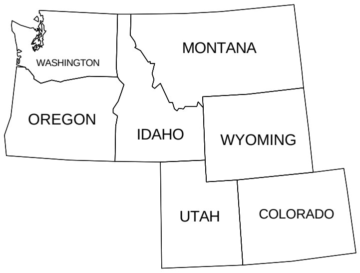

FEDERAL AVIATION ADMINISTRATION
NORTHWEST MOUNTAIN REGION

CONSTRUCTION MANUAL FOR AIRPORT PAVEMENTS

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May 1999

PAVEMENT CONSTRUCTION MANUAL

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PAVEMENT CONSTRUCTION MANUAL

I. INTRODUCTION.

The objective in constructing any pavement is to provide a pavement satisfying design criteria and possessing such uniform characteristics of quality that it will have maximum serviceable life with minimum maintenance. This objective may be achieved only through detailed attention to each step in the construction of a pavement.

Quality management of pavement construction is essential to prevent failure of pavements and/or high maintenance costs. The control of the quality and the production is the responsibility of the contractor and the assurance of the quality is the responsibility of the inspector and owner. Many times one inspector is responsible for a number of contracts or features of one contract, which may be under construction at the same time. The inspector should be thoroughly familiar with all provisions of the contract documents, including submittals.

The objective of this manual is to alert the inspector to those items during pavement construction that are important, to make him/her aware of contractor deficiencies that do occur, and to provide information necessary to insure that pavement quality is satisfactory. This manual provides guidance on most aspects of pavement construction from subgrade through asphalt concrete or Portland cement concrete. This manual is not intended to take the place of other technical publications or contract specifications, but to provide additional information that should be helpful to the inspector to insure that a quality project is obtained. In case of conflict between this manual and the contract specifications, the contract specifications will govern.

II. SUBGRADE, SUBBASE, and BASE.

A. Introduction.

The subgrade is the in-situ soil on which a pavement section is constructed. Subbase and base courses are higher quality materials having greater strength that are placed over the subgrade to protect it from being overloaded when subjected to traffic. Drainage of the subgrade and bases is essential during construction and for the life and strength of the section. The surfaces should always be sloped to drain and not contain pockets where water will pond.

The underlying materials for flexible pavements must be dense enough to prevent significant additional densification when subjected to traffic and must be strong enough to support stresses imposed on it. The design of a flexible pavement considers the density and strength of each layer and establishes minimum thickness requirements for each layer. It is up to the inspector to insure that plans and specifications are complied with so that the design density and strength are obtained resulting in satisfactory pavement performance.

For flexible pavements, the California Bearing Ratio (CBR) is a measure of strength of the unbound pavement layers. For fine grained soils, such as silts or clays, this is measured in the laboratory. For coarse-grained materials and for subbase and base course materials, the CBR value is assigned based on the aggregate grading, plasticity index, and density. Deviation from the specification requirements will often result in a CBR value lower than that used in design possibly leading to early failure of the pavement. The inspector must insure that the aggregate grading, plasticity index, and density stay within specification requirements to assure satisfactory performance.

For rigid pavements, the modulus of subgrade reaction (K) is used to measure the strength of the underlying pavement layers. The K value is determined by the plate bearing test. Many times the design of rigid pavements includes a base course to prevent pumping of the underlying subgrade, support paving equipment, and/or to reduce the thickness of concrete required. The K value is determined for the base course and a composite K value is computed for designing the thickness of Portland Cement Concrete. If the gradation of the base course deviates from the specifications, the base course may not prevent pumping of the subgrade material through the base course. If the gradation or density does not meet specification requirements, the K value may be reduced below the design value resulting in inadequate pavement strength.

B. Subgrade Construction.

In subgrade construction, it is necessary to insure that the subgrade is built to the proper grade and smoothness and to insure that the density requirements are met. Frost susceptible materials are critically dependent on grade and uniformity to prevent differential frost heave. For airfield pavements, the finished grade is normally measured on a 16-foot grid. Any areas that do not meet the allowable tolerance should be reworked until all tolerances are met, otherwise deficiencies may result in poor pavement performance.

Normally, for subgrade construction, blue-tops are used to insure that grade is met. The material is bladed with a motor-patrol to obtain satisfactory grade. After the grade and density requirements are satisfied, the blue-tops should be removed and the area adjacent to the blue-tops should be rolled until density requirements are met. It is important to remove blue-tops to allow for compaction in these areas and to prevent migration of the blue-tops toward the surface after the pavement is constructed. These stakes will migrate through thinner surface courses such as P-609 (surface treatment). This migration is normally caused by freezing and thawing of the underlying materials. Failure to obtain satisfactory density adjacent to blue-tops will result in settlement due to densification under traffic and result in a rough surface.

Depending on the type of soil, a compaction may be accomplished with a number of roller types. Sheepsfoot rollers are good for fine grained (cohesive) soils while vibratory rollers are good for cohesionless soils. Rubber tire rollers are good for most soils; however, soft soils may rut excessively when rolled with a rubber tire roller. The tire pressure may require adjustment to obtain optimum results. Static steel wheel rollers are useful in smoothing out the subgrade surface.

During construction, the water must be at or near optimum to get satisfactory compaction. Standard specifications usually require moisture to be within +-2% of optimum. For fine grained soils, a high water content may result in pumping of the material being compacted. This pumping action is caused by excess pore water pressure building up underneath the rollers which can actually break down the material being compacted. The subgrade may require stabilization to provide satisfactory performance. The subgrade materials should never be placed or compacted frozen.

Expansive soils should normally be compacted approximately 2 percent above optimum and the maximum density determined in accordance with ASTM D 698. If any expansive soils are encountered, it is advisable to have a soils engineer, experienced and familiar with expansive soils, onsite and/or available. Common design procedures include removing up to 5 feet of soil and replacing with non-expansive, impermeable material or subexcavating and thoroughly mixing with other non-expansive native materials. Cut areas in expansive materials require particular attention since the overburden has been removed which allows dramatic movement.

The items an inspector should look for during subgrade construction are included in the checklist section.

C. Subbase and Base Course Construction.

Placement and compaction of subbase and base course materials are similar to that for subgrades; however, materials for subbase and base courses are usually brought to the site from another location. Subbase and base courses contain coarse-grained material and provide more strength than subgrade materials. A pavement is designed to be progressively stronger as each additional layer is constructed. For this reason, the subbase should be stronger than the subgrade and the base course should be stronger than the subbase. The purpose of the subbase and base course for flexible pavements is to distribute the load over a wide area so that the stress applied at any point in the pavement does not exceed the allowable stress at that point. Although base courses have little effect on the thickness of a PCC section, they are required, in many cases, to provide frost protection and a stable platform for construction equipment.

Density and water content are important to insure that adequate strength is obtained. With coarse-grained materials, the material should be saturated for optimum compaction. Most materials, however, have enough fine grained materials in the mixture to prevent free drainage of water and these mixtures should be compacted at optimum water content as determined from the moisture-density relationship. The optimum water content in the field may vary slightly from that determined in the laboratory depending on the type of equipment used. This difference in optimum water content is caused by differences in compactive effort between the laboratory and field and variation in soil type.

Pavement layers composed of crushed aggregate particles provide higher strength than pavement layers composed of uncrushed particles. Base course materials are typically required to be crushed because of the strength required near the pavement surface. Some base course specifications require 100% fractured faces on one side (reference is made to the asphaltic concrete section for a discussion of the process). Testing should be conducted to insure the material meets specifications. Visual observations should also be made by the inspector to determine if the aggregate particles are sufficiently crushed. When it appears that the aggregate does not meet the requirement for crushed faces, the inspector should request additional testing. If it does not meet the specification requirements, the contractor should take steps to correct the problem.

The gradation of the aggregate is important to insure adequate strength and to prevent damage due to frost. The amount of material passing the No. 200 sieve (and 0.02 mm size in some specifications) must be controlled within acceptable limits to prevent frost damage. Free draining base courses are often used to prevent frost damage caused by build up of water in the pavement system. If the aggregate gradation is not accurately controlled, the base course may not be free draining resulting in accumulation of water and build up of pore water pressure under traffic and / or frost damage resulting in premature pavement failure. Degradation often occurs during handling and compaction of the materials. The in-place, after compaction, gradation is the acceptance that the inspector should test.

The Atterberg Limits are useful in controlling the quality of subbase or base course materials. A high plasticity index (PI) is an indication that the material contains too much clay to be suitable in the pavement structure. A high PI may indicate that the material will shrink or swell excessively during changes in water content.

Subbase and base course materials should be stabilized if required by design to improve strength and durability. Asphalt or Portland cement is normally used to stabilize the types of materials used in subbase and base courses. Care should be taken when using Portland cement to insure that too much compressive strength is not attained and result in reflective pavement cracking.

Stabilized subbase and base course materials are normally mixed in a pugmill where the water content and cement can be closely controlled. This method results in a better controlled product and is normally required for airfield pavement rather than mixed in-place material.

Subbase and base course materials can be placed by a number of methods including: motor-grader, jersey-spreader, and asphalt paver. Base course trimmers are also being used to attain accurate grades and smoothness. Each of these methods have advantages and disadvantages that make them acceptable or unacceptable for a number of applications.

The motor-grader is usually used for grading the subgrade material to the desired grade and sometimes for placing subbase and base courses. The motor-grader has the advantage of being able to work in areas having odd shapes and it can be used to grade and shape in-place materials. Disadvantages of the motor-grader include the requirement that the operator has to be very good to prepare a satisfactory grade and segregation of the materials often occur when working the materials back and forth. Elevations should be taken prior to and after grading to insure that the desired grade and thickness is being obtained. Blue-tops are normally used to mark the amount of material to be added or removed. Compaction must be accomplished during the grading process to insure that the final grade is acceptable after compaction. After the desired grade and density have been obtained, the blue-tops should be removed and the material compacted in the location of the blue-tops. Many minor problems have occurred in the past with pavement performance due to inadequate density adjacent to the blue-tops.

The jersey-spreader has been used for placing subbase and base course materials. It does a good job of placing the material to the desired grade; however, segregation at the longitudinal joints is often a problem.

The asphalt paver is the best method for placing pavement materials. It does a very good job of placing the materials to the desired grade and segregation is not a problem, if the paver is operated correctly.

Base course trimmers are used to trim the base to an accurate grade. They are normally used after initial compaction but prior to final compaction. A stringline grade control is normally used to control the trimmer grade. The trimmers tend to segregate the coarser aggregate from the surface, so the gradation samples should be taken from the in-place material.

During construction of the various pavement layers, it is essential that provisions be made for surface drainage of water. During construction, the slope must be maintained to drain water from the area of construction. (The use of a prime coat will help prevent intrusion of water into the unbound layers.) When satisfactory drainage is not provided, rainfall can significantly damage the in-place unbound material resulting in delays in construction and often the necessity to repair must of the in-place material.

For coarse-grained materials, vibratory rollers, rubber tire rollers, and static steel wheel rollers are often used. With some materials, the vibratory roller can be used alone to obtain compaction and a smooth even surface. The rubber tire roller does impart a kneading action to the soil resulting in a tight dense surface.

Density of the in-place material is normally determined by nuclear gage, balloon-method, or sand-cone method. The nuclear gage is fast and can provide an accurate measurement of density if calibrated correctly. The back-scatter method does not provide as accurate results as the probe-type (direct transmission). The balloon and sand-cone are the preferred methods for measuring in-place densities. Larger than average particles will interfere with the readings of the nuclear gage. If the operator is not careful, this machine can become out of calibration. Continuous calibration of the gage is required for all projects that are being controlled with a nuclear gage to insure that the gage continues to provide accurate readings.

The grade and smoothness must be checked on each layer being constructed to insure that the grade and smoothness of the finished pavement surface is satisfactory. The surface smoothness of the top of the base courses will be partially reflected in an asphaltic concrete surface. A high grade in the underlying pavement layers even when within allowable tolerances may result in reduced thicknesses of the upper layers or increased final elevation. To minimize this problem, the grade of underlying layers should not exceed the specified grade. The grade of these layers should be equal to, or slightly lower (with tolerance), than the specified grades.

Proof-rolling is often required after completion of construction of the base course on many airfield pavements. It is essential that the proof-roller have the specified weight and tire pressure and apply the specified number of coverages. The proof-roller is used to locate soft spots and to provide additional density in the unbound layers to insure satisfactory performance.

III. ASPHALT CONCRETE.

A. Introduction.

Asphalt concrete (AC) is a mixture of asphalt cement and well-graded, high quality aggregate, thoroughly compacted to provide a stable, watertight mixture. Asphalt concrete provides a resilient, waterproof, load distributing medium that protects the base course against water and traffic. The flexibility of asphalt concrete permits minor adjustments in the pavement surface due to traffic loads and active soils without detrimental effects. Asphalt concrete is not as resistant to heat and blast effects from jet aircraft nor to fuel spillage.

B. Cold Milling Existing AC.

Cold milling of existing asphalt is often done to match existing grades, remove a layer down to delaminated surface, leveling the surface, or for other reasons. The cold milling machine rotates the teeth with an upward stroke so the materials fails in tension. Milling within 1 inch from the bottom of a lift or an unbonded layer will result in the random sections of asphalt being removed between the mill line and the bottom. The milled material may be used in a recycled mix, blended with at least 50% virgin base course material, or it can be stabilized and used as base course. The material should not be used as a base without stabilization or with normal compaction techniques to avoid possible long-term deformation. **Heat-planers** (or heater-scarifier) should never be used on pavements since they heat the asphalt to uncontrolled temperatures and cause premature oxidation. Heat-planers are not permitted to be used in many areas due to the air pollution caused by their use.

C. Prime and Tack Coats.

Prime coats are used on aggregate base courses for airfield pavements. Prime coats will provide bond to the base course and protection from the weather or traffic. The prime coat, when an emulsion is used on a dense graded base course, will not penetrate into the base and pickup on tires and equipment tracks.

Tack coats are required for pavement overlays to bond the new asphalt with the existing pavement. Emulsions are the most common and less expensive. Emulsions require warmer weather and a longer time for the water to evaporate off (break) to begin paving. Tack coats on the other hand can be used for less desirable weather conditions. Some areas do not permit cutbacks to be used since their volatiles are hydrocarbons. Harder grade asphalts should be used for tack coats on airfields.

Prime and tack coats should be re-applied if they become weathered or dirty.

D. Material Properties and Significance.

1. Density. Density of the asphalt concrete is required to produce a stable mixture that is waterproof and durable. If satisfactory density is not obtained in the mixture, sudden failure may occur in some cases or a gradual failure over a long period of time may occur due to densification under traffic or durability problems such as oxidation and raveling.

Density is important to insure that the voids in the total mixture are within an acceptable range. Studies have shown that a mixture generally becomes unstable when the air voids in the in-place mixture are approximately 3 percent or lower. Studies have also shown that asphalt concrete becomes permeable to water when the air voids exceed approximately 8 percent. Most mixtures are designed to have 3-5 percent air voids in the laboratory compacted samples.

Field density is required to be at least 98 percent of the laboratory density. Leveling courses are difficult to achieve 98 percent compaction due to inconsistent lift thicknesses. Density sampling in these areas should be done with this in mind so as to not penalize the contractor for inconsistencies beyond control.

Standard laboratory compaction has been developed to provide a density in the laboratory equal to the density that would be expected in the field. A minimum of two laboratory compacted samples are to be averaged to determine the standard laboratory density. On each side of the sample, 50 blows with a Marshall hammer (10-lb. hammer with 18-inch drop) should be used for low pressure tires (less than 100 psi), while 75 blows with the hammer on each side of the sample should be used for high tire pressure (greater than 100 psi). Generally 50 blows are used for lighter general aviation airports and non-aircraft roads and 75 blows are used for heavy airfield pavement.

The same type of Marshall hammer that is used for mix design is used to compact samples for control of mixture during construction. There can be a significant difference in density obtained with a mechanical hammer and that obtained with a manual hammer. The manual hammer is specified in the test procedure; however, a mechanical type is most common. If a mechanical hammer is used, it should be calibrated to give the same density as that which would be obtained with a manual hammer. When calibrating the mechanical hammer, at least 5 samples should be compacted with the manual hammer (50 or 75 blows as specified). Five samples each should also be compacted at various blow counts and plotted as shown on Figure 1. Where the lines intersect is the number of blows to be used by the mechanical hammer.

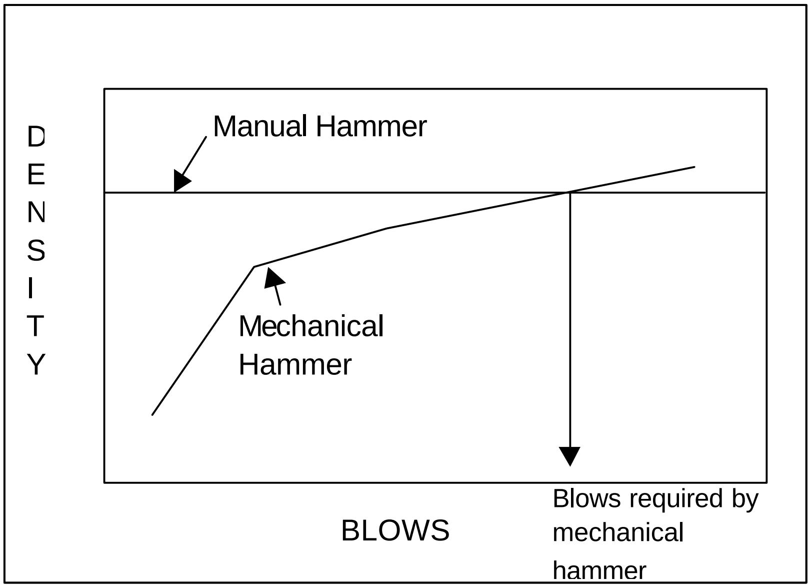

Figure 1

This should be done for each mix design. It is also important that a guide to control the vertical axis of the hammer not be used during compaction.

2. Grade of Asphalt. The asphalt grade will be specified in the project specifications. Asphalt cements are classified by one of four methods: penetration, viscosity, viscosity of asphalt after rolling thin film oven test, or Superpave binders. Penetration graded asphalt cements include 40-50, 60-70, 85-100, 120-150, and 200-300 grades. Viscosity graded asphalt cements include AC-2.5, AC-5, AC-10, AC-20, AC-30, and AC-40 grades. Asphalt cement graded by "Aged Residue" (AR) from the rolling thin film oven test include AR-1000, AR-2000, AR-4000, AR-8000, and AR-16000 grades. Most asphalt concrete project specifications require a viscosity graded asphalt cement be used. Some projects, generally in the Northwest United States, will use the AR graded asphalt cements. A few scattered projects continue to use penetration graded asphalt cements. The most recent specifications for asphalt cements is the use of Superpave binders. These binders are expected to perform better in hot and cold conditions. Latex or “rubber” (styrene butadiene) can also be added to the asphalt cement (2%) successfully and will retard oxidation and minimize stripping of some aggregates, by providing an increase in film thickness. The latex additive is required for all porous friction course (PFC) pavements.

A viscosity / temperature should be obtained from the asphalt supplier for each lot of cement. Figure 2 is an example of this curve. The temperature of the asphalt at 170 centistokes will result in the ideal mixing temperature to provide adequate film thickness. The temperature at 280 centistokes is the ideal compaction temperature. The asphalts with flatter slopes on this curve are less susceptible to thermal cracking. Some projects are specifying specific viscosity relationships to temperatures.

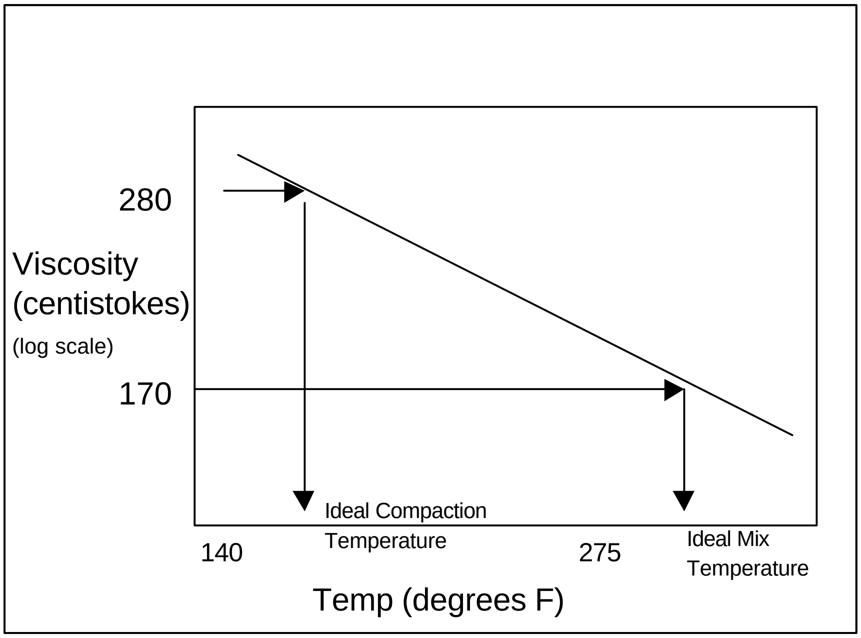

Figure 2

Generally, the softer asphalts, such as AC-2.5, AC-5, 200-300 pen, 120-150 pen, AR-1000, and AR-2000, are used in colder climates. These asphalt cements are softer than normal and provide better performance during cold weather. Since these asphalts are relatively soft, the temperature during placement will be lower than normal. As an example, an AC-5 may be placed and compacted at approximately 260 degrees F, and an AC-20 may be placed and compacted at approximately 285 degrees F. (These temperatures are typical of what might be used but are certainly not absolute.) Many factors must be considered when selecting an optimum mixture temperature for an asphalt concrete project. It is also important to know the viscosity of recycled asphalt cement. This is used to proportionally predict the viscosity of the new asphalt required. The best way to achieve the specified viscosity is by using a softer asphalt, but rejuvenating agent should only be used as a last result.

3. Aggregate Quality. The best measure of aggregate quality is a record of past performance. Aggregate sources that have performed well in the past should perform well in the future. There are a number of tests that can be used to evaluate aggregate quality. The Los Angeles Abrasive Test (ASTM C 131) is used to measure the abrasion resistance of aggregates. Aggregates that fail to meet this test may break down during handling, mixing, compaction or under traffic resulting in overall poor performance of the asphalt concrete. This test is conducted prior to the start of the project and would not normally be conducted during the project unless the aggregate source changes.

Another aggregate test that is often used is the Sulfate Soundness test (ASTM C 88). This test is not widely accepted by the asphalt paving industry, but it does sometimes allow the designer to screen out known unsatisfactory materials with this test. This test should be conducted prior to start of work and should not be conducted again unless required due to a change in aggregate source.

Some aggregates (usually with high silica contents) are prone to stripping. Additives can sometimes be used in the asphalt cement to minimize the effect. Past experience with the aggregate (history) should be considered and the immersion-compression test (ASTM D 1075) can be conducted to check for the stripping potential.

Particle shape and angularity of aggregates are important factors in insuring satisfactory pavement performance. Some aggregates tend to crush into flat and elongated particles. Shape of aggregate can sometimes be improved by changing types of crushers used in the crushing operation or by changing feed rate. Flat and elongated particles in asphalt mixtures usually result in the mixture requiring more asphalt for optimum performance. The flat and elongated particles cause the mix to be difficult to place and compact. Tearing and pulling of the mixture often results in an undesirable surface texture when using these types of aggregates.

Many asphalt concrete pavement mixtures perform poorly because improperly crushed aggregate was used in production of the mixture. It is often difficult to obtain satisfactorily crushed aggregates when using gravel. In many cases, the aggregate is small in size to begin with and additional crushing results in even smaller particle sizes. The best method to insure that the aggregate is satisfactorily crushed is to remove all material finer than the desired maximum size aggregate prior to crushing. For instance, assume that a crushing operation is set up to produce a 3/4-inch maximum size aggregate. All material smaller than 3/4-inch should be removed (and wasted) initially by screening and the material larger than 3/4-inch should be crushed. The owner is usually not involved in the crushing operation but simple tests can be conducted to insure that the aggregate has been properly crushed. The aggregates can be visually inspected to insure that they meet the specification requirements for crushed faces. A mix composed of improperly crushed aggregate may present a number of problems, including difficult to compact, lack of stability, low skid resistance, and loss of adhesion between asphalt and aggregates.

Porous aggregates often cause problems in determining optimum asphalt content and in performance of asphalt concrete mixtures. Highly absorptive aggregates tend to absorb asphalt at a rate depending in part on temperature of mixture and time that mixture is held at the higher temperature. Variations in asphalt absorption are detrimental since the optimum asphalt content is a function of the amount of asphalt absorbed into the aggregate. Another problem often encountered when using absorptive aggregate is the variability in porosity of the aggregate. The source of aggregate needs to have a consistent porosity and not vary from location to location within the rock source being quarried. Normally, any aggregate having less than 2.5% absorption is considered nonabsorptive and that having more than 2.5% is considered absorptive. The specific gravity test is conducted (Rice method) during the mix design and once or twice per week during construction. When blend sands are used that have a different specific gravity than the other aggregates, this test should be conducted more often especially if variations occur in the blend.

4. Aggregate Gradation. The aggregate used in asphalt concrete must be well graded to provide necessary aggregate interlock to provide satisfactory performance. All sizes from coarse to fine should be contained in the asphalt mixture. A 3/4-inch maximum aggregate size provides higher stability and improved skid resistance. The finer aggregate size provides a tighter pavement surface and can be used in placing thinner lifts, but will have lower stabilities. (The lift thickness should be at least twice as thick as the maximum aggregate size.)

The amount of material passing the No. 200 sieve greatly affects the properties of an asphalt concrete mixture. An increase in the amount of material passing the No. 200 sieve usually results in a lower optimum asphalt content and higher stability at optimum asphalt content. The higher stability is believed to be temporary. This decrease in asphalt content usually results in a loss of durability in the mixture. On the other hand, a decrease in the amount of materials passing the No. 200 sieve usually results in a higher optimum asphalt content and lower stability. Mixtures having a high percentage of material passing the No. 200 sieve are normally more sensitive than other mixtures to a change in asphalt content.

The amount of natural sand used in an asphalt mixture must be limited to insure a satisfactory project. Natural sand is often rounded causing a reduction in mixture stability if excess is used. Natural sands also often contain organic material and clay balls making it undesirable for use. The specifications for airfields normally limit the amount of natural sand to no more than 20 percent of the total aggregate. Another problem that can occur with natural sand is less bond between the sand and the asphalt cement. Natural sand has to be added to some mixes to lower the stabilities and make it easier to compact.

5. Marshall Stability. The Marshall Stability test is used as a rough measure of the mixture stability under loads. There is not a good correlation between Marshall stability and stability of an in-place asphalt concrete subjected to traffic. The Marshall Stability test is used as one parameter in determining the optimum asphalt content. It is also useful during construction as a tool to evaluate control of the asphalt mixture. For instance, a change in Marshall Stability from one test to another may be indicative of a change in aggregate gradation, asphalt content, or some other mix property that otherwise may go undetected. The Marshall Stability test is conducted at 140 degrees F since this is the highest temperature to which most asphalt concrete pavements will be subjected to during the life of the pavement.

The Marshall Stability test should not be conducted on cores cut from in-place pavement. This test should only be conducted on laboratory compacted samples. Since Marshall Stability is related to density, the stability value measured from a core from in-place pavement will normally be significantly lower than that measured on laboratory compacted samples. Mixes with high stabilities (exceeding 2500) become difficult to compact and are not desirable.

6. Flow. The flow value is measured during conduct of the stability test. The flow, which is reported in 0.01 inches, is a measure of the vertical deformation of an asphalt concrete core from the time load is applied to the sample until it fails. For most mixtures, the flow will be within the range of 8 and 20.

The flow can be used as a general indication of a brittle mixture or an unstable mixture. A mixture having a flow value less than 8 is often considered to be brittle, while a mixture having a flow value greater than 16 is likely to be unstable for airfields, and greater than 20 is likely to be unstable for lighter general aviation and roads. The flow is used to help select optimum asphalt content and should be monitored during construction.

7. Voids in Total Mix (VTM). The VTM is a measure of the volume of air in an asphalt concrete mixture expressed as a percentage of the total volume. This is critical for the durability of the mix. Voids less than 3% will rut under traffic and greater than 8% will deteriorate more rapidly. The mix should be designed with a void content between 3 to 5%. This will assure proper void content when compacted to 98% of the design mix. Another term that is often used is voids in the mineral aggregate (VMA). The VMA is a characteristic of the aggregate gradation. The VMA is equal to the VTM plus the percent of asphalt cement by volume. When the VTM is too high, the mix will be stiff and the mixture will have low durability. When the VTM is too low, the mixture will be unstable under traffic and may present bleeding problems. The VTM is controlled by selecting the correct amount of asphalt cement.

8. Voids Filled with Asphalt. The amount of voids filled with asphalt is equal to the volume of asphalt (in percent of total volume) divided by VMA. The amount of voids filled is inversely proportional to the VTM. A high percent of voids filled indicates an unstable mixture that may tend to bleed while a low percent of voids filled is typical of a stiff mixture having low durability.

E. Mix Design

The selection of optimum asphalt content is one of the most important steps to insure a quality product is obtained. When the steps are followed in the Asphalt Institute Manual MS-2 to select optimum asphalt content, a mix will be selected that provides the needed stability in hot weather and the desired durability in all environmental conditions assuming satisfactory aggregate and asphalt cement are used.

A mix design should be developed for all asphalt concrete projects. The mix design must be developed to assure that the aggregate and asphalt cement are satisfactory, an acceptable aggregate gradation can be produced, and satisfactory mixture properties are produced. The mix design should indicate the proportion of each aggregate and asphalt cement. The mixture properties such as unit weight, stability, flow, voids in total mix, and voids filled with asphalt should also be reported.

It is important to remember that the optimum asphalt content is determined based on aggregate and asphalt samples sent to the laboratory. The aggregate samples often do not closely represent the aggregate in the field due to poor sampling techniques or other problems. Suitable aggregate and asphalt cement samples must be obtained for conducting a suitable mix design. Provisions should be made to modify the mix design based on field conditions otherwise a mixture may be produced with too much or too little asphalt resulting in poor pavement performance.

F. Asphalt Plants.

Asphalt plants should have the capability of heating the materials to the required temperature, adding the correct proportions of each material to the mixture, and properly mixing the materials. There are two types of plants are “batch” and “continuous.” The two types of mixers used are “drum” and “pugmill.” All of these plants can produce a satisfactory mixture if properly used. Rescreening of the aggregate is performed in the continuous mix and batch plant, therefore, some small amount of variation in the cold feeder and stockpiles can be tolerated without adversely affecting the mixture quality. Care should be taken with all plants to minimize segregation of materials in the stockpiles.

The cold feeder should be calibrated for all plant types so that the amount of material (adjusted for water content) being fed from each feeder is known. This is essential for feeding the proper proportions of each material into the mixture. To properly calibrate a belt scale on continuous plant, a known length of the belt should be swept clean, material weighed, and calculated with the speed.

It is essential that the inspector routinely inspect the asphalt plant. By visual observation, the inspector can evaluate the stockpiles for contamination such as clay balls, crushed faces, segregation, and intermingling of stockpiles. These items are very important and difficult to evaluate after the materials have been mixed and hauled to the job site.

Another item that can be observed at the plant is the condition of the truck beds prior to being filled with asphalt. Many times the beds are not satisfactorily cleaned out after hauling soil or other materials. This contamination can adversely affect the quality of asphalt concrete mixture. Diesel fuel has been used on some occasions to clean out trucks, but this leads to mixture contamination. This contamination is even more critical on thin lifts, like PFC's, and will result in tearing behind the paver.

G. Placing.

Pavers are used to place the asphaltic concrete and hand work should be kept to a minimum. It is important to have a continuous moving operation and the paver hopper be kept full. The paver will have a vibrating screed and sometimes also a tamping screed. The screeds are normally preheated at the start of paving. The lane should be placed at the top of the crown first to prevent water form being trapped at the longitudinal joint.

It is important to obtain proper grade and smoothness to insure that the pavement is smooth, meets thickness requirements, and drains water from the surface. Failure to meet grade or smoothness may result in a pavement that fails to provide acceptable performance for the owner. The paver should not be stopped and started continually. This will result in a bump which will be difficult to roll out.

Stringlines are normally required to be used during the paving operation to control the paver so that the desired elevation is obtained. Lasers have been used to control grade but difficulties often result when grades change making the stringline method the most desirable approach to grade control.

The stringlines are normally anchored at 25-ft. centers. The lines should be pulled tight during placement to prevent sagging of the string resulting in construction of an unsatisfactory surface. During construction these lines should be visually inspected to insure that construction equipment has not dislocated the posts or stringlines.

The preferred method of grade control involves placing a stringline (or laser control) on each side of the paver for the first pass. For each additional pass, the paver will use a stringline on one side of the paver and match the adjacent asphalt concrete on the opposite side. This approach provides positive grade control. Provisions must be provided for keeping a pathway open for the trucks to back into the paver since a stringline is on both sides.

Another method that is sometimes used to control grade involves using a stringline or ski on one side of the paver for the initial pass and setting the paver slope control to place the asphalt concrete to the desired slope. This method works well for pavements having no more than two paving lanes but should not be used where multiple lanes are required. Any error is progressive and often results in unacceptable deviation from the desired grade. This method should not normally be used on airfields.

H. Compaction.

More pavement problems occur because of low in-place pavement density than any other single cause. Density is important to prevent seepage of water into the underlying layers, to prevent excessive oxidation of the asphalt cement, to prevent additional densification under traffic, and to provide adequate shear resistance.

The first step in obtaining adequate field density is to correctly establish the laboratory density. The laboratory samples must be properly prepared to determine the correct laboratory density. Samples must be at the correct temperature for compaction; the pedestal must be tightly fastened to a solid floor, preferably a concrete slab; a manual hammer without a guide at the top of the hammer must be used; and the correct number of blows (50 or 75) must be applied to both sides of the sample. These are the primary sources of problems; however, the standard should be reviewed to insure that all procedures are followed.

Laboratory samples should be prepared every day during construction for comparison to asphalt concrete placed that day. A test section should be constructed prior to paving to establish the roller patterns and technique for attaining density.

A major cause of low compaction is the lack of sufficient quality rollers and operators on the job. The operator must be experienced in rolling asphalt concrete, otherwise low density can be expected. Many projects are completed with only static and/or vibratory steel wheel rollers; however, rubber tire rollers should also be used. Normally, a heavy rubber tire roller, weighing 4,500 pounds per wheel and having tires capable of being inflated to at least 90 psi, is required to obtain adequate density for a mixture designed for high tire pressure. A slightly smaller roller with slightly lower tire pressure can be used to obtain density with a mixture designed for low tire pressure.

Vibratory steel wheel rollers can sometimes be used to compact asphalt concrete to the desired density; however, many times the density will build up to some amount then begin to decrease with additional rolling prior to being compacted to the specified density. In this case, the rubber tire roller should be used, prior to break-over in density with vibratory roller, to roll and increase the density to the desired amount. Rolling with steel wheel rollers often cause the surface of the asphalt to develop hairline cracks after a number of passes or on a radius. The rubber tire rollers, when used in addition to the steel wheel roller, can help to obtain the density without developing hairline cracks on the pavement surface. Another advantage of the rubber tire roller is its ability to produce a tight asphalt concrete surface that prevents water penetration and improves durability.

The asphalt concrete mixture should be placed at a temperature which it can be compacted immediately. If the mixture is placed too hot, the rollers will have to wait to roll the mixture, resulting in nonuniform cooling and nonuniform density in the asphalt concrete. For best results, the mixture temperature should be selected so that the rollers can operate immediately behind the paver.

It is difficult to obtain the required in-place density, especially in the longitudinal and transverse joints. Sufficient rollers required to obtain this density must be available during construction of the project. Steel wheel rollers are required for breakdown and finish rolling. A steel wheel vibratory roller has demonstrated improvement over static steel wheel rollers for breakdown rolling. A vertical construction joint will improve the joint densities. Experience has shown that 2-3 inches of material can be removed from the free edge with a cutting wheel prior to placing the adjacent lane to improve joint density.

A nuclear gage is often used to measure density of asphalt concrete during construction. It is helpful since it can be used to determine density prior to completion of rolling allowing additional rolling to be performed if needed. Density results obtained with a nuclear gage should not be used for acceptance tests but rather control tests if the contractor elects to use it. The owner should not be put into a position of using a nuclear densometer to control the densities or requiring the contractor to use a test method different from the acceptance test. The only acceptable method for measuring asphalt concrete density for acceptance is to cut cores and weigh them in air and water to compute density. The density is reported as a percent of laboratory density so it is required that the laboratory densities, standard deviation, and payment be determined each day for asphalt concrete placed.

Heat check-cracking is a common problem during compaction of AC, especially in thin lifts. This normally happens when the tiller wheel of the roller is in the front during the breakdown pass. The temperature of the lift surface and the bottom is less than the center and the viscosity of the mix is lower in the center. Because of the horizontal force of the wheel, the mix tends to move horizontally at some depth. This means the mix at the surface should also move, but since it is cooler and stiffer it will move less and results in hairline cracks. The cracks are normally not connected, 3-4 inches long and 3/8-1/2-inch deep. Other situations, such as slippage, will have the same result but wider and deeper cracks.

I. Surface Smoothness.

Smoothness of asphalt concrete is important to provide a satisfactory ride. Smoothness is normally measured with a 16-ft. straightedge. A record of the measurements should be made and kept for the project records. Failure to meet smoothness requirements usually indicates some localized construction deficiency. Profilographs are also being used to monitor the smoothness in the longitudinal direction. This method is efficient and provides a record.

The underlying surface has to be smooth prior to placing the asphalt mat since 20% of the deviation will be reflected in the upper surface. Failure to meet smoothness requirements usually result from improper operations of the asphalt paver or rollers. A low spot normally results at places where the asphalt paver stops. Most pavers use vibratory screeds which result in localized compaction when stopped. Many problems can occur during the rolling operation that result in a rough pavement. Rollers stopping on the pavement surface may cause depressions that cannot be removed by further rolling. Rollers that turn too sharply or that start or stop too quickly can also cause smoothness problems.

The best method to obtain a smooth pavement is to keep the plant, paver, and rollers moving continuously. The use of belly-dumps and pickup machines have provided good results for large projects. Continuous stopping and starting results in poor smoothness. The plant should be set up to produce asphalt concrete at a rate not to exceed that which can be placed and compacted with available equipment. The speed of the equipment should then be adjusted so that excessive stopping and starting is not necessary.

The surface of the runway, used for jet aircraft, will normally be grooved or has a porous friction course applied. This will improve the friction characteristics during wet weather.

All pavement deficiencies should be noted and forwarded to the project engineer and, subsequently, to the contractor. The contractor's quality control report should also note the deficiency. The contractor should provide the owner with a plan of action to correct all deficiencies. Skin-patching is unacceptable since it will ravel and is not durable.

J. Testing Requirements.

Testing should be done by laboratories meeting requirements of ASTM D 3666, per the specification. Sampling should be done at random locations which are selected as required in the specifications. Sufficient testing must be performed to insure that the product being produced meets the specification requirements. Routine tests for asphalt concrete include sieve analysis of aggregate, extraction test to determine asphalt content and gradation of aggregate, laboratory compaction and density, stability, flow, voids in total mix, voids filled with asphalt, grade, smoothness, mix temperature, and field density. All of these tests are routine and should be conducted daily. Under the contractor quality control program many of the control tests may be required to be conducted by the contractor's laboratory; however, this does not relieve the owner of the responsibility to verify the contractor's results. Verification may include observing the contractor conduct these tests or it may involve conducting tests to verify the contractor's results.

Specifications required by the FAA have reduction in pay clauses for material not meeting the specifications. These specifications require that the owner perform a specified amount of testing for quality assurance. It is important that the owner-controlled laboratory perform the amount of testing required and in accordance with the specified procedure otherwise the contractor will have a legitimate claim that testing was not performed as specified and therefore should not be acceptable for basis of payment. The pay reductions are based on density and also consider consistency of the density, by use of the standard deviation. A computer spreadsheet is available to compute the payments for asphaltic concrete. Contact the local Airports District Office for a copy.

It is important that testing be conducted and reported in a timely manner. All tests for a work day should be completed at least by the end of the following work day.

IV. POROUS FRICTION COURSE (PFC).

A. Introduction.

PFC's are used successfully on runway surfaces but they have to be constructed correctly. The existing surface has to sloped adequately to permit the PFC to drain. A test section should be done for all PFC's to establish the mix and construction techniques.

> Note: One method to establish the optimum AC content is with the use of a glass dish. Various AC content mixes are made in increments of 0.5% (5.5%, 6.0%, 6.5%, etc). The mix which will completely cover the bottom of the dish should be used to start the test strip. The AC content should then be increased in the test strip until it starts to bleed. The content then is decreased by 0.5%.

B. Materials and Plant.

The aggregates are to have fractured faces in all sizes in order to get stability and interlocking. Minus #200 material should be kept to a minimum. A clean mix promotes drainage and gives a smoother ride since the fines can build up and cool under the paver screed and cause tearing.

A rubberized (styrene butadiene) asphalt shall be used in the PFC mix to minimize oxidation and provide a stronger bond.

The temperatures of the aggregate and asphalt cement should be monitored closely. Rubberized asphalt will have to be handled at a higher temperature than normal asphalt cement. The mix should not sit in the silo and trucks for a combined time exceeding 15 minutes or the asphalt material will drain down. This time constraint will require the plant be located near or at the project site.

C. Placing and Compacting.

A tack coat is critical to bond the horizontal surface at approximately half the normal rate (.05 gallon per square yard). Do not tack coat the vertical joints or edge. Re-tack surfaces which become dirty, tracked from trucks or sit overnight. Use hard base asphalt emulsion for tack coats.

The pavement temperature should not be less than 50 degrees F when placing PFC and it has to be dry. The minimum material placing temperature is 225 degrees F. Temperature control is very important and the PFC will tend to cool rapidly when placed in 3/4-inch thick lifts. **Do not place if there is a cool breeze or if the ambient temperature is less than 70 degrees F.** The mix tends to form a hard skin in the truck which will cause tearing under the paver. The paver should continuously move and should not stop for changing trucks. The trucks should not back into the paver but rather be picked-up by the paver as it moves forward. The paver can lay approximately 100 feet with material in the hopper. If a delay occurs due to a breakdown or waiting for trucks, the machine should be picked up, cleaned out, and start new. Depositing the mix in front of the paver and the use of wide pavers have given excellent results. Cool material will cause tearing. The screed should be preheated at the start of paving and the heater kept on for any delay or stoppage. The paver should run fast enough to provide a smooth surface and also timed for the number of trucks and rate of the plant. An automatic screed control system with a 50- to 70-foot ski should be used. Bleeding areas will result if delays occur and the asphaltic cement has time to drain down.

Lower areas should be placed first because after a rain the PFC will continue to drain for a long period of time. A paver should only be used and not a blade or loader. Hand work should be kept to a minimum but if any raking is necessary, only use hot material. Sometimes it is better to leave a tear than trying to repair it by raking. Layers should not overlap. Remove mistakes or extra material immediately while the material is still hot. Fill underlying irregularities with one pass. PFC can be placed up to 2-inches in one layer without too much difficulty.

A minimum of two 10-ton steel-wheel rollers should be used for each paver. Rolling should be done with two passes immediately, in the non-vibratory mode, behind the paver. The edge should be rolled first since it will leave a ridge if it cools. The roller should be kept as close to the paver as possible. The trucks should never travel on the PFC even if it means they have to backup a considerable distance.

D. Curing.

Traffic has been put on a PFC after 2 hours but caution should be used. Painting can be accomplished the next day as temporary marking. The final painting should be completed after the pavement is 30 days old.

V. PORTLAND CEMENT CONCRETE (PCC).

A. Introduction.

PCC mixtures are composed of aggregate, cement, water, and usually one or more admixtures. These pavements which are hard, durable, and waterproof (assuming joints are satisfactorily sealed) may or may not contain steel reinforcement. PCC pavements usually referred to as rigid pavements, are fuel and blast resistant. Rigid pavements total sections can be relatively thin over weak soils (when compared to flexible pavements); however, underlying materials such as swelling clays will result in the PCC buckling and cracking.

B. Material Properties and Significance.

1. Aggregate Quality. The aggregate quality is very important to the performance of PCC. Some aggregates can react with the cement and cause failure from severe expansions or contain porous particles which result in popouts. The best measure of aggregate quality is past performance in PCC pavements under similar environmental and traffic conditions. Many of the tests that are used to evaluate aggregate for asphalt concrete mixtures are also used to evaluate PCC aggregates. ASTM C 33 contains the quality requirements for the concrete aggregate. Alkali-silica reactions (ASR) are common in our region. Aggregates should be checked and low alkali cement and/or flyash may have to be included in the mix. Methods to determine if a problem exists are as follows:

(a) Aggregate track record from operational pits and quarries (track record).
(b) The petrographic analysis (ASTM C 295).
(c) Quick chemical test (ASTM C 289).
(d) Mortar-bar expansion test (ASTM C 227 & C 1260).

The Los Angeles Abrasion Test (ASTM C 131) is used to measure the abrasion resistance of aggregates. Aggregates that fail to meet this test requirement may break down during handling causing a significant increase in the amount of material passing the No. 200 sieve (dust). This dust may coat the aggregate resulting in a reduction of bond strength between the cement paste and aggregates resulting in lower strength. This test is conducted prior to start of project and would not normally be conducted during project unless the aggregate source changes.

Another aggregate test that is often used is the sulfate soundness test (ASTM C 88). This test is used to measure the relative freeze-thaw resistance of aggregates. Although this test does not accurately measure the freeze-thaw resistance of aggregates, it does identify aggregates that can potentially cause problems. If the test indicates a potential for freeze-thaw, an actual mix should be made and a freeze-thaw test conducted.

Particle shape and angularity of aggregates are important in the mix design and performance of PCC mixtures. Flat and elongated particles tend to make a harsh mix that is difficult to handle. This requires more water to improve workability and more cement to maintain an acceptable water/cement ratio resulting in higher overall costs for the PCC. Care must be taken when using mixtures containing flat and elongated particles to insure satisfactory consolidation during placement.

Satisfactory PCC mixtures can generally be produced with crushed or uncrushed aggregates. The bond between the cement paste and aggregate is normally the weakest point of a PCC mixture and therefore failure occurs along the perimeter of the aggregates. The cement paste usually bonds better to freshly crushed aggregate hence the strength of mixes containing crushed aggregate is often higher than those mixes containing uncrushed aggregate. The crushed faces also provide more interlock and higher flexural strengths. If sufficient strength cannot be obtained with uncrushed aggregate, then the aggregate should be crushed or another source used. Mixes containing crushed aggregate often require more water (due to an increase in sand content) to improve workability and more cement to keep the water/cement ratio at an acceptable level.

Aggregate porosity can affect the performance of PCC mixtures. Aggregate having high porosity can be successfully used; however, steps must be taken to insure the total water in the mixture is satisfactorily controlled. These aggregates should be maintained close to a saturated surface dry (SSD) condition in the stockpile so that the aggregate will not absorb water from the mixture during performance resulting in poor workability and overall poor performance.

2. Aggregate Gradation. The aggregate gradation (ASTM C 136 and C 117) is not overly important in PCC mixtures but there are some items that are important. The amount of material passing the No. 200 sieve must be maintained low to insure that dusts do not coat the aggregate resulting in a loss in bond strength. Mixtures having larger aggregate sizes usually result in a lower design cement factor and, therefore, results in lower costs. Mixtures well-graded from coarse to fine usually require less cement due to the lower void structure between the aggregates.

3. Cementatious Material.

(a) Portland Cement: Portland cement should conform to ASTM C 150, Type I or II. In some cases, a low alkali and false set requirement will be included. Low alkali cement should be used in areas where a potential exists for aggregates to be partially reactive but acceptable if used with a low alkali cement. Caution is made for the use of type III cement since it can set up quicker than normal and may not provide the later age strength that is achieved with other cements.

(b) Portland-Pozzolan Cement: Portland-Pozzolan cement should be permitted in the specification. It normally will be required to conform to the requirements of ASTM C 595, Type (IP) or Type I (PM), including limit on Mortar Expansion, "Table 2, Physical Requirements."

(c) Pozzolan: Pozzolan should conform to ASTM C 618, Class F, including limit on available alkalies, "Table 2 Supplementary Optional Chemical Requirements," and limit on reactivity with cement alkalies, "Table 4 Supplementary Optional Physical Requirements." In some cases, type C pozzolan may be permitted but the qualities are normally less uniform. Flyash from prequalified sources may be specified. Prequalification can be used in lieu of supporting data for uniformity requirements. For all cases, each lot shipped should be accompanied by a certification and test data.

(d) Temperature: The temperature of the cement (and pozzolan) as delivered to storage at the site, should not exceed 150 degrees F.

4. Flexural Strength. The flexural strength test (ASTM C 78) is used to measure the strength of PCC for the construction of pavements. This test property must be routinely measured and satisfactory results are essential for satisfactory pavement performance. Airfield pavements are designed to obtain the desired flexural strength within 28 days. Tests are conducted at earlier dates to estimate the 28-day strengths. The main factor influencing the flexural strength is the water/cement ratio but is also influenced by factors such as aggregate fractured faces. Cement factors exceeding 700 pounds have resulted in decreasing flexural strengths. This was believed to be caused by separation of aggregates and loss of interlock.

5. Air Content. Entrained air (ASTM C 231 and C 173) is essential in a PCC pavement to insure satisfactory performance under freeze-thaw conditions. Air entrainment should be used in a pavement and will provide resistance to freeze-thaw and surface scaling from de-icing and other chemicals. Air is entrained by using one of a number of brands of air entraining admixtures meeting the requirements of ASTM C 260. Slipform mixes with low slumps are sometimes difficult to entrain air into. It is important that the specific admixture(s) be used during mix designs. Increases in temperatures will also result in a lower air content for the same admixture dosage. Entrained air results in an increase in mixture workability and also results in some reduction in strength. Loss of strength due to excessive air is much more apparent with flexural than compressive strengths. Entrapped air which may result from improper consolidations is undesirable.

6. Slump. The slump test is run to monitor the consistency. Slump does not give an indication in total of the workability. Mixes with the same slump can differ greatly on the workability. ASTM C 143 is the standard for conducting the slump test.

7. Thickness. Thickness testing is a critical test. The paving grades and forms are also checked to assure thickness but acceptance is based on random cores. The thickness is one of the main factors in the PCC life since 1 inch of thickness can affect the structural life (due to fatigue) by a multiple of two.

8. Yield. Yield tests (ASTM C 138) are conducted by determining the unit weight of the concrete with a 0.5 cubic foot container. The unit weight is compared with the weights from the batch plant to verify the proper cement content and mix design. This is necessary since concrete is batched using weight measurements and paid for using volume.

C. Admixtures.

1. Accelerating Admixtures. Accelerating admixtures are often used in PCC mixtures when there is a need for the concrete to set and gain strength quicker than conventional concrete. The rapid strength gain may be needed to allow earlier removal of forms, to open to traffic at an earlier date, and to reduce required curing time. The addition of accelerators to increase the rate of strength gain may result in a slightly lower ultimate strength. Type III cement can be used to provide an earlier strength gain than normal concrete.

2. Air-Entraining Admixtures. All PCC concrete should contain air entrainment. PCC mixtures that are not air entrained become damaged when exposed to chemicals or freeze thaw conditions while critically saturated. A number of materials can be used to entrain air but these materials should meet the requirements of ASTM C 260. The addition of an air entraining admixture increases the workability of a PCC mixture and reduces the strength. The amount of entrained air can be determined by ASTM C 231 and C 173. Low slump mixes (for slip-form construction) will require additional admixture for the proper air content. Temperature also affects the content since higher temperatures will result in an increase in the dosage of admixture.

3. Water Reducing Mixtures. The water/cement ratio of PCC is important to insure durability and adequate strength. Low water/cement ratio, if mixture is properly produced, results in high durability and high strength while a high water/cement ratio results in low durability and low strength. Caution should be taken to test the water-reducing admixture since some have resulted in lower flexural strengths at later ages, although compressive strengths have increased. The admixture should meet ASTM C 494 for flexural strengths at 28 and 90 days. The water reducing agent provides for better workability and thus allows the use of a lower water content resulting in a more durable pavement. Overdosage of some brands can retard the set as a retarding admixture. High dosages of others can result in early slump loss. High-range water reducing admixtures (superplasticizers) are also available but are not normally used in pavement concrete except for special circumstances.

4. Retarding Admixtures. Set retarding admixtures should meet ASTM C 494. These admixtures are normally used during warm weather to provide additional time to place and finish the concrete since heat will accelerate the set. The admixture should

be used as recommended by the manufacture since an overdose or improper mixing with other admixtures can over retard or "kill" the set.

D. Plants.

The purpose of a concrete plant is to proportion the components of a Portland cement concrete mixture in accordance with the mix design. These components will include some of the following items: aggregate, cement, water, pozzolan, water reducing admixture, air entraining admixture, and accelerating admixture. The materials may either be mixed in a stationary plant or in a transit mixer. For slipform paving operations, it is important that the plant be located near the site. Transit mixers are not recommended for slipform construction since they are less efficient at mixing and it is difficult to unload the low slump mixes.

It is important that the various mixture components be consistently added at the proper amount to insure a satisfactory project is obtained. The most difficult item to control is water. A small increase or decrease in water can greatly affect the appearance and performance of the PCC. The water in the mix and aggregate weights should be continuously adjusted for any moisture changes in the aggregates. Aggregates left in bins overnight will have additional moisture in the lower portion from drainage. It is a good practice to empty the bins each day. The stockpiles must be closely monitored to insure proper corrections are made for the amount of water absorbed by the stockpile. For absorptive aggregates, it is desired that the stockpile be maintained approximately in a SSD condition, otherwise the aggregate will tend to pull water out of the PCC mixture causing variations in water content throughout the mixture. For all other aggregates, the stockpiles should be maintained at or above SSD and handled in a manner to provide a consistent moisture content.

Since the stockpiles tend to dry from the outside during the day, care must be exercised in using material from the stockpile so it is blended for a uniform moisture. For instance, the material that has been exposed to sunlight for 5-6 hours will be much dryer than the interior portion of the stockpile. If the aggregate has very low absorption, the problems are minimized, but common sense needs to be exercised to reduce fluctuations in moisture content.

The stockpiles need to be handled to minimize segregation and / or contamination from other materials. Contamination from underlying materials can occur when located on soft foundations and when attempting to use all of the lower material in the pile. Stockpiles should be constructed in a way that prevents separation of coarse particles in the stockpile. Cone shaped stockpiles should not be allowed since the coarser aggregate tends to roll down the side of the stockpile. Bulldozers should not be allowed on stockpiles since they tend to break down the aggregate and to segregate the various aggregate sizes.

The designated area for stockpiling aggregates at a PCC plant is often small, sometimes resulting in overlapping of stockpiles. This should not be allowed. Each stockpile should be maintained so that contamination from adjacent stockpiles does not occur. This can sometimes be accomplished by using walls to separate the various aggregate sites.

Construction of PCC in hot weather often results in water loss from the PCC due to evaporation. American Concrete Institute (ACI) 305 should be used as a reference for hot weather concreting. This can result in poor handling characteristics and unsatisfactory hydration. Plastic shrinkage cracking of freshly placed pavement can also occur when the surface experiences rapid evaporation. This is common in warm and arid conditions with a wind. Arbitrarily adding additional water does not solve any of these problems; it may only make matters worse. The best solutions to the hot weather problem is to reduce the mix temperature, dampen the base course prior to placing, and apply the cure immediately. Keeping the stockpiles damp and / or by using crushed ice as a partial replacement for water will reduce the concrete temperature. Night placement is also an option to minimize the effects of hot weather.

Concrete should be placed and maintained above 40 degrees F for strength to develop. It should not be exposed to freezing until adequate strength is attained. ACI 306 contains standards, including insulation factors, for cold weather concrete. Calcium chloride is a type of accelerator and not an anti-freeze. If used, it should be done with caution at rates not to exceed the recommended dosage. Non-chloride admixtures should be used if steel reinforcing or metallic embedments are present.

E. Placement and Finishing.

The PCC should be placed as specified and in such a way that neither excessive entrapped air nor segregation occurs. One of the first steps is to insure that the subgrade, if dry, is not allowed to absorb water from the PCC mixture. The subgrade should be damp prior to placement of PCC to prevent it from pulling water from the fresh PCC. Excessive use of water on the subgrade should not be allowed since this excess will be absorbed by the PCC resulting in a high water / cement ratio and conversely low strength and durability.

The subgrade on which the PCC is to be placed should have sufficient strength to support the PCC. This is considered during design of the pavement; however, many times areas are encountered that are considerably weaker than the design subgrade. If these areas are extensive, a new design may be required. If these areas are small, the low quality material should be removed and replaced with material at least equal to the quality of the design subgrade. Examples of poor quality areas may include organic material, voids in the subgrade, and wet areas.

When reinforced concrete is used, the steel should be placed in the concrete at the specified location by using chairs or by placing the concrete in two layers. One layer can be placed followed by the steel placement, and then the top layer placed. When steel is not correctly placed, cracks or other damage may occur to the PCC prior to being subjected to traffic.

Dowels or tie bars are often used at construction joints and contraction joints. Dowels, keys, and thickened edges are used for load transfer at construction joints. The tie bars are used to prevent the joint from extensively opening or “walking” due to seasonal temperature changes. The tie bar should be bonded within the concrete on both sides of a joint and dowels should be bonded on one side. The unbonded, oiled portion of dowel must be on one side of the joint and bonded portion must be on the opposite side. Tiebars are used to prevent walking to maintain load transfer from the aggregate interlock at contraction joints (or keys for construction joints).

Dowels and tie bars along a joint should be parallel to each other and perpendicular to the joint. When the dowels are not correctly placed, damage can occur to the PCC or prevent joint movement. Damage due to the improper placement usually consists of spalling at joint and/or a crack parallel with joints at end of the dowels.

Dowels are placed on chairs or inserted at the location of a **contraction** joint to provide additional load transfer. Care must be taken to insure that they are correctly placed so that saw cut will be centered over dowels. Dowels **should never be inserted** into the pavement **construction** joint but rather grouted into a drilled hole. All of these dowels should be checked with a hand level and square to insure the tolerances.

When concrete is placed, it is preferred that the PCC be placed as near its final location as possible. Segregation occurs when PCC is placed then moved to another location. Trucks unloading PCC directly in front of the paver or into a hopper help to minimize segregation.

The forms for fixed form construction must be placed at the proper elevation to insure adequate thickness and to meet final grade. The forms should be constructed sufficiently strong so that they do not bend or warp when the PCC is placed. A slight outward movement of the forms may result in improper alignment and/or slumping of the PCC adjacent to the forms. Roller type bridge-deck finishers are not recommended and do not provide a concrete section which is properly consolidated and to grade without the use of excessive slump. When using higher slump mixes, a weak surface and low strength concrete will result.

One advantage of slipform construction is that the time and material to construct fixed forms is not needed. The mixture used during slipform construction is somewhat stiffer than the mixture required for fixed form construction. Since the mixture is stiffer, it is more difficult to place without entrapped air. If the PCC is not vibrated sufficiently, it will have entrapped air; if the PCC is over-vibrated, excess mortar may migrate to the vibrators resulting in the development of cracks after curing. Over-vibration is very rare and normally under-vibration is most common. However, when slipform paving is used, the vibrators should be automatically stopped when the paver forward movement stops.

When PCC is used in areas subjected to high speed traffic (runways or taxiways), the skid resistance may not be sufficient if it is not properly finished. The surface is grooved for runways after curing to provide a satisfactory surface. At other times, a broom or wire drag finish is used to provide a satisfactory surface. The texturing operation must be frequently inspected to insure that aggregate is not pulled from the surface. The direction of the texture must allow for proper drainage.

The concrete should be placed so that after vibration and consolidation the PCC surface is at the proper grade. If the grade is not properly controlled, the final surface may be rough to ride on and may not drain properly. The smoothness is also important to provide a quality PCC. Slumping at the edge when slipform paving is used is one place that often presents smoothness problems. To prevent edge-slump, the concrete slump should be maintained at less than 1 inch. To maintain a consistent slump, it is very important to produce a consistent mix and control the water in the aggregates and mix. The PCC should be checked for smoothness when still workable so that any minor smoothness problems can be corrected. The bull float, when properly used, should remove minor smoothness problems.

F. Curing and Protection.

The application of curing compound or moisture is critical for warmer weather with wind. Drying shrinkage cracks could occur instantaneously if curing is slow at being applied. After the PCC has been placed, it must be cured to prevent water evaporation and to allow for satisfactory hydration of the cement. To allow for proper curing, the surface can be sealed with a curing compound or maintained damp. The curing compound must completely cover the PCC to prevent evaporation. Any skips in coverage will allow evaporation and have detrimental effects on the PCC. The PCC surface can be covered with burlap or some other material and kept damp. The PCC should be cured as long as that time specified in the project specification. The strength should be monitored with field-cured beams prior to permitting traffic on it.

G. Joints.

Contraction joints are normally sawcut or preformed material is inserted while the concrete is fresh. The preformed method requires care for alignment of the material in all directions. Also the concrete has to be properly consolidated but not over-finished near the joint. Load transfer of joints is discussed in paragraph titled “Placement and Finishing.”

Sawcuts must be made at designated places to insure that the PCC cracks at the desired location during curing. If sawcuts are not made, the PCC will crack after the PCC has cured sufficiently to allow the surface to be sawed without spalling or other problems.

Sawing too early will result in spalling along the sawcut. If too much time is allowed prior to making the saw cut, the PCC will crack due to shrinkage. This is most critical for transverse contraction joints at doweled fill-in lanes. The sawcut almost always has to be made within several hours of the time of placement, depending on the temperature. An approximate time to wait is when a nail will start to scratch the surface to begin cutting.

Additional sawcutting is done to widen the joint for a proper sealant dimension. After the sawcut has been made and prior to opening to traffic, the joints should be sealed. The sealer serves two purposes: it keeps water and non-compressibles out of the joint. Water passing through the joint can cause the subgrade to lose strength and can also cause pumping under traffic. The non-compressibles can cause spalling or in extreme cases blow-ups if they are allowed to accumulate in the joints. Prior to placing liquid joint sealants, the joint should be cleaned, blown dry with a filtered air, and a backer rod or tape should be used in the bottom of the sawed well to prevent the sealant from sticking to the bottom of the reservoir and provide the proper reservoir size. When the backer rod is used, the amount of sealant to fill the well will be reduced so original size must account for this. The top of the sealant should be below the PCC surface when completed.

H. Testing Requirements.

Laboratories conducting acceptance testing the PCC should meet ASTM C 1077 per the specification. There are a number of tests that have to be conducted during the mix design and construction operation. Some of these tests include: aggregate gradation, air content, slump, unit weight and yield, flexural strength, thickness, grade, and smoothness. All of these tests should be conducted in accordance with specified procedures. Any test result that fails to meet the specification requirements should be evaluated to determine action that needs to be taken. It is important that sufficient tests be conducted to control quality of finished PCC. The thickness and strength tests should be evaluated per the contract for pay reductions. The payment calculations also consider the consistency of the strength with use of the standard deviation. The calculation can be done with the use of a spreadsheet program, which is available. Contact the local Airport District Office for a copy.

VI. INSPECTOR'S DAILY REPORT.

The inspector's daily report is an important document and should be completed so that important information is permanently recorded. These documents are often used for settling claims in court or out of court. Without good construction records, the owner is at a disadvantage and often ends up accepting marginal work or paying additional money for low quality work.

A review of inspection reports for a number of projects has shown that many are deficient in recording important information during construction. This section discusses items that are important during construction and that should be included in the inspector's daily report.

First of all, the report should clearly identify the project that is being inspected. Many times there are several contractors working in the same area and care must be taken to clearly identify which contractor is being inspected. Probably the best method for doing this is to identify the project by contract number. It may seem obvious, at the time the inspection was made, what project was being inspected; however, 3-4 years after the project is completed, it may be difficult to decipher this information.

It is important to list the type of work being performed, such as placement of base course material, application of prime coat, sealing joints, applying curing compound to concrete, etc. These items may seem unimportant at the time; however, they may become very important when settling a claim.

The location of work being performed should be noted. This description should include all work for the day. For instance, if PCC is being placed, it might be said that PCC was placed on the second lane from the west side from station 100+00 to station 23+50.

Weather information should be provided in the inspection report. As a minimum, this information should include low and high temperature of the day and whether or not rainfall occurred during the day.

Any deficiencies observed during the day should be noted along with a list of people notified. A note should be made when and how a corrective action is taken. The deficiency should continue to be noted until corrected or until the owner decides to waive corrective action. If corrective action is waived, it must be approved by the FAA and done formally in writing.

Surface smoothness (straight-edging) monitoring should be done systematically and a record be kept of all measurements.

If the inspector is responsible for reviewing contractor's tests, a note should be made in the report concerning the time when the report was received and whether or not the test results met requirements. If they do not meet requirements, appropriate individuals should be notified. All tests should be recorded and payments calculated. Failed tests should be discussed and cross-referenced to retests and acceptance.

VII. CONTROL CHARTS.

One of the most difficult jobs for a pavement inspector is to accumulate test data and record it in a way that can be readily used. The best method for doing this is by the use of control charts to record and summarize data and to identify trends in test results.

Control charts are used to plot individual test results along with the specification limits. A plot of the running average, which will smooth the plot of individual test results, is also useful in looking at test results. For example, suppose that asphalt concrete specifications require that the moving average of the last five samples tested for asphalt cement content be within 0.25 percent. A plot of individual values and the moving average would be useful in this case to summarize the data and show its relation to the specification requirements.

Control charts are used as a method for summarizing and recording date and indicating trends in the process. Test results, which fall outside the specification limits shown on the control charts, are used for summarizing and graphically showing the data results and are not to be used to accept or reject material, unless required by the specifications.

Control charts can be better utilized by showing any significant changes in the process during construction. For instance, a change in the roller weight or tire pressure should be shown on the control charts for density. This will provide some insight into the effect these changes have on density of material being constructed.

Some of the pavement characteristics being measured are functions of other parameters. For instance, the density of a layer may be related to the gradation of the material. Hence, an unsatisfactory gradation may result in a reduction in the in-place density. Control charts can be used to show this relationship. After determining the cause of the problem, in this case aggregate gradation, steps can be taken to correct the problem and thus improve pavement properties such as density.

There are a number of properties that should be plotted on control charts to adequately describe the overall quality of construction. The items that need to be plotted on control charts for subgrade construction include water content and density. Other properties may be plotted if sufficient testing is done to provide data for control charts. Data which should be plotted for subbase and base course materials includes density, water content, and aggregate gradation. Data that should be plotted for asphalt concrete includes aggregate gradation, asphalt content, mat density, and joint density. Data that should be plotted for Portland cement concrete includes air content, slump, 7-day flexural strength, and 28-day flexural strength (if project continues for that length of time).

The contractor may plot the control charts on some projects while the owner may plot them on other jobs. From a quality viewpoint, it is not important who plots the charts, but it is important that they are plotted correctly and that the owner and contractor have access to them.

When the data being plotted comes from the contractor quality control tests, it is essential that the owner verify these test results by overseeing tests or conducting independent tests.

VIII. INSPECTOR'S CHECKLIST.

There are a number of items an inspector should check prior to and during construction. The checklists provided in this section do not include all aspects of construction but they do cover the most important aspects (except for **SAFETY**) and certain other areas that are known sources of problems. The checklist should be reviewed as construction progresses to insure that important items are not overlooked.

A. Checklist for Subgrade, Subbase, and Base Course.

(1) Pavement should be laid out in accordance with plans and specifications.

(2) Unsatisfactory material such as topsoil and other organic material should be removed. (In arid areas where adequate moisture may be a problem, any vegetation should be disked as soon as possible. The vegetation will pull moisture from the soil.)

(3) Verify that aggregate specified to be crushed is crushed and tested.

(4) Materials should not deviate substantially from those used in design unless pavement is redesigned.

(5) If applicable, check grading of material routinely.

(6) As specified in the specifications, laboratory compactive effort should be used.

(7) Check liquid limit and plastic limit as required.

(8) Material should contain optimum water content when compacted. Check for unique soil properties and requirements.

(9) Layer thickness should be as specified.

(10) Segregation of materials during construction should not be allowed.

(11) Field density should be checked to verify compliance with specifications.

(12) Smoothness should be checked and recorded to insure requirements are satisfied.

(13) Final elevation of all layers should be in accordance with plans and specifications.

(14) Deficiencies during construction should be noted and this info should be provided to project engineer and contractor.

(15) Deficiencies should be corrected at earliest possible date.

(16) The base course of some airfield pavements may be proof-rolled.

(17) Control charts should be prepared and kept up-to-date.

(18) Record quantity of material placed and accepted, along with method of measurement. For large pay items ; a cross check of measurement, i.e., weigh tickets.

19) All permits are properly obtained.

20) Do I have a 16-foot straight-edge?

B. Checklist for Asphalt Concrete.

(1) Aggregate should meet requirements for crushed faces.

(2) The amount of natural sand used in the mixture should not exceed that allowed by the specifications.

(3) Aggregate grading should be checked to insure compliance with specifications requirements.

(4) The asphalt cement should be tested prior to start of project if the source is unknown, past problems, or unique requirements. A certification with test reports and a sample should accompany each lot.

(5) The mix design should be conducted in accordance with specified procedures to establish job mix formula. The mix design should be provided prior to production to permit review and corrections as necessary.

(6) For laboratory compaction, a manual hammer weighing 10 pounds and having an 18-inch drop should be used.

(7) As specified, a 50-blow or 75-blow compactive effort should be used for compaction. Identify the correct procedure and check if it was used.

(8) The asphalt plant should be calibrated to provide material proportioned as specified in the job mix formula.

(9) All prime coat placed over unbound layers should be absorbed into underlying layers prior to covering with asphalt concrete. Check for contamination of prime coat.

(10) A tack coat should be used to bond asphalt concrete overlay to underlying bound layers.

(11) When grade control is required, a stringline should used to establish screed height.

(12) Test strip completed and results acceptable prior to starting production work (per contract). Contact the Engineer FAA ADO if problems are encountered.

(13) Thickness and/or grade of asphalt concrete layer should be checked to determine compliance with plans and specifications.

(14) Mix temperature at plant and site is monitored and kept at optimum.

(15) Temperature of mix immediately after should be checked and recorded.

(16) Cores of asphalt concrete should be obtained and tested to determine compliance with density specification requirements.

(17) A nuclear gage should not be used for density of asphalt concrete.

(18) Asphalt content and aggregate gradation should be measured and compared to job mix formula and specification requirements.

(19) Smoothness of compacted asphalt concrete should be measured and recorded.

(20) Deficiencies should be noted and provided to project engineer and contractor.

(21) Are edges and lips being controlled? (maximum 3”, preferred 1-1/2”)

(22) Deficiencies should be reported to contractor to be corrected immediately.

(23) Special care must be taken to construct asphalt concrete having satisfactory density in the longitudinal joint.

(24) Test data should be reviewed daily for compliance with specifications. Data should be plotted on control charts so that overall quality can be readily determined. Retests should be noted and cross-referenced to failed

tests.

(25) Mix should be checked for aggregate size and segregation.

(26) Watch for subgrade disturbance under loaded trucks and correct soft spots before placing pavement.

C. Checklist for Portland Cement Concrete.

(1) Preconstruction.

a. Read the project specification and reviewed the plans?

b. Check the mixing plant for calibration.

c. Does the proposed cement meet the specification?

d. Have cement, pozzolans, and admixtures been tested and approved?

e. Are aggregates from an approved source or have they been tested?

f. Is water from an approved source?

g. Has the proposed concrete mixture proportion been tested and approved? Did it meet the project specifications?

(2) Before and After Mixing.

a. Are cements and pozzolans stored properly and protected from dampness?

b. Are admixtures protected against freezing?

c. Visually check aggregates for the following:

1. Contamination (foundation soils, mud from equipment, wind blown dust, clay balls, etc.)

2. Segregation (watch storage and handling procedures).

3. Flat and elongated particles (function of crusher operation).

4. Moisture in sand allowed to drain before use and consistent.

d. Is base properly placed, graded, and at proper grade? Has trash, loose material, etc., been removed from area to be paved?

e. Are all forms, slipform paver stringlines, reinforcing steel, tie bars, and/or dowel bars of the proper size, properly placed, and adequately secured?

f. Are all floats, screed, and/or conforming plates straight, free of defects, and capable of providing desired finish?

g. Are paving vibrators operating, vibrating at specified frequency, properly spaced, and capable of being inserted to adequate depth in the concrete?

h. Is there an automatic cutoff for the vibrators if the paver stops?

i. Are pads available to place under tracks of slipform paver when it must operate with one or more tracks on an adjacent already paved line?

j. Are there adequate backup equipment and materials to handle problems (e.g., forms and dowels for transverse construction joints, backup saws for sawing contraction joints, method of applying curing compound, etc.)?

k. Are plans for adverse weather reasonable and is needed equipment available (e.g., rain, hot\dry conditions, cold weather)?

(3) Mixing and Placing Concrete.

a. Is the production concrete proportioned the same as the submitted mix design?

b. Are adjustments being made at the plant for moisture content of the aggregates (particularly the sand)? Is anyone checking the moisture content of the aggregate? Is wash water being left in the trucks prior to loading? Is water being added to trucks after loading?

c. Is there any sign of segregation, hardened balls of cement, or contaminants in the concrete?

d. Is supply of concrete to paver continuous and uniform?

e. Are tests being properly run? How do you know?

f. Are the Fresh Concrete Tests within specification?

1. Concrete temperature.

2. Slump.

3. Air content.

4. Time since cement added to mix (or since batched).

5. Unit weight.

g. Are strength specimens being prepared, cured and handled properly? (Beams require special handling and storage precautions.)

h. Do not add water to the concrete.

i. Check batch weights and do yield calculations.

(4) Behind the Paver.

a. Is hand finishing and spot repair held to a minimum?

b. Is smoothness being checked behind the paver?

c. Are keys, if specified, centered and of proper dimensions?

d. Is edge slump behind slipform paver within specifications?

e. Do not spray water on fresh concrete surface for finishing or any other reason except curing.

f. Is texture as specified?

g. Is curing as specified and adequate? If a curing membrane is used, is it continuous and uniform on all of the exposed concrete?

h. Is sawing started as soon as possible and continued without stop until finished? Are lights available for night work?

i. Are dowels correctly aligned when required?

j. Is unnecessary traffic kept off of the concrete?

k. Is curing protection maintained, including after sawing, when forms are removed, etc?

l. Is anyone tabulating, graphing, and evaluating the control and acceptance test results?

m. Are strengths acceptable and have thickness cores been taken (randomly per specs) and appropriate payments or reductions made?

IX. TROUBLESHOOTING CHARTS.

Problems occur during pavement construction that must be corrected so that a quality product is obtained. The cause of these problems must be determined so that corrective steps can be taken. The troubleshooting charts presented in this section provide the inspector with the most likely causes of problems. At times, problems will result from other causes; however, the guidance provided is useful in isolating the most likely causes of these problems.

A. Troubleshooting Chart for Subgrade, Subbase, and Base Course.

PROBLEM	VISUAL SYMPTOM	HOW TO MEASURE	CAUSE OF PROBLEMS
Low density	(1) Surface appears loose and open	(1) measure density by specified method	(1) improper water content (2) insufficient rolling or incorrect roller types (3) layer too thick for satisfactory compaction
Soft spots	(1) depressions (2) excessive movement under rollers	(1) visual observation only	(1) water content too high (2) segregation of materials (3) weak underlying material
Unsatisfactory grade	(1) birdbaths	(1) survey	(1) improper grade control
Unsatisfactory grade	(1) coarse appearance (2) fine appearance (3) surface varies from coarse to fine	(1) sieve analysis	(1) segregation during handling (2) change in gradation of material delivered (3) variation of inplace material
Soil too plastic	(1) excessive movement under rollers	(1) sieve analysis (2) Atterberg limits	(1) improper aggregate gradation (2) LL and PI too high

B. Troubleshooting Chart for Asphalt Concrete.

PROBLEM	VISUAL SYMPTOM	HOW TO MEASURE	CAUSE OF PROBLEMS
Low Asphalt Content	(1) uncoated aggregate (2) brown color (3) dry appearance (4) stiff mixture	(1) extraction test	(1) faulty scales or metering device (2) improper mix design
High Asphalt Content	(1) shiny appearance (2) slump of mix in truck (3) bleeding in a PFC	(1) extraction test	(1) faulty scales or metering device (2) improper mix design
Improper Gradation	(1) coarse appearance (2) fine appearance (3) dry appearance	(1) sieve analysis	(1) faulty scales (2) cold feed improperly set (3) segregation during handling (4) change in material delivered to plant (5) improper mix design
Low density	(1) voids on surface	(1) density test	(1) improper rolling or rollers (2) improper mix temperature (3) low asphalt content (4) improper aggregate gradation (5) improper laboratory design (6) stability too high
Improper grade	(1) birdbaths	(1) survey	(1) not using stringline (2) stringline improperly set
Improper grade	(1) birdbaths (2) rough ride	(1) straightedge	(1) stopping and starting paver (2) quick starts and stops

PROBLEM	VISUAL SYMPTOM	HOW TO MEASURE	CAUSE OF PROBLEMS
			(3) underlying surface uneven (4) excessive manual operation of thickness control on paver
Roller checking	(1) hairline cracks	(1) visual observation only	(1) mix too hot (2) excessive rolling with steel-wheel roller (3) too much tack coat (4) dirty existing surfaces (5) too many fines in mixture
Improper bond to underlying area	(1) hairline cracks (slippage)	(1) visual inspection of cores	(1) too much tack coat (2) not enough tack coat (3) dirty existing surface (4) unsatisfactory tack coat material
Steaming loads	(same)	(1) visual	(1) excessive moisture in aggregate (2) mix temperature too low to dry aggregates
Smoking loads	(same)	(1) visual	(1) excessive mix temperature

C. Troubleshooting Chart for PCC

PROBLEM	CAUSE OF DEFINITION	ACTION
False set	Unusual stiffening of concrete far ahead of expected initial set with little evolution of heat. (Rare)	Do not add water. Plasticity can be restored with additional mixing. Notify cement supplier.
Premature hardening; lack of working time	Improper use of accelerator or cement type; high concrete temperature.	Use retarders, avoid type III cement, lower concrete temp. Use pozzolans as cement substitute.
Slump out of specifications or varying	Change in water content or aggregate gradation, concrete temp. too high (stiffens with temp. increase).	Check aggregate moisture contents and gradations, check water being added at the plant, check if someone added water on site, lower concrete temperature.
Air content fluctuating	Pozzolan varying, cement brand changed, sand gradation change, worn mixer blades, overloading mixer, temperature change, excessive and/or variable mixing, organic contamination, interaction with admixtures such as calcium chloride, improper air entraining agent or change in brands. Varying water content & slump.	Check materials and construction and procedures
Excessive concrete temperature	Temperatures, hot cement. Excessive time after batching.	Lower concrete temperature by chilling water, adding ice, cooling aggregate, pave at night. If cement temperature out of specification contact supplier.

PROBLEM	CAUSE OF DEFINITION	ACTION
Failure to set	Organic contamination, retarder not dispersed (soft spots).	Check water and aggregates and equipment for contamination. Improve mixing to disperse retarder.
Sticky mix	Sand too fine, using wood float on air entrained concrete.	Change sand gradation, use magnesium or aluminum floats.
Honeycombing	Inoperative vibrators, inadequate vibration, excessive vibrator handling, mixing and segregation	Check vibrators, improve materials, spacing, concrete placing procedures to avoid segregation.
Edge slump	Poor and / or nonuniform concrete, improper equipment operation, and / or unskilled labor.	Adjust mix design and construction procedures.
Smoothness problems	Nonuniform concrete, "stop and go" paver operation, too much or too little concrete in front of paver.	Improve mixing and construction procedures.
Popouts	Unsound aggreates, clay balls	Check aggregates
Scaling, dusting	Over-finishing, premature freezing of concrete	Improve finishing technique. Protect concrete from freezing.
Plastic shrinkage, cracking	Excessive loss of moisture from concrete due to temp., humidity, wind, and / or pave at night, improve curing procedures.	Lower concrete temperature use wind breaks and sun screens.
Contraction cracking	Sawing too late, slab sizes too large.	Saw sooner or use inserts into plastic concrete
Raveling of sawcut	Sawing too soon	Wait longer to saw.

PROBLEM	CAUSE OF DEFINITION	ACTION
Joint spalls	Excessive hand finishing, trying to fix edge slump of low spots by hand manipulated concrete, nonuniform concrete resulting in wavy longitudinal joint that spalls when sawed, collateral damage from equipment, slipform paver tracks, screeds, etc.	Improve construction practice.
Low strength concrete samples	Improper sample preparation, curing, or testing, excessive w/c ratio, contamination, batching errors, improper mixing, inadequate consolidation, inadequate curing. Handling of beams is critical and curing in water will result differently than a fog cure.	Check sampling, materials, batching, mixing, constructin and curing procedures.

X. FINAL CONSTRUCTION REPORT.

A detailed final construction report is required for all AIP construction projects. The report shall be a summary of the project and discuss any construction problems and the corresponding solutions. All testing per the specifications should be tabulated. All acceptance testing shall also be listed along with the statistical calculations, pay factors and dollars for each lot. The following is a partial outline for the final project report. This outline only includes items relative to pavement construction, and the local Airports District office should be contacted for a complete report handout.

A. Construction.

(1) Copy of bid abstract including engineering estimate.

(2) Brief narrative on methods and time of construction, problem areas, unusual conditions and unique features.

(3) Prime and subcontractors.

(4) Breakdown of cost of all construction work, including amount and FAA approval date for all contracts, change orders and supplemental agreements.

(5) Table showing notice to proceed date, contract time, and scheduled and actual completion date for each contractor (approval for time extensions and liquidated damages listed and explained).

(6) Statement concerning compliance with contract labor related clauses; posting of minimum wage rates and EEO posters, review of payroll and job classifications; explain any labor problems.

(7) Materials and test results.

(a) Material sources, certificates of compliance, manufacturer's quality control test results.

(b) Job Mix (formulas) Designs and dated changes during construction.

(c) Summary chart of field test results.

- Summary of data by lot including statistical analysis (densities, strengths, core thickness, averages, means, ranges, deviations) as appropriate.

- Comparison with specifications.

- Justification for accepting any below specification test results, retests and computations for payment.

- How random sampling/test locations determined.

(d) Results of pavement test strip.

(8) Completion.

(a) Final quantities (include design estimated quantities).

(b) Justification for variations in quantities from design quantities.

(c) Liquidated damages.

(d) As-built drawings (submitted separately).

(e) Final inspection report. Include a list of any exceptions to the contract and schedule of corrective actions giving method, responsible party, and estimated date of correction as applicable.

(f) Copy of contractor's statement that no further payment is due and that all subcontractors and material suppliers have been paid in full.