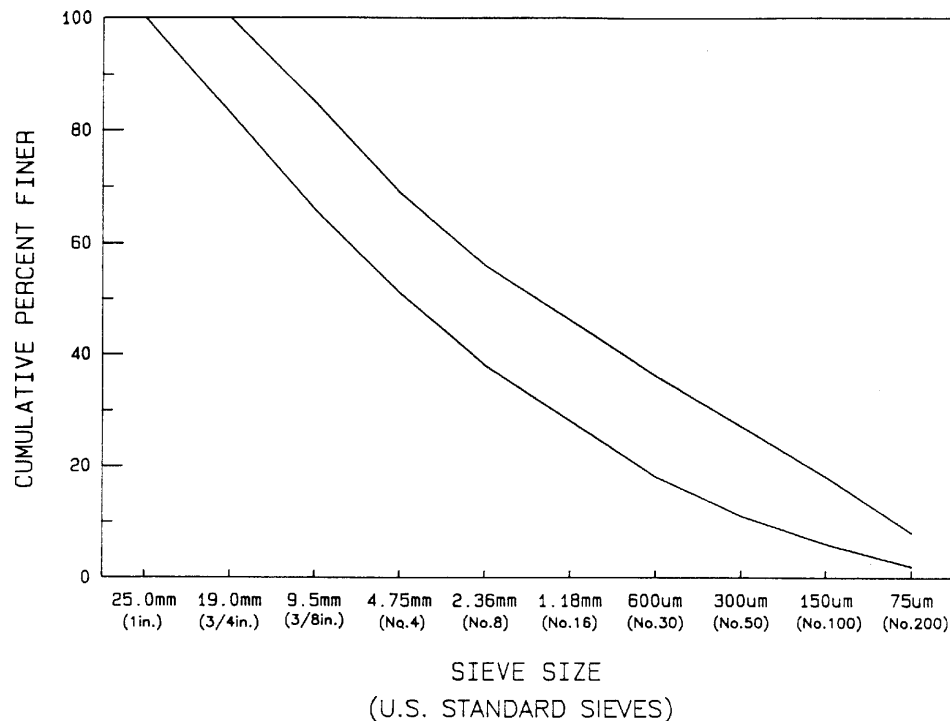


Fig. 3.2—Typical range of RCC pavement aggregate gradation

standards or specifications, its performance in concrete, and its availability at the project location. Guidance on the use of pozzolans and other finely divided mineral admixtures in concrete is given in ACI 226R.

### 3.4—Water

Water quality for RCC pavement is governed by the same requirements as for conventional concrete.

### 3.5—Admixtures

Air-entraining admixtures have had only limited use in RCC pavement mixtures. However, laboratory research has conducted at the U.S. Army Engineer Waterways Experiment Station has indicated that RCC pavement mixtures can be properly air-entrained using commercially available air-entraining admixtures at dosage rates 5 to 10 times greater than conventional concrete. The practicality of producing air-entrained RCC in the field has not yet been demonstrated. To date, minimizing frost damage in RCC has been achieved by proportioning mixtures with sufficiently low water-cementitious material ratios (w/c) so that the permeability of the paste is low. Once concrete has dried through self-desiccation, it is difficult to again become critically saturated by outside moisture. The use of proper compaction techniques which lower the entrapped air-void content, increase strength, and lower the permeability of the concrete should also improve the pavement's frost resistance. However, proper air-entrainment of RCC is the best way to assure adequate frost resistance.

Chemical admixtures, including water-reducing admixtures and retarding admixtures, have had only limited use in RCC, primarily in test sections and laboratory investigations. The ability of a water-reducing admixture to lower the

water requirements or to provide additional compatibility to an RCC mixture appears to be somewhat dependent on the amount and type of aggregate finer than the No. 200 (75- $\mu$ m) sieve. Retarding admixtures may be beneficial in delaying the setting time of the RCC so that it may be adequately compacted or so that the bond between adjacent lanes or succeeding layers is improved.

## CHAPTER 4—MIXTURE PROPORTIONING

### 4.1—General

RCC mixture proportioning procedures and properties differ from those used for conventional concrete due to the relatively stiff consistency of the fresh RCC and the use of unconventionally graded aggregates. The primary differences in proportions of RCC pavement mixtures and conventional concrete pavement mixtures are:

1. RCC is generally not air-entrained
2. RCC has a lower water content
3. RCC has a lower paste content
4. RCC generally requires a larger fine aggregate content in order to produce a combined aggregate that is well-graded and stable under the action of a vibratory roller
5. RCC usually has a NMSA not greater than  $\frac{3}{4}$ -in. (19 mm) in order to minimize segregation and produce a relatively smooth surface texture.

The relatively high cementitious material contents and high quality aggregates used in RCC distinguish it from soil cement and cement-treated base course. In order for RCC to be effectively consolidated, it must be dry enough to support the weight of a vibratory roller, yet wet enough to permit adequate distribution of the paste throughout the mixture during the mixing and compaction operations. Concrete suitable for

compaction with vibratory rollers differs significantly in appearance, in the unconsolidated state, from that of concrete having a measurable slump. There is little evidence of any paste in the mixture until it is consolidated. However, RCC mixtures should have sufficient paste volume to fill the internal voids in the aggregate mass. Several methods have been used to proportion RCC pavement mixtures. These methods can be placed into one of two broad categories:

- 1) proportioning by use of concrete consistency tests
- 2) proportioning by use of soil-compaction tests

#### 4.2—Proportioning by evaluation of consistency tests

This method essentially involves proportioning the RCC mixture for optimum workability at the required level of strength, using an apparatus such as the Vebe described in ACI 211.3. The Vebe apparatus has been modified by the Corps of Engineers and the Bureau of Reclamation in order to make it more suitable for use with RCC. It consists of a vibrating table of fixed frequency and amplitude, with a metal container having a volume of approximately 0.33 ft<sup>3</sup> (.0094 m<sup>3</sup>) securely attached to it. A representative sample of RCC is loosely placed in the container under a surcharge having a mass of 29.5 or 50 lb (13.3 or 22.7 kg), depending on which modified apparatus is selected. The measure of consistency is the time of vibration, in seconds, required to fully consolidate the concrete, as evidenced by the formation of a ring of mortar between the surcharge and the wall of the container. Although modified Vebe times of 20 to 30 seconds have been reported as appropriate for RCC containing 1½- to 3-in. (38 to 76 mm) NMSA and used in mass concrete applications, these times normally represent concrete that has a consistency too wet to properly place and compact in pavement applications.

Limited laboratory research indicates that modified Vebe times, as determined under a 50-lb (22.7 kg) surcharge, of 30 to 40 seconds are more appropriate for RCC pavement mixtures.<sup>9</sup> The modified Vebe time should be determined for a given RCC mixture and compared with the results of on-site compaction tests conducted on RCC compacted by vibratory rollers to determine if adjustments in the mixture proportions are necessary. The optimum modified Vebe time is influenced by the water content, NMSA, fine aggregate content, and the amount of aggregate finer than the 75 micrometers (No. 200) sieve. RCC mixtures containing more than approximately five percent aggregate finer than the No. 200 sieve may be difficult to accurately test using the modified Vebe apparatus, because the mortar in these mixtures is difficult to bring to the surface under vibration.

Mixture proportioning methods using consistency tests usually require fixing specific mixture parameters such as water content, cementitious materials content, or aggregate content, and then varying one parameter to obtain the desired level of consistency. In this way, each mixture parameter can be optimized to achieve the desired fresh and hardened RCC properties. One of the primary considerations when using the methods described in ACI 207.5R which, use consistency tests, is the proper selection of the ratio (*pv*) of the air-free volume of paste to the air-free volume of mortar. RCC pave-

ment mixtures should contain sufficient paste volumes to fill all internal voids between the aggregate particles. The *pv* affects both the compatibility of the mixture and the resulting surface texture of the pavement.

#### 4.3—Proportioning by soil compaction methods

Methods that use these tests involve establishing a relationship between dry or wet unit weight and moisture content of the RCC by compacting specimens over a range of moisture contents. It is similar to the method used to determine the relationship between the moisture content and the unit weight of soils and soil-aggregate mixtures. The apparatus and compactive effort used to fabricate the moisture-density specimens corresponds to that described in ASTM D 1557, Method D.

The cementitious material content is determined by the strength and durability requirements of the pavement, and is often expressed as a percentage of the dry total weight of materials (cementitious and aggregate). Cementitious material contents ranging from 10 to 17 percent by dry weight are typical for RCC pavement mixtures. This range corresponds to approximately 350 to 600 lb of cementitious material/yd<sup>3</sup> (208 to 356 kg/m<sup>3</sup>) of RCC.

The fine and coarse aggregates, as previously noted, are combined to create a well-graded blend. The unit volume of fine and coarse aggregate per unit volume of RCC may be calculated after the optimum moisture content of the RCC mixture is determined.

The optimum moisture content of the mixture is defined as the moisture content corresponding to the peak of the moisture content-density curve, and is dependent on the properties of the aggregates used and the cementitious material content. Strength loss will occur in a mixture that has a moisture content significantly below the optimum due to the presence of additional entrapped air voids. Strength loss will also occur in a mixture if the moisture content is significantly above the optimum due to an increase in the water-cementitious material ratio (*w/cm*). Moisture-density curves are normally established over a range of cementitious material contents in order to determine the minimum cementitious material content which will meet the design requirements. Moisture-density tests are conducted and a moisture-density curve is established for each cementitious material content-desired. Strength test specimens are then compacted at the optimum moisture content for each particular cementitious material content. From these tests, a curve of strength versus cementitious material content (or water-cementitious material ratio) is established to select the cementitious materials content.

#### 4.4—Fabrication of test specimens

Conventional concrete specimen fabrication procedures, such as those currently standardized by ASTM, cannot be used to fabricate RCC test specimens due to the stiff consistency of the concrete. Although a number of procedures have been used, none have yet been standardized. The procedures frequently used involve vibrating the fresh RCC in a vibrating table under a surcharge, or compacting the sample

with some type of compaction hammer following the procedures of ASTM D 1557.

For specimens compacted by vibration, the number of lifts used by various agencies has varied from one to three depending on the type of specimen. The surcharge has varied from 25 to 200 lb (11.3 to 90.7 kgs), or approximately 1 to 7 psi (0.0069 to 0.0483 MPa), again depending on the type of specimen. Complete compaction of RCC specimens may be difficult when using a vibrating table as evidenced by the fact that samples sawed or cored from RCC pavements sometimes have unit weights greater than those of fabricated specimens of similar age and moisture content. This incomplete specimen compaction in the laboratory may be particularly prevalent when a vibrating table is used that has a low amplitude when a surcharge is used. Vibrating tables used to date have included the Vebe table, those meeting the requirements of the relative density test for cohesionless soils (ASTM D 4253 and D 4254), and those meeting the requirements of ASTM C 192. Depending on the mixture proportions and the vibrating table available for use, it may be beneficial to produce trial batches at moisture contents slightly higher than optimum to facilitate compaction of the concrete.

Specimens compacted by means of a compaction hammer may have unit weights approximating those of samples taken from RCC pavements, however a significant number of blows may be required for adequate compaction. The number and height of the blows are normally maintained constant between specimens to achieve uniformity of results. Although compaction of cylinders may be feasible using a compaction hammer, uniform compaction of beam test spec-

imens for flexural strength with this method may be impractical.

ASTM Subcommittee C09.45 on Roller Compacted Concrete is developing procedures for fabricating laboratory test specimens for determination of unit weight and strength of concrete having consistency similar to that of roller compacted concrete.

## CHAPTER 5—ENGINEERING PROPERTIES

### 5.1—General

A review of the reported engineering properties of RCC indicates that they are similar to those of conventional paving concrete. Strength properties of RCC pavements are primarily dependent on the cementitious material content, aggregate quality and degree of compaction. Although RCC has been in use for paving for several years, only a limited number of investigations has been carried out to evaluate its engineering properties. Currently, no standard procedure exists for fabricating and testing RCC specimens in the laboratory. Therefore, it is not possible to directly compare properties of laboratory prepared “RCC” specimens without considering the procedures used to fabricate test specimens. As a result, the data base on engineering properties of RCC is based primarily on tests of specimens (cores and beams) obtained from actual paving projects or from a few full-scale test sections.

### 5.2—Compressive strength

Table 5.2.1 shows compressive strengths of cores obtained from Canadian projects after several years of service. This data is based on only a limited number of cores obtained from each project. Table 5.2.2 shows compressive strength of cores obtained from several U.S. projects. It is seen from Tables 5.2.1 that high compressive strengths can be achieved and that the strength levels are comparable to strength levels obtained for conventional concrete using similar cement contents.

### 5.3—Flexural strength

Because of the difficulty of obtaining sawed beam specimens from actual pavement sites, there is not much information available on flexural strength of RCC. Typical results from tests of sawed beams from selected RCC pavement projects are given in Table 5.3. These data are also based on a limited number of specimens obtained from each project.

**Table 5.2.1—RCC core compressive strengths for British Columbia projects<sup>10</sup>**

| Project                    | Age of core, years | Cement content, percent | Compressive strength, psi (MPa) |
|----------------------------|--------------------|-------------------------|---------------------------------|
| Caycuse log sort yard      | 4                  | 13, 8 <sup>1</sup>      | 4210 (29.0)                     |
| Caycuse log sort yard      | 8                  | 13                      | 5880 (40.5)                     |
| Lynterm container port     | 3                  | 8                       | 4690 (32.3)                     |
| Fraser Mills log sort yard | 1                  | 13                      | 4700 (32.4)                     |
| Bullmoose coal mine        | 1                  | 14 <sup>2</sup>         | 2200 (15.2)                     |
| Fraser surrey dock         | 1                  | 12                      | 4570 (31.5)                     |

Notes:

1. Two lift construction—top 6 in. (152 mm) lift with 13 percent cement content, bottom 8 in. (203 mm) lift with 8 percent content.

2. 50 percent cementitious content was natural pozzolan.

**Table 5.2.2—RCC core compressive strength results for several U.S. projects**

| Project | Age, months | Nominal lift thickness tested, in. (MPa) | Specified compressive strength, psi (MPa) at 28 days | Average compressive strength, psi (MPa) |                     |             |
|---------|-------------|------------------------------------------|------------------------------------------------------|-----------------------------------------|---------------------|-------------|
|         |             |                                          |                                                      | Top half of core                        | Bottom half of core | Uncut core  |
| A       | 9           | 7 (178)                                  | 4500 (31.0)                                          | 8120 (56.0)                             | 6350 (43.8)         | 6760 (46.6) |
| B       | 19          | 6.5 (165)                                | 5000 (34.5)                                          | —                                       | —                   | 4740 (32.7) |
| C       | 19          | 8.5 (216)                                | 5000 (34.5)                                          | 4330 (29.9)                             | 2450 (16.9)         | 4560 (31.4) |
| D       | 18          | 8.5 (216)                                | 3670 (25.3)                                          | —                                       | —                   | 7030 (48.5) |
| E       | 12          | 10 (254)                                 | 2000 (13.8)                                          | 2290 (15.8)                             | 4630 (31.9)         | —           |
| F       | 28          | 7 (178)                                  | 4500 (31.0)                                          | 5260 (32.3)                             | 4230 (29.2)         | —           |
| G       | 32          | 8.5 (216)                                | 5000 (34.5)                                          | 6890 (47.5)                             | 4910 (33.9)         | —           |

Source: Unpublished data, S. Tayabji.