U.S. Department
of Transportation
Federal Aviation Administration

Memorandum

Subject: **ACTION:** Engineering Brief No. 66,
Rubblized Portland Cement Concrete Base Course

Date: February 13, 2004

From: Manager, Airport Engineering Division, AAS-100

Reply to Attn. of: R. Joel

To: All Regions
Attn: Manager, Airports Division

Engineering Brief No. 66, *Rubblized Portland Cement Concrete Base Course*, copy attached, provides guidance and specifications for rubblization of existing Portland cement concrete pavements. This process has been employed in the pavement industry for many years with a recent initiative to expand into airfield applications. The in-place recycling process reduces the existing concrete pavement to a material comparable to an aggregate base course. Once the existing pavement is reduced, a new pavement surface course is constructed of either hot mix asphalt or Portland cement concrete.

One of the sited advantages of this process is the elimination of reflective cracking in asphalt overlays. Asphalt overlays placed directly onto existing Portland cement concrete pavements will reflect the joints and cracks which are present in the underlying concrete pavement. Once reflected into the asphalt overlay, these cracks represent a major maintenance concerns and are a known source of foreign object damage.

The enclosed specification may be considered for airfield use on a case-by-case basis and will require a modification to FAA Standards. Request for approval of the modification should include detailed project information regarding the existing pavement condition and the proposed pavement design.

Recommendations for improvement to this engineering brief are encouraged and should be furnished to: Manager, Airport Engineering Division, AAS-100, 800 Independence Ave., S.W., Washington, DC 20591.

Signed by

Rick Marinelli

attachment

ENGINEERING BRIEF NO. 66
RUBBLIZED PORTLAND CEMENT CONCRETE BASE COURSE

PURPOSE: The purpose of this engineering brief is to provide interim guidance on the use of fractured slab technology where existing Portland cement concrete (PCC) pavements are fractured into small pieces and used as base or subbase material for new flexible or rigid pavement sections. Information provided in this brief was provided by industry representatives and the Air Force Civil Engineering Support Agency (AFCESA).

When used in a flexible pavement section, the intent of rubblizing existing concrete pavement is to prevent reflective cracks typically associated with Hot Mix Asphalt (HMA) overlays placed directly on existing PCC pavements. Reflective cracking is prevented by obliteration of the existing pavement distresses and the destruction of the existing slab action.

When used in a rigid pavement section, the rubblized layer is intended to provide a uniform subbase for the PCC surface.

DEFINITION: Rubblization – is the process of fracturing PCC pavements into small pieces thereby destroying any slab action. The rubblization process fractures the existing PCC into a coarse granular type base or subbase. The process is intended to produce pieces of uniform gradation throughout the fractured concrete.

BACKGROUND: The rubblizing process is one fracture slab technique that has been researched in the mid-eighties and implemented in the early nineties by the Asphalt Institute (AI) and the National Asphalt Pavement Association (NAPA). Additional fracture slab technologies include breaking/seating on reinforced PCC and cracking/seating on non-reinforced PCC. Other techniques used to eliminate reflective cracking when PCC pavements are overlaid with HMA include saw-cut/seal and crack relief layers. Additional technical information on the use of these techniques, including evaluation, selection of appropriate techniques, design considerations and construction methods are provided in AI's MS-17 manual and NAPA's report 117.

AREAS OF USE: Rubblization with HMA overlay may be considered for all airfield applications provided the design requirements of AC 150/5320-6 (current version) are met. Of particular interest is the restriction of paragraph 312b which precludes the design of sandwich construction. Rubblization and overlay of a rigid pavement with a stabilized subbase is questionable as to whether or not the final section creates a sandwiched layer. Research performed by proponents of the resonant breaker equipment indicates that the rubblized layer may be essentially impermeable with the exception of a permeable zone at the top of the rubblized layer. Properly drained, the rubblized concrete should perform satisfactorily over typical stabilized subbase materials.

Rubblized layers are not to be considered as stabilized base materials. This limitation will restrict the use of rubblization techniques where stabilized bases are required. Relief from this restriction may be requested on a case-by-case basis under the guidance provided in paragraph 320 of AC 150/5320-6D. Validation of material qualities must be provided.

Pavements that have extensive cracking, faulting, or rocking slabs and need repair or replacement are good candidates for rubblization. If the pavement has an existing subgrade moisture problem, the problem must be addressed and a satisfactory solution provided if the rubblization process is to be successful. To be considered for rubblization, the pavement needs to have an existing subbase or subgrade of sufficient quality to allow proper rubblization of the existing concrete.

ADVANTAGES OF RUBBLIZATION: Rubblization and overlay with HMA can be performed quickly and typically at a lower cost than conventional removal and replacement. Environmental concerns may be minimized since there is no need to haul materials to or from the construction site. The process does not produce a waste product which would require offsite disposal.

Rubblization converts the PCC pavement into a compatible flexible base having an appropriate modulus for a flexible base. This tight angular interlocked material provides a stable material that is not susceptible to moisture damage. The material can be classified as a frost free material.

Once an airfield pavement is rehabilitated using rubblization and a HMA overlay, future upgrades can be performed in accordance with conventional flexible pavement design techniques.

EQUIPMENT: Resonant Breaker and Multi-Head Breaker machines are the two basic types of equipment used to rubblized concrete pavements. Equipment requirements are described in the attached specification. Rubblization equipment is shown in Figures 1 and 2.

Resonant Breaker. Various models of the resonant breaker exist. Some models have an 18-inch (450 mm) wide beam and a smaller breaking foot, 6 to 7 inches (150 to 175 mm), with smaller counter weights. Other models have beams varying in size up to 26 inches (650 mm) with breaking shoes up to 12 inches (300 mm). Counter weights range from 12,000 to 20,000 pounds (5440 to 9066kg) in increments of 4000 pounds (1815 kg). Resonant breaker equipment has successfully rubblized PCC pavements up to 26 inches (650 mm) thick. Typical production rates per machine are 6000-8000 square yards per day.

As the gross weight of a resonant breaker can be significant, it is important to protect the freshly rubblized material from being overloaded by the repetitive operations of the breaker. Light duty pavement or pavement with soft subgrades or high water tables may require that special flotation tires be used on the breaker to avoid damaging the rubblized and underlying layers. The resonant breaker machine in Figure 1 has been equipped with flotation tires for reduction of tire pressure on the rubblized material.

Multi-Head Breaker. A typical multi-head breaker is a rubber-tired, self-propelled unit which carries 1,000 to 1,500 pound hammers mounted laterally in pairs. Half of the hammers are in a forward row and the remainder diagonally offset in a rear row so that there is continuous breakage from side to side. Each pair of hammers is attached to a hydraulic lift cylinder which operates as an independent unit. Each unit can develop between 1,000 and 8,000 foot pounds of energy depending upon drop height selected. The units can cycle at a rate of 30 to 35 impacts per minute. The typical machine is eight foot wide and carries twelve hammers eight inches in width. An extension wing, carrying two 1,500 pound hammers, can be added to each side for a total breaking width of up to 13 feet. Pavement breaking can be as narrow as 2.67 feet or increased in increments up to 13 feet. Typical production rates per machine are 6000-8000 square yards per day.

Multi-head breakers can be teamed with guillotine breakers to rubblized very thick pavements. The guillotine breaker pre-fractures the existing pavements and allows the multi-head breaker to complete the rubblization process.

RESULTING MATERIAL PROPERTIES: By fracturing the existing PCC into a coarse granular material, the rubblization process reduces the properties (reduces stiffness) of the existing PCC to be compatible with a HMA overlay. Rubblizing a PCC pavement makes its modulus compatible with an HMA modulus and eliminates most of the following types of distresses in both the PCC and HMA overlay.

- Reflective Cracking
- Loss of Bonding/Raveling
- Moisture Damage in HMA
- Rough Riding/Faulting

FACTORS AFFECTING PARTICLE SIZE: Rubblized pavement resembles a tightly interlocked puzzle with a noticeable increase in particle size towards the bottom of the layer. Major factors affecting particle size with the rubblizing process are:

1) **Thickness and quality of the PCC.** Particle size of the rubblized material will vary with depth in the rubblized layer. Particles in the upper 2-4 inches (50-100 mm) of the rubblized layer generally ranges from sand size up to about 3 inches (75 mm). The lower portion of the slab is a fractured semi-solid layer. Maximum specified particle size should be no greater than 1.25 times the slab thickness. For most airfield applications, the largest particle size desired is 12 to 15 inches.

2) **Type of reinforcement.** Heavy reinforcement will absorb some of the energy which results in larger pieces below the reinforcement.

3) **Equipment being used.** The resonant frequency breaker fractures the slab at approximately 30 to 45 degrees from the surface as it moves forward resulting in various particle sizes. Multi-head breakers may fracture at a similar angle or a near vertical angle depending upon support conditions. Due to the angle of fracture thicker slabs will inherently have larger pieces on the lower portion.

4) **Condition and type of subbase and subgrade materials.** Horizontal or layered cracking may occur on pavements with a soft subbase or high voids under the existing slabs. These pavements may also result in larger fractured pieces due to the lack of support. If horizontal cracking is observed, additional measures to improve the subbase support prior to rubblization must be employed.

PREPARATION OF THE PAVEMENT SURFACE. For the rubblization equipment to properly transmit the energy required to fracture the existing PCC pavement, the equipment must come into direct contact with the PCC. All asphaltic overlays and/or patches must be removed prior to rubblizing the underlying concrete.

EXISTING STRUCTURES: Underground utilities and stabilized subbase materials need to be protected during the rubblization process. Construction specifications typically require that the contractors operate their equipment in such a manner as to not damage existing features. It is then the responsibility of the contractor to modify their operations to protect identified features. Multi-head hammers may require reduced impact loads or altered impact patterns to avoid damaging underlying features. Proponents of the resonant breaker process report that underground utilities and existing subbase layers are not affected by the high frequency energy applied to the rubblization process. It is proposed that the discontinuity between the rigid slab and the underlying feature dissipates the resonant energy imparted to the slab. Operated correctly, both the resonant beaker and the multi-head hammer equipment can be used safely.

Another common specification is to isolate the underground features and prevent rubblization equipment from operating directly over the feature. This means assures that the equipment does not contact the pavement directly above the feature in question. The isolation requirement is typically a full depth saw cut around the feature to prevent impact and vibration damage.

In-pavement fixtures such as drainage inlets or electrical fixtures must be addressed during the project design. Isolation of the fixtures or removal and replacement may be required during the rubblization process. Electrical conduits must be addressed and protected if present.

DRAINAGE SYSTEMS: Some or all of the rubblized material is generally considered permeable and requires that sub-drain systems be installed to allow removal of water which may accumulate in the permeable portion of the rubblized material. It is recommended that an appropriate drainage system be installed prior to the rubblization process. Sufficient time should be allowed for moisture to drain ahead of the rubblization action to dry the subbase and subgrade. As the rubblization process starts, additional water may be seen exiting the outlets due to the rubblization process and vibratory rolling. A recommended drainage system is shown in Figure 3. The drainage system is intended to drain free water that may enter the rubblized pavement from the pavement surface and entrapped water from the base or subgrade. The perimeter of the drainage trench is wrapped in an appropriate filter fabric.

Construction inspection of the drainage system before and after rubblization may be done with video cameras and laser grade checking devices to make sure the system is properly installed. In the past, improper construction and grade control appeared to be weak links of this system.

RELIEF TRENCHES: When a resonant breaker is used, relief trenches may be required as the rubblization process expands the rubblized PCC horizontally. Fractured slab expansion may be accommodated by existing wide cracks and joints which are often adequate to carry the expansion without a relief trench. Smaller resonant machines will require relief trenches more often than larger breakers. The need for trenching depends largely on the size of the machine being used and the slab thickness. Thicker slabs are more likely to require relief trenches. When trenching is required, it usually occurs at a 30 to 40 foot interval. In most cases the larger machines will not require relief trenches. If trenches are required, they should be in accordance with the attached specification. See Figure 4 for an example. The need for a relief trench can be realized when a slab is no longer taking the impact energy. The hammer and anvil effect is being demonstrated; i.e. the hammer begins bouncing on the surface as a result of the reflected energy. This need can be verified by digging a test pit. Relief trenches are not necessary when using the multi-head breaking equipment.

TEST PITS: Test pit procedures as described in the attached guide specifications are used to check the finished product. Test pits can be difficult to excavate and will require proper replacement. Figure 5 depicts a typical test pit excavation.

DESIGN PROCEDURES: Design of new rigid pavement sections over rubblized material may be performed in accordance with standard design procedures of AC 150/5320-6D, *Airport Pavement Design and Evaluation.* Figure 2-4 from the AC may be used to determine the effective k-value on top of the rubblized layer. Whether the rubblized layer is treated as a well-graded crushed aggregate or a bank-run sand and gravel depends upon the anticipated properties of the rubblized material. In most instances, the material will be equal to or better than a well-graded crushed aggregate. The designer should evaluate the sensitivity of the design thickness to these parameters and whether or not rounding of the final thickness affects this decision.

Existing flexible design procedures can be used in the selection of the HMA overlay thickness. An evaluation of the rubblized material by a non-destructive testing procedure is the best approach; however this data cannot be made available up front in the design process. A limited amount of testing on airfield pavements has been done. There has been a considerable amount of data collected at various levels of highway design. Advisory Circular 150/5320-6D can be used to design the overlay. The procedures of Chapter 3, Chapter 5, or Chapter 7 may be used for the design with the exception that a minimum 4 inch asphalt surface course is required for pavements designed for aircraft with gross weights less than 30,000 pounds and a minimum 5 inch asphalt surface course is required for all other pavements. (NOTE: Chapter 7 will be introduced with Change 3 to the AC) Both procedures require a realistic estimate of strength parameters (modulus or CBR value) of the rubblized material. For layered elastic design procedures, the Asphalt Institute provides guidance in their MS-17 manual and recommends the following design formula, which was developed from the NAPA study in highway design for a 95% design reliability factor:

Design Modulus = Average Modulus – 1.645 (S_t) **Equation 1**

Where S_t = one standard deviation

Average Modulus = the arithmetic average of the data

Rubblized pavements modulus have been found to vary from a low of 30 ksi to over 300 ksi depending on the original pavement thickness, base type and condition of base layers. Pavements that are less than 9 inches (225 mm) and have marginal bases and subgrade conditions will be at the low end of the modulus range. Thicker pavements over 9 inches with good bases or stabilized bases have shown much higher modulus values. Pavements constructed by pre WW II methods typically have low modulus values. The idea in rubblization is to have a lower design modulus on the rubblized PCC than the HMA. The particle size and whether any steel reinforcement remains bonded are factors in the modulus value. The larger size fractions will produce a higher modulus, but too large results in reflective cracking.

When strength parameters are unknown, it is a fair assumption that most rubblized material will perform equal to or better than FAA standard Item P-209. Unless additional project specific information is available, a one-to-one substitution should be used in the design procedures provided that sufficient subgrade conditions exist to allow proper rubblization.

LEVELING COURSE: The rubblized surface can not be trimmed or fine graded with a motor grader as the moldboard will catch on larger pieces and roll them up, dislodging an area of the rubblized surface. Rather, it may be necessary to place a leveling course on top of the rubblized layer to accommodate grade and profile corrections. Successful leveling courses have included Item P-209 or Item P401 materials with specified nominal depths. Leveling course can be accounted into the design provided the minimum anticipated thickness is used. Minor modifications to the attached specifications will be necessary to account for placement of a leveling course.

TRAFFIC CONTROL: Excessive heavy construction traffic may cause a reduction in modulus by breaking down the interlock. After the rubblized material has been prepared and surface rolled, precautions should be taken to minimize construction traffic on the facility until the HMA is applied.

ECONOMIC CONSIDERATIONS: Rubblization of an existing rigid pavement structure may or may not be an economically superior design alternative. In addition to assuring that structural requirements are met, the designer should consider how the rubblization process affects the cost of the completed pavement. In many cases, the HMA overlay thickness may be significant due to weak subgrade conditions and relatively thin rubblized layers. In such cases, other design alternates such as an unbonded rigid overlay or thinner HMA overlays on non rubblized pavement may prove structurally and economically equal or superior.

Figure 1. Resonant Breaker Machine

Figure 2. Multi-Head Breaker Machine

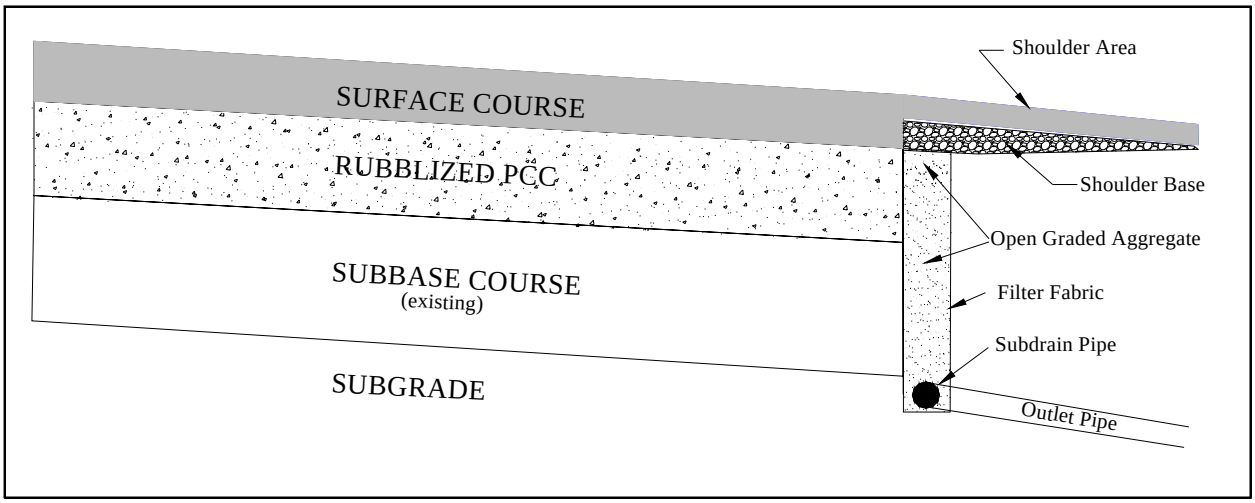

Figure 3. Typical Drainage System

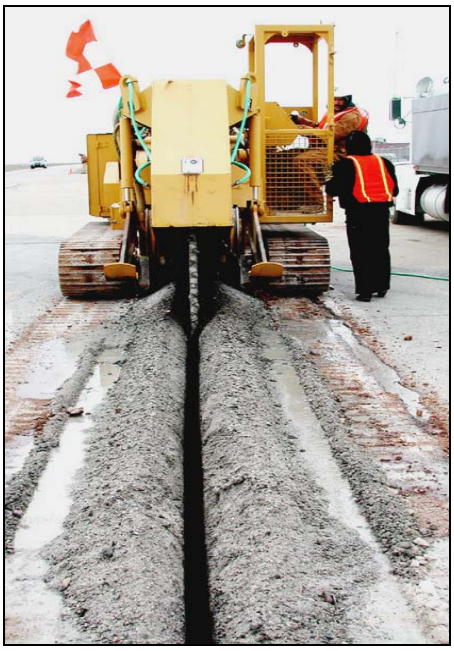

Figure 4. Relief Trench

Figure 5. Inspection Test Pit

Original Signed by
Rodney Joel

Rodney Joel, P.E.
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ITEM P-215 BASE COURSE FROM RUBBLIZED CONCRETE PAVEMENTS

DESCRIPTION

215-1.1 GENERAL DESCRIPTION. This work consists of rubblizing and seating (rolling) the existing Portland cement concrete (PCC) pavement prior to placing a new bituminous concrete or PCC pavement. The work shall be accomplished in accordance with the standard specifications and details shown in the plans.

MATERIALS

215-2.1 GENERAL. Only approved materials, conforming to the requirements of these specifications, shall be used in the work. They may be subjected to inspection and tests at any time during the progress of their preparation or use. The source of supply of each of the materials shall be approved by the Engineer before delivery or use is started. Representative preliminary samples of the materials shall be submitted by the Contractor, when required, for examination and test. Materials shall be stored and handled to insure the preservation of their quality and fitness for use and shall be located to facilitate prompt inspection. All equipment for handling and transporting materials and concrete must be clean before any material or concrete is placed therein.

215-2.2 PLANT MIX BITUMINOUS CONCRETE. Bituminous concrete for patching will be as described in Specification P-401. The weight in tons of the bituminous concrete patching material actually used in the work shall be determined in accordance with Item P-401.

215-2.3 CRUSHED AGGREGATE BASE. Aggregate base course for patching will be as described in Specification P-209. The weight in tons of the aggregate base course patching material actually used in the work shall be determined in accordance with Item P-209.

215-2.4 UNCLASSIFIED EXCAVATION. Unclassified excavation for patching will be the volume of materials removed in accordance with Specification P-152. The volume of material will be determined in accordance with Item P-152.

CONSTRUCTION METHODS

215-3.1 GENERAL. The Contractor shall furnish all labor, materials, and services necessary for, and incidental to, the completion of all work as shown on the drawings and specified herein. All machinery and equipment owned or controlled by the Contractor, which he proposes to use on the work, shall be of sufficient size to meet the requirements of the work, and shall be such as to produce satisfactory work; all work shall be subject to the inspection and approval of the Engineer.

215-3.2 RUBBLIZATION AND SEATING EQUIPMENT. Rubblization shall be accomplished by the use of a pavement breaker machine that is capable of delivering sufficient energy to rubblize the pavement full-depth in a manner that completely destroys the concrete slab and all slab action. Sufficient seating equipment shall be used to thoroughly settle the rubblized concrete and to provide a smooth surface for the bituminous concrete overlay. The type of rubblization machine and the minimum types of associated rolling equipment used in the rubblization process shall be either the resonant breaker process or the multi-header breaker

process. If necessary to achieve rubblization size requirements, Contractor may pre-fracture with a guillotine breaking device.

215-3.3 RESONANT BREAKER PROCESS.

215-3.3.1 Resonant Breaker Machine. This is a self-contained, self-propelled resonant frequency breaker specifically designed for the purpose of rubblizing PCC pavement. The machine shall be capable of producing low-amplitude (25 millimeters [1 inch] maximum) blows of 8.9 kilonewtons (2000 pounds force), and delivering blows to the existing PCC surface at a rate of not less than 44 cycles per second. If necessary, the breaker shall be equipped with a screen to protect nearby structures, vehicles or aircraft from flying chips during the fracturing process.

215-3.3.2 Resonant Breaker Seating Equipment. The contractor shall provide and use a smooth double steel drum vibratory roller. The roller shall have a gross weight of at least 9.1 metric tons (10 tons), and be operated in the high frequency low amplitude vibratory mode, to settle and seat the rubblized pavement and provide a smooth surface for the bituminous concrete overlay.

215-3.4 MULTI-HEAD BREAKER PROCESS.

215-3.4.1 Multi-Head Breaker Machine. This is a self-contained, self-propelled multi-head breaker specifically designed for the purpose of rubblizing PCC pavement. The machine shall be capable of rubblizing the pavement a minimum width of 3.9 meters (13 feet) per pass. Pavement-breaking hammers shall be mounted laterally in pairs, with half the hammers in a forward row and the remainder diagonally offset in a rear row so there is continuous breakage from side to side. The lift height of the hammers shall be independently adjustable. If necessary, the breaker shall be equipped with a screen to protect vehicles from flying chips during the fracturing process.

215-3.4.2 Multi-Head Breaker Seating Equipment.

215-3.4.2.1 The contractor shall provide and use the following seating equipment:

215-3.4.2.1.1 Z-Grid Roller. This is a vibratory steel drum roller fitted with a "Z" pattern grid on the drum face. The roller shall have a gross weight of at least 9.1 metric tons (10 tons), as operated in the vibratory mode, to settle and seat the rubblized pavement, and provide a smooth surface for the bituminous concrete overlay.

215-3.4.2.1.2 Pneumatic-Tire Roller. A pneumatic-tire roller with a gross weight of at least 22.7 metric tons (__tons) shall be used after the Z-grid roller to further settle and seat the rubblized pavement.

*** Engineer’s Note: A 10 ton pneumatic roller is typically specified for PCC pavements with thicknesses ranging from 8 to 12 inches. A larger roller (up to 25 tons) may be required to properly seat rubblized material resulting from very thick pavements. A smaller pneumatic tire roller may be necessary for use on light duty pavements or pavement with very poor subgrades.***

215-3.4.2.1.3 Smooth Steel Drum Vibratory Roller. The contractor shall provide and use a smooth steel drum vibratory roller. The roller shall have a gross weight of at least 9.1 metric tons (10 tons) as operated in the vibratory mode, to settle and seat the rubblized pavement and provide a smooth surface for the bituminous concrete overlay.

215-3.4.2.2 Rubblization machines and rollers of other design that will accomplish similar results may also be used with the approval of the Engineer. All rubblization and seating equipment necessary to perform the work will be considered essential to the completion of the project, and will not be paid for separately.

215-3.5 CONSTRUCTION REQUIREMENTS.

215-3.5.1 Preparation Prior to Rubblization.

215-3.5.1.1 Drainage System Installation. Prior to rubblization operations, drainage systems as specified on the plans shall be installed. Drainage systems shall be properly functioning for a minimum of two weeks prior to rubblization.

215-3.5.1.2 Removal of Existing Asphalt Surfaces. Prior to the rubblization operations, existing asphalt overlays and patches shall be removed from the PCC pavement surfaces to be rubblized. Existing full-depth asphalt patches shall remain in place, unless directed for removal by the Engineer.

215-3.5.1.3 Saw-Cut Joints. A new full-depth saw-cut joint shall be made along an existing joint at all pavements where rubblized PCC abuts pavement that will remain in place. All load transfer devices between the planned rubblization and PCC pavement remaining in place shall be severed.

215-3.5.1.4 Shouldering. Shoulder adjustments and/or any pavement widening shall be completed up to the elevation of the existing pavement grade prior to beginning the rubblization operations. These areas can be used to support the rubblization machines while the existing PCC pavement is being rubblized.

215- 3.5.2 Test Strip and Test Pit to Establish Procedure.

215-3.5.2.1 Test Strip. Before the rubblization operations begin, the Engineer will designate a test section of approximately 50 meters by 3.6 meters (150 feet by 12 feet). The contractor shall rubblize the test section using varying degrees of energy and/or various striking heights until a procedure is established that will rubblize the pavement to the required extent as contained in these specifications.

215-3.5.2.2 Test Pit. A 1.2-meter (4-foot) square test pit shall be excavated in the middle of the test strip, at a location selected by the Engineer, to determine that the breaker is producing pieces of the specified sizes as contained in these specifications. The rubblized particle sizes shall be checked throughout the entire depth of the pavement. The test pit material shall be removed from the project and the hole filled using coarse aggregate material as determined by the Engineer. The replacement material shall be placed and properly compacted by the contractor.

215-3.5.2.3 The Engineer and the contractor shall mutually agree upon the rubblization procedure based upon compliance with the performance criteria contained herewithin. The established procedure shall be used to rubblize the remainder of the pavement. The contractor shall continuously monitor the rubblization operation, and make minor adjustments in the striking pattern, striking energy, number of passes, and other factors necessary to continually achieve acceptable breaking throughout the project. The contractor shall inform the Engineer of any major adjustments that may be required in the process to provide rubblized pavement that conforms to the specification requirements contained herein. Additional test pits may be required by the Engineer to confirm that the PCC pavement is adequately rubblized.

215-3.6 RUBBLIZATION CRITERIA.

215-3.6.1 The existing concrete pavement shall be rubblized into particles with at least 75% (as determined by visual observation) particles smaller than: 75 millimeters (3 inches) at surface; 300 millimeters (12 inches) in bottom half. For reinforced Portland cement concrete (RPCC) pavement, the reinforcing steel shall be substantially debonded from the concrete and left in place, unless protruding above the surface. Concrete pieces below the reinforcing steel shall be reduced to the greatest possible extent, and no individual piece shall exceed 380 millimeters (15 inches) in any dimension.

215-3.6.2 Due to lack of edge support, concrete pieces below the reinforcing steel up to 380 millimeters (15 inches) in any dimension will be accepted along the outside edge of the existing PCC pavement, up to 380 millimeters (15 inches) from the edge.

215-3.7 GENERAL RUBBLIZATION PROCEDURES.

215-3.7.1 The rubblization shall be done in partial widths when necessary to maintain traffic as shown on the plans and contained in the contract documents.

215-3.7.2 When the rubblization process is adjacent to active pavement, measures shall be taken to prevent debris from entering the active pavement.

215-3.7.3 In areas where the pavement is to be overlayed prior to completion of the rubblization, the initial rubblization will extend a minimum of 2 feet (600mm) beyond the width of the pavement to be overlayed.

215-3.7.4 For the resonant breaker process, rubblizing shall begin at a free edge or previously broken edge and progress toward the opposite shoulder or longitudinal centerline of the pavement. Continuous coverage of the entire PCC pavement surface, overlapped if necessary to achieve adequate rubblization with the breaking shoe, shall be required. Additional passes of the resonant breaker machine may be required if larger concrete pieces remain above the reinforcement.

215-3.8 DUST CONTROL. The contractor shall minimize the dispersion of dust from the rubblization operation until the rubblized surface is overlayed with bituminous concrete. The contractor shall provide a water truck, operator, and all water necessary for dust-control purposes. Excessive water shall not be applied to the rubblized surface. Dust control is incidental to the

rubblization process and will not be paid for separately. The Engineer shall approve dust-mitigation measures.

215-3.9 DAMAGE TO BASE, UNDERLYING STRUCTURES, AND OTHER FACILITIES. The rubblization machine and rollers shall be operated in a manner that will avoid damaging the base, underlying structures, utilities, drainage facilities, bridge approach slabs, bridge decks, and other facilities on the project. If any damage occurs, the contractor shall immediately cease his operations, notify the Engineer, and repair the damage at the direction of the Engineer. Repairs shall be made in a timely manner and at the expense of the contractor.

215-3.10 REMOVAL OF EXPOSED REINFORCING STEEL. Reinforcing steel in the rubblized pavement, if any, shall generally be left in place. Reinforcing steel that becomes exposed at the surface during the rubblization process or rolling operations shall be cut flush with the rubblized surface, or slightly below the surface, and removed from the project by the contractor. The contractor shall also remove any loose joint filler, expansion materials, or other similar items.

215-3.11 SEATING PROCEDURES.

215-3.11.1 The contractor shall use the rolling equipment contained in these specifications as described below.

215-3.11.1.1 Resonant Breaker Process. The rubblized PCC pavement shall be rolled with a minimum of three passes over the entire width of the pavement with a vibratory steel drum roller. For this operation, a pass is defined as forward and back over the entire surface area. The Engineer may require additional passes to satisfactorily seat the rubblized pavement and provide a smooth surface that is ready for the bituminous concrete overlay. The roller shall be operated at a speed not to exceed 1.8 meters (6 feet) per second.

215-3.11.1.2 Multi-Head Breaker Process.

215-3.11.1.2.1 Prior to placing the bituminous concrete overlay, the entire width of the pavement shall be rolled by vibratory and pneumatic-tire rollers following the sequence contained herein. For this operation, a pass is defined as forward and back over the entire surface area.

215-3.11.1.2.1.1 After rubblizing, a minimum of two passes with the Z-grid roller shall follow the multi-head breaker machine, followed by a minimum of one pass with the pneumatic-tire roller.

215-3.11.1.2.1.2 Immediately prior to bituminous concrete overlay, roll a minimum of one pass with the vibratory steel drum roller.

215-3.11.1.2.2 The Engineer may require additional passes of the rolling equipment to satisfactorily compact the rubblized pavement and provide a smooth surface that is ready for the bituminous concrete overlay. Additional rolling at the direction of the Engineer shall be considered incidental to the work, and will not be paid for separately. Rolling should not be performed in wet conditions.

215-3.12 UNSTABLE AREA PATCHING.

215-3.12.1 If unstable areas occur because of expansion of the existing concrete pavement, they shall be removed to a maximum length of 1.2 meter (4 feet) in length by 3.6 meters (12 feet) in width and replaced with full-depth bituminous concrete (patching) at the direction of the Engineer. Patching procedures shall conform to the standard specifications, and shall be completed prior to placing the bituminous concrete overlay. Patching will be paid for as a separate bid item as provided in the appropriate Specification Item.

215-3.12.2 Areas of poor subgrade support that are identified during the rubblization and seating process shall be patched at the direction of the Engineer. Generally, the rubblized pavement, base course, and subgrade material will be removed from unstable areas. The material will be replaced with aggregate base course or hot mix asphalt as directed and compacted in lifts as required in the standard specifications.

215-3.13 PROGRESS OF THE WORK. In no instance shall more than 48 hours elapse between rubblizing the pavement and the placement of the bituminous concrete overlay. If rain occurs between these operations, this time limitation may be waived to allow sufficient time for the rubblized pavement to dry to the satisfaction of the Engineer.

METHOD OF MEASUREMENT

215-4.1 MEASUREMENT. Rubblization of concrete pavement will be measured by the square yard.

BASIS OF PAYMENT

215-5.2 CONCRETE PAVEMENT RUBBLIZATION. This item shall include full compensation for rubblizing the existing PCC pavement, rolling the pavement, and for all equipment, tools, labor and incidentals necessary to complete the work. In addition, this item shall include full compensation for all labor, equipment, tools, and incidentals necessary to furnish and apply water for dust control, provide test sections and test pits, saw-cut joints, cut and remove exposed concrete reinforcing material, remove joint filler and other debris, cleanup, waste removal and disposal, and preparation of the rubblized surface prior to the bituminous concrete overlay.

Payment will be made under:

Item P-215-5.2 Rubblization - per square yard

End of Item P-215