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Technical Letter
No. 1110-3-487

1 March 1998

Engineering and Design
USE OF PETROLEUM CONTAMINATED SOIL
IN COLD-MIX ASPHALT STABILIZED BASE COURSE

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1. Purpose. This letter provides information and guidance for design and construction of mixtures using petroleum contaminated soil and similar hydrocarbon waste for cold-mix asphalt stabilized base course (ASB) construction.
2. Applicability. This letter is applicable to all HQUSACE elements and USACE commands having military construction and design responsibility.
3. References. See Appendix A.
4. Distribution. Approved for public release; distribution is unlimited.
5. Background.
 - a. It is estimated that 25 percent of all underground petroleum storage tanks over 20 years old have some leakage into the surrounding soil. This leakage generally results in approximately 23 to 38 m³ (30 to 50 yd³) of contaminated soil for each leaking storage tank. However; contaminated soil amounts exceeding 7,650 m³ (10,000 yd³) have been encountered on military installations. The U.S. Army Engineer Waterways Experiment Station (WES) has conducted research and participated in contaminated material disposal projects.
 - b. This ETL provides guidance and design recommendations for the use of petroleum contaminated soil in pavement construction. The information provided is for cold-mix applications of these materials in base course construction. Use of contaminated soils in hot-mix asphalt pavement applications has been accomplished, but discussion of this process is beyond the scope of this letter. ASB should only be utilized when laboratory analysis has shown that the process will result in a material that will meet existing state and federal requirements for leachate. A substantial amount of regulatory support is required to comply with all regulations.
6. Action. The enclosed guidance and design recommendations should be used by the Army for the design and construction of pavements using contaminated soils.

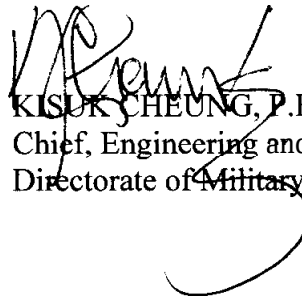
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7. Implementation. This letter will have routine application for all future military projects as defined in paragraph 8c, ER 1110-345-100.

FOR THE COMMANDER:

2 Appendixes



KISUK CHEUNG, P.E.
Chief, Engineering and Construction Division
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APPENDIX A

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APPENDIX B

USE OF PETROLEUM CONTAMINATED SOIL IN COLD-MIX ASPHALT STABILIZED BASE COURSE

1. Application. The guidance and information provided herein are applicable to the design and construction of mixtures using petroleum contaminated soil and similar hydrocarbon waste for cold-mix asphalt stabilized base course (ASB). This ASB can consist of bituminous base courses, bituminous binder and wearing courses, bituminous road-mix surface courses, or cold-mix recycling methods where these mixtures can function as base course materials.

2. Introduction.

a. Leakage of petroleum products from underground storage tanks (USTs) and accidental spills of petroleum products contaminate the surrounding soil and eventually enter the groundwater system. Many petroleum products when in the soil do not pose a serious environmental threat, except for possible migration into the groundwater system (Dineen 1991). The term petroleum is used to refer to gasoline, diesel, motor oil, heating oil, and other petroleum based materials. Nationwide there are approximately 2 to 3.5 million USTs (Meegoda et al. 1992). Estimates are that approximately 25 percent of all underground tanks that have been in place for more than 20 years are leaking some petroleum (Czarnecki 1988 and Meegoda et al. 1992). Nationwide the number of confirmed instances of leakage between 1993 and 1994 had grown from 170,000 to over 260,000 (Durgin 1993 and EPA 1995). The amount of contaminated soil generated from this leakage has been estimated to average from approximately 38 to 380 m³ (50 to 500 yd³) per UST site, with more than 75 percent of the sites involving less than 765 m³ (1,000 yd³) of soil (Czarnecki 1988 and Friend 1996). Experience at military sites in Alaska indicates that the volume of contaminated soils associated with an UST can be as high as 7,650 m³ (10,000 yd³). Costs associated with site remediation involving soil contamination generally vary from \$10,000 to \$125,000, and if groundwater contamination occurs costs can increase ten fold (EPA 1995 and Cole 1994).

b. In 1984, under the amendments to the Resource Conservation and Recovery Act (RCRA) a formal regulatory program was developed to deal with leaking underground storage tanks (Czarnecki 1988). These amendments enabled the states to enforce environmental standards for USTs, provided they meet the minimum federal standards. Many states now vigorously encourage the removal of all storage tanks after 25 years of service (Czarnecki 1988). Most states have well-defined procedures for cleaning up petroleum spills. Generally, a sand or some solid absorbent is spread to contain and/or absorb all liquids, and then the entire mass is removed and isolated (Czarnecki 1992).

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c. The Comprehensive Response Compensation and Liability Act (CERCLA) generally excludes petroleum and petroleum fractions from the definition of a CERCLA hazardous substance. Petroleum, petroleum derived products, and environmental media contaminated with these materials are typically regulated by the RCRA under 40 CFR 260 - 268, 270, and 280, rather than other environmental regulations. Petroleum contaminated material can be classified as a hazardous waste under 40 CFR 261 or as a regulated material under 40 CFR 280. Petroleum contaminated material may likely be regulated as a *hazardous waste* in two situations. First, if there is free product and the material exhibits an ignitability characteristic (40 CFR 261.21). Second, if the material exhibits a Toxicity Characteristics (TC) (40 CFR 261.24). The most likely TC for petroleum contaminated media is for Benzene (D018 0.5 mg/1 TCLP). The RCRA has an exclusion from the hazardous waste regulations, as stated 40 CFR 261.4(b)(10) "Petroleum-contaminated media and debris that fail the test for the Toxicity Characteristic of 261.24 (Hazardous Waste Codes D018 - D043 only) and are subject to the corrective action regulations under part 280 of this chapter." Therefore, if a soil is a hazardous waste for D018 - D043 *only*, and the source was from a UST corrective action, hazardous waste regulations do not apply. Therefore, the only restrictions that need to be evaluated to conduct ASB applications will be the state UST regulations. An evaluation of the 40 CFR 266 Subpart C - **Recyclable Materials Used in a Manner Constituting Disposal** indicates that there is a three part criteria that must be met in order to recycle hazardous waste in a manner that constitutes disposal.

(1) Products produced must be made available for the general public.

(2) The recyclable materials must have undergone a chemical reaction in the course of production so as to become inseparable by physical means.

(3) The products must meet applicable land disposal restrictions (40 CFR 268).

If all three of the above criteria can not be met, it does not appear there are any regulatory "exclusions" for environmental media contaminated with petroleum that exhibit a RCRA hazardous waste characteristic, if the material is from a *non-UST* source. Recycling (as ASB) non UST media that exhibits a hazardous waste characteristic does not appear allowable. Therefore, the source of contamination can have a large impact on project cost as well as regulatory requirements. Individual states may have more stringent regulations, with some considering petroleum contaminated soils to be hazardous. This may be especially true for gasoline contamination due to the volatility and resultant fire and explosive hazards of this material (Cole 1994). The classification of petroleum materials as regulated, rather than hazardous, substances can be critical in cleanup cost considerations. The EPA does have a program called Excellence through Leadership (XL) Program). The regulated community may petition the Regional Administrator for regulatory relief from a requirement if there is an environmentally sound management procedure that is not only allowed by the regulations. Non UST contaminated media exhibiting a TC under codes (D018 - D043) would appear to be a good candidate for this program.

d. Contaminated soil has been used in ASB construction in several states (Ellison 1991). Typical ASB mixtures normally consist of approximately 95 percent aggregate and 5 percent asphalt cement binder (by weight of total mixture), where the aggregate provides the load-bearing properties and the asphalt binds the aggregates together (Friend 1996). For use in ASB, the soils are normally screened and used without thermal pretreatment (EPA 1992). When contaminated soil is used in the ASB, the soil replaces part of the clean aggregate, and the asphalt cement immobilizes the petroleum contaminants in the soil (Friend 1996). The effectiveness of ASB in immobilizing contaminants has not been well documented. Consequently, many regulatory agencies have not readily supported this technology (Friend 1996).

3. Soil Types and Requirements.

a. Almost any type of soil including clay/silt, sand, gravel, and boulders can be incorporated into ASB in certain applications. However, when the contaminated soil is predominately a sand, it is normally not a candidate for ASB because of other insitu remediation technologies that can be more applicable including isolation/containment and passive remediation (Ellison 1991). Contaminated soils that contain large amounts of clay, especially expansive clays, will not perform well in ASB or in any application of road construction (Dineen 1991).

b. The amount or level of liquid petroleum or hydrocarbon material that can be held in soil above the water table (unsaturated) varies with the particle size of the soil. The larger the particle size, the smaller the amount of liquid petroleum that can be held without draining out of the soil. Fine sand/silt combinations will be able to hold 2 to 3 times the amount of liquid that a coarse sand can hold, and the coarse sand will hold a similar amount more than a coarse gravel (API 1989). This is generally true for all petroleum materials ranging from lighter (gasoline) to heavier materials (fuel oils).

c. To perform as an effective base or stabilized material, a given range of aggregate gradation and particle shape must be developed. Generally, small amounts of contaminated material could be blended with other aggregates, prior to the addition of asphalt cement, to obtain satisfactory material for almost any use. The higher the quality of the aggregate in the contaminated soil, the more that can be used in relation to additional aggregate, provided levels of contamination are acceptable. The Corps of Engineers has Guide Specifications (CEGSs) that have been developed for bituminous base courses (CEGS-02242), bituminous binder and wearing courses (CEGS-02742), bituminous road-mix surface courses (CEGS-02744), or cold-mix recycling (CEGS-02965). The appropriate CEGS can be selected based upon existing conditions in regards to the type and degree of contamination and the intended use of the contaminated soil mixture. The corresponding requirements for aggregate gradation and particle shape given for the various types of mixtures will have an effect in deciding the applicability of a particular type of asphalt mixture. Generally, the closer to the surface the material is placed the greater the quality required.

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4. Test Methods.

a. The level of contamination is an important parameter in determining the suitability of a contaminated soil for use in a ASB. Several states and other agencies use Total Petroleum Hydrocarbons (TPH) as a measure of contamination (Bell 1990, Bauman 1991, and Friend 1996). The problems with using TPH as the measure of contamination include a lack of national standards for measuring TPH and some analytical inconsistencies. Also, the parameter does not measure risks or indicate availability to humans or the environment (Bauman 1991 and Friend 1996). Several states use total benzene, toluene, ethyl benzene, and xylene (BTEX) or specific compound levels as the measure of contamination (Bell 1990). The relative mobility of the BTEX compounds make them the toxics of concern in many petroleum materials (Bauman 1991). While these are more effective than the TPH-based approaches, they may not allow for cleanup levels to be based on ability to achieve desired leachate levels (Friend 1996). The use of chemical-specific, risk-based approaches will allow a greater range of remediation technologies including ASB in dealing with contaminated soils. Benzene, listed in the 40 CFR 261.24 Toxicity Characteristics table, is the fuel related component most likely to cause concern. In an UST remediation project the 40 CFR 261.4(b)(10) exclusion can be applied to streamline the use of contaminated soil in ASB. However, if the contaminated material is not from an UST then the material is fully regulated under 40 CFR 260-268. The use of these materials in an ASB would be subject to 40 CFR 261.6 **Requirements of Recyclable Materials**. This section defines what constitutes recyclable materials and references 40 CFR 266 Subpart C. These regulations govern the use-limits for disposal (i.e. applied to or place on the land) of recyclable hazardous waste. If the original soils fail TCLP for organics, then the universal treatment standards are triggered under the land disposal restrictions (40 CFR 268.40/268.48) and the ASB produced will need to meet the regulatory limits identified in these.

b. Determination of the type or types of petroleum materials present in a contaminated soil will involve first an extraction process followed by an analysis of the extract. The type of test equipment most widely used to investigate this extract is the gas chromatograph (Fan, Krishnamurthy, and Chen 1994). This test is ideally suited for BTEX and all aromatic volatile organic compounds (API 1989 and Fan, Krishnamurthy, and Chen 1994). Test methods such as the EPA 8000 series are widely used methods that employ the gas chromatograph (API 1989). EPA 8020 and EPA 8240 are test methods often used for BTEX contaminants. EPA 8105 Modified and EPA 8100 Modified are test methods often used for kerosene, gasoline, diesel fuel, and jet fuel. Other sources of test procedures are the American Petroleum Institute and several states which have developed test methods of their own.

c. The amount of hydrocarbon leachate obtained from a sample of ASB material is used to measure the effectiveness of the asphalt mixture procedure. A Toxicity Characteristic Leaching Procedure (TCLP) extract test on various mixtures of ASB with the contaminated soil as part of the mixture will provide information on the mixture's ability to contain the contamination within

the ASB mixture. This test involves examination of any leachate from sample ASB mixtures with and without contaminated materials generally through use of a gas chromatograph.

5. Contamination Types and Levels.

a. The types of petroleum hydrocarbon materials that can appear in contaminated soils can vary considerably. The following is a list of possible materials (after Ellison 1991):

- Gasoline
- JP/4 Naphtha
- Jet Kerosene
- Lubricating Oil
- Diesel
- Light Fuel Oils No. 1 and No. 2
- Heavy Fuel Oils Nos. 4, 5, and 6
- Crude Oil
- Used Oil
- Asphalt

From this list the types normally associated with ASB material would include: diesel, light and heavy oils, crude oil, and asphalt. Gasoline contaminated soils can be dangerous, especially at high levels of concentration, due to their volatility which can constitute a fire or explosive hazard (Cole 1994). Diesel can incorporate a broad range of petroleum products which vary significantly in composition. Research has shown that all distillate fuels, such as diesel, contain polycyclic aromatic hydrocarbons (PAHs) (Stone 1991). The toxicity of diesel can be primarily related to these levels of PAH and these levels will vary widely between different diesel materials (Block et al. 1991).

b. One difficult issue of interest is the need to develop appropriate levels of contamination. There is a need to quantify low and high levels of contamination. Appropriate detection limits are needed. Some states and other agencies have allowable limits at or below detection limits for standard tests (Bauman 1991). Some materials are more difficult to detect than others and even the type of soil that was contaminated can have an effect on the results.

c. Soils lightly-contaminated with gasoline when used in small amounts can be used to produce ASB, but the final product tends to be of low quality (EPA 1992 and Friend 1996). This is because the light fraction hydrocarbons soften the asphalt cement binder, making the binder act like a cutback material which would require complete curing or evaporation of the gasoline to allow the asphalt cement to bind properly. Light and heavy fuel oils have been most commonly used to produce ASB; however, they also normally do not meet most state department of

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transportation (DOT) paving standards for mixture strength parameters such as Marshall and indirect tensile tests (EPA 1992).

6. Costs.

a. The costs involved in the use of contaminated soils in ASB will vary considerably with the type and level of contamination as well as with geographic location, due to differing requirements between states. In 1991, Ellison (Ellison 1991) gave a most likely cost range of \$65 to \$98 per m³ (\$50 to \$75 per yd³) and stated that under ideal conditions the range might be \$33 to \$65 per m³ (\$25 to \$50 per yd³). These costs do not directly reflect the costs involved in alternative methods of treatment or disposal or the costs involved in building an ASB without contaminated soils. Costs can be significantly reduced by combining both operations, disposal and construction, into one project. Savings will be reduced if the contaminated soil has to be transported long distances or if substantial amounts of the existing contaminated soil can not be used in the ASB (Dineen 1991). The costs involved must include the cost of toxicity or leachate testing to achieve regulatory approval.

b. Cost estimates on alternative methods of dealing with contaminated soils reflect a desire to achieve the most economical and environmentally sound method of remediation. Disposal costs in solid waste landfills will vary greatly in regards to geographic location and the type and level of contamination. Costs can range from \$4 to \$132 per ton with the national average in 1988 being \$27 per ton (EPA 1992). Costs associated with the use of contaminated soil in hot-mix asphalt mixtures, in 1992, ranged from \$50 to \$100 per ton (EPA 1992). Other remediation alternatives tend to have somewhat higher costs associated with them when compared to ASB procedures; however, they also can accommodate more variation in petroleum substances and levels of contamination. There are no direct cost comparisons available between the various remediation techniques that consider contaminated materials at levels of contamination suitable for the ASB procedure.

7. Performance History.

a. The ASB produced with contaminated soils has generally been used as fill material and for surfacing light-duty access roads, storage areas, and parking lots (Friend 1996). Contaminated soils have been used in ASB construction for surface courses for secondary roads (Neeley 1990 and Ellison 1991).

b. The Waterways Experiment Station (WES) has provided technical assistance on material characterizations, mix designs, and construction procedures on two projects using contaminated materials for asphalt pavement construction. A diesel contaminated soil, a contaminated asphalt cement, and existing reclaimed asphalt pavement (RAP) were used to construct ASB at Eielson AFB, AK. At Guam, a contaminated asphalt cement and asphalt cutback were used to develop

mix designs with local aggregates for both cold- and hot-mix asphalt mixtures. These asphalt materials were eventually used to construct a hot-mix asphalt pavement. The following paragraphs detail the information gained through conversations with various personnel at Eielson AFB and Guam and an evaluation trip to Eielson AFB.

Eielson AFB, AK

(1) Introduction

The Alaska District, U.S. Army Corps of Engineers (CE), developed a roadway improvement project to incorporate diesel contaminated soil and other waste materials into pavement construction materials for a roadway project. This achieved two objectives: (1) the disposal of contaminated materials in a cost-effective manner and (2) improvement of roadway quality with minimal expenditure of funds. Personnel from the Alaska District and the USAE Waterways Experiment Station formed a design team for this project. They established design sections and specification requirements. Since the materials used for construction were not uniform and did not meet all Corps of Engineers material specification requirements, the design requirements were non-specific and the project required close field control. The term *improved gravel surface* was used instead of *ASB surface* to prevent unrealistic expectations from Eielson personnel, because of the unknowns caused by the materials used.

(2) Materials

The diesel contaminated soil came from the removal of an UST during construction on the base. This resulted in the accumulation of approximately 230 m³ (300 yd³) of diesel contaminated soil. Another of the waste materials used in the project was an asphalt cement. This asphalt cement came from a site called the *asphalt lake*. This was the abandoned site of an asphalt plant that was used during the initial construction of pavements on the base. This location was also used for many years as the site for subsequent asphalt plant placement. This accumulation of asphalt cement (*asphalt lake*) had been formed over the years through spillage and abandonment of barrels of asphalt. In this remote area, barrels were often the only practical way to deliver asphalt cement to the plant. Barrels left over from the initial construction were made of wood. This asphalt cement contained pieces of wood, old metal tie bands, and other debris that had to be removed prior to using the asphalt cement. The other waste material used was a recyclable asphalt concrete pavement (RAP). The asphalt cement and asphalt cement saturated local soil were removed from the *asphalt lake* and stockpiled directly on top of the RAP stockpile.

(3) Material Investigation

Prior to construction, a laboratory analysis was conducted to determine if the asphalt mixture

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containing the contaminated soil would be susceptible to leaching. A laboratory analysis was performed on the contaminated soil by the Corps of Engineer's North Pacific Division (NPD) asphalt testing laboratory. This analysis included performing a Toxicity Characteristic Leaching Procedure (TCLP) on the contaminated soil. The contaminant levels of the soil varied from less than 100 to more than 10,000 ppm (EPA 8100 MOD). The NPD laboratory also performed an analysis using the diesel contaminated soil as part of a cold mix asphalt mixture. The mixtures produced with and without contaminated soil were constructed using CRD-C 649 and were analyzed with leachate tests. The CRD method is the standard CE procedure used to produce and test Marshall specimens and is similar to the American Society for Testing and Materials (ASTM) test method D-1559. Nine Marshall samples were made from each mixture and allowed to cure at room temperatures. These samples were divided into groups of three and then tested for Marshall Stability at 7 and 14 days at room temperature; one group was tested at 60 degrees C (140 degrees F). The stability values obtained show that an adequate road construction material could be produced using diesel contaminated soil and a cold mix construction method. TCLP extract tests on mixtures with and without contaminated materials showed that unacceptable levels of leaching would not occur.

(4) Design

(a.) The contaminated materials were to be incorporated into an improved gravel surfacing for the Ski Lodge Road. The existing roadway was approximately 1.3 km (0.8 mi) long with a gravel surface. The length of roadway that received the contaminated soil base course was approximately 550 m (1800 ft) long and 7.3 m (24 ft) wide. This road provides access to the Ravenwood Recreation Area, which consists of the local skiing area and skeet range. The roadway receives the majority of its traffic during the ski season and there is very little heavy vehicle traffic.

(b.) The design of the roadway cross-section was intended to maximize the use the available contaminated and waste materials and provide the Air Force base with an improved gravel surface. This use of contaminated soil gave the double benefit of providing locally available, inexpensive roadway construction materials and minimizing waste disposal costs by providing an alternative to landfill disposal or incineration. The design used was intended to seal the contaminated material between layers of asphalt materials with a multilayer design. Consideration of the volume of materials available resulted in a cross-section design consisting of a subbase, base course, and surface course. The subbase layer consisted of two 150 mm (6 in.) lifts of the asphalt cement and asphalt contaminated soils from the *asphalt lake* and a silty-sandy granular material blended at a ratio of 1:1. The base course layer consisted of a 100 mm (4 in.) lift of RAP blended at a ratio of 1:20 with the contaminated soil. The base course was stabilized with a CSS-1 asphalt emulsion. The surface course was a 75 mm (3 in.) lift of RAP also stabilized with a CSS-1 asphalt emulsion. The planning and performance of this project was done in accordance with the "Cold Asphalt Recycling" section (pages 14 and 15) of the Alaska Department of

Environmental Conservation's Guidance Manual for Storage, Remediation, and Disposal of Non-UST Petroleum Contaminated Soils, dated July 29, 1991.

(c.) The use of a surface treatment on top of the cold-mix RAP surfacing was investigated. It was not used, partly due to concerns with the short construction season and also in the belief that sealing the roadway would prevent proper curing and might trap moisture within the recycled pavement. Local experience has shown that surface treatments have not performed well in this area.

(5) Construction

Initial in-place mixing methods proved acceptable; however, difficulties due to oversized materials in the RAP stockpile and the existence of various debris materials in the stockpile slowed the mixing with the pulvermixer. The subgrade materials were only partially mixed, in that a loader alternated bucket loads of each material into the dump trucks for transport to the construction site. A late start and the slowed construction rate resulted in placement of only the subbase layer during the first year. During the winter the contractor was able to process the RAP stockpile through a crusher, resulting in a RAP material that was more homogeneous and properly sized for construction of a ASB. This crushing allowed the RAP material to be mixed in the pugmill of an asphalt stabilization plant during the second years construction, eliminating the need for in-place mixing. The pugmill mixing allowed for closer control of the proportions of the contaminated soil and surface mixtures. Both layers were placed with conventional asphalt concrete paving and compaction equipment. The minimum compactive effort applied consisted of at least two passes with a vibratory roller, four passes with a pneumatic roller, and finish rolling with as many passes with a steel-wheel roller as required to achieve density.

(6) Performance

The use of the materials at this site for pavement construction resulted in substantial savings in removal and disposal costs. The only distresses noted on the pavement surface were transverse cracks which occur randomly every 30 to 60 m (100 to 200 ft), minor surface imperfections (open surface texture, related to mixture design), and some minor surface damage cause by snow plows. The roadway has provided excellent performance by eliminating the need for occasional grading (required with the previous gravel surface) and by eliminating dust problems inherent with gravel roads. The materials placed on the road were only designed to provide an improved surfacing; however, the resultant surface has provided performance similar to that expected from a hot-mix asphalt concrete pavement. The contaminated materials provided a satisfactory material for pavement construction; the roadway has performed very well for almost 4 years. A recent pavement condition survey (PCI) obtained a value of 87, which categorizes the pavement as being in excellent condition.

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(7) Lessons Learned

(a.) This paragraph highlights important details or information that were gained during the design and construction of this project. Central plant (pugmill mixing) provides superior mixing when compared to in-place mixing of materials. The placement of these materials with a conventional asphalt paver proved very successful in obtaining desired grades and surface smoothness and in preventing mixture segregation. Large pieces of RAP material proved difficult to break up and required many passes of the pulvermixer to achieve the desired sizes. The cold weather, over the winter, allowed the contractor to crush the RAP into particle sizes of 50 mm (2 in.) or less. In anything but sub-freezing temperatures, especially with soft asphalt cements used in the area, crushing of the RAP would not have been possible. The smaller size of the RAP made it possible to mix the materials in a pugmill. The procedures used resulted in an excellent pavement for low intensity traffic.

(b.) Recent laboratory evaluation showed that the two mixtures contained near optimum asphalt content and other mixture properties, indicating that satisfactory performance could be expected. When the surface mixture was placed on a heavily trafficked quarry road with a suitable amount of base course it developed minimal distress and was providing a suitable riding surface. This would indicate that with high quality materials (RAP and asphalt cement) and good mixture design, construction procedures, and quality control, a high quality base or intermediate course for pavements can be constructed.

(8) *Guam*

(a.) The source of the contaminated materials on Guam included a large number of old rusting and leaking 55 gal drums containing asphalt cement and other petroleum materials. WES did an evaluation of the petroleum materials from samples obtained from several barrels and learned that the majority contained an asphalt cement similar in properties to an AC 20. A small number of the barrels contained a cutback asphalt cement equivalent to an MC 70. There were over 200 barrels of the asphalt materials and the cost to encapsulate each barrel inside another container and ship them for disposal was estimated at over 1 million dollars.

(b.) WES performed mix designs using these asphalt materials and local aggregates for both hot- and cold-mix asphalt concrete mixtures. The base decided to use the cutback material as a prime and a tack coat and use the asphalt cement to produce hot-mix asphalt. Two parking lots were paved with these materials.

(c.) Rather than paying the cost of disposal, the base was able to use these asphalt materials in pavement construction, turning a cost into a benefit. The parking lot pavements are performing

well and are expected to provide a service life equal to conventional hot-mix asphalt concrete pavements.

8. Construction Considerations.

a. Contaminated soils considered for use in ASB may contain cutback or emulsified asphalt, which may require additional considerations in the construction process. Cutback asphalts are no longer widely used in pavement construction due mainly to environmental concerns. Some contaminated soils, depending on the type and level of contaminant, can contain hydrocarbon levels similar to those found when using a cutback asphalt cement (Dineen 1991).

b. If ASB mixtures contain emulsified or cutback asphalt cements, they will need time to cure. This cure takes place as the water or solvent that was combined with the asphalt cement evaporates and only the asphalt cement binder remains. Generally, a 100 mm (4 in.) layer of ASB should be allowed to cure for at least 5 to 7 days depending upon weather conditions. The mixtures will cure faster in warmer, drier climatic conditions. The manual TM 5-822-8 provides guidance on cold-mix and stabilized materials.

c. The use of a test section prior to starting full production is recommended to verify the acceptability of the mix design and the construction procedures. A test section can be used to judge the ability of the construction procedures to satisfactorily mix and place the material. Usually, a percentage (normally 86 percent) of the theoretical maximum specific gravity is the amount of compaction required. The test section allows for verification of the compaction equipment and roller patterns. Obtaining samples for density verification can be difficult depending on the characteristics of the ASB material. Normally, asphalt concrete pavements are cored to obtain samples for density determination. However, the ASB may break apart under coring or subsequent handling. Other options that can be used are to saw cut a square or rectangular section, or a nuclear density gage calibrated with sand cone or water balloon densities may be utilized. When placing the mixture with a paver, the longitudinal joints should be constructed as a hot joint would be in hot-mix asphalt placement. This should increase joint density and increase the durability of the ASB mixture. Where this type of construction can not be accomplished, cutting back the compacted edge to a width at least equal to the depth of the layer, prior to placing the adjoining material should increase the density and durability of the joint.

d. Placement of a contaminated soil within an ASB will require a high degree of mixture control and uniformity. To achieve this the ASB should be mixed in a stationary pugmill mixer. These mixers allow various materials to be mixed, usually by weight, and allow for close gradation control and for accurate metering of asphalt and water into the mixture.

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9. Quality Control/Quality Assurance.

The quality control and quality assurance operations for ASB construction with contaminated soil should follow procedures as currently specified in CEGS-02233 or other appropriate specifications. Depending upon the properties of the contaminated soil, exact requirements may have to be expanded to allow the use of the soil, provided it will perform satisfactorily for the desired purpose.

10. Summary.

Contaminated soil has been used successfully by the U.S. Army Corps of Engineers to construct cold-mix asphalt base course at Eielson AFB in Alaska, and according to the literature in several installations have been made within the lower 48 states of the United States. The main parameters governing the use of a contaminated soil are the type of petroleum contaminant and the amount or degree of contamination. The type of contaminant can affect the type of asphalt cement that is added to the ASB material. Exact limits on the amount of contaminant that can be used are not well defined and would generally vary with the type of soil and will affect the amount that can be used in the overall ASB mixture. Leachate tests on various formulations that also provide the desired mixture strength and durability properties will provide definitive answers in regards to allowable levels of contaminated soil in the ASB mixture.

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