

AERÓDROMO MUNICIPAL DE SEIA
Reparação pontual da pista principal
Projeto de Execução



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PROJETO
(PJT.CNS---/19)

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AERÓDROMO MUNICIPAL DE SEIA

Reparação pontual da pista principal

Projeto de Execução

I – Memória Descritiva e Justificativa

1 - Enquadramento e âmbito do presente projeto

A presente memória descritiva e justificativa é relativa ao projeto de reparação de uma deformação localizada registada no PK 0+250, aproximadamente, que implicará o saneamento da estrutura existente e execução de novas camadas estruturais de pavimento, seguida de regularização da totalidade da plataforma, antes da aplicação das camadas de reforço.

Cabe apenas referir, em termos de drenagem, e efeito de enquadramento do estudo específico apresentado no Volume II deste projeto, que a pista se encontra praticamente ao mesmo nível que o da faixa de terreno em que se insere, a qual se prolonga, para além dos limites da pista, 140 m para Sudoeste e 37 m para Nordeste, tendo uma largura variável (incluindo a largura da pista) entre 60 m e 80 m, estando esta faixa razoavelmente regularizada e nivelada (declives máximos da ordem dos 2 %), não existindo quaisquer órgãos específicos de drenagem que promovam o afastamento das águas pluviais da plataforma pavimentada.



Figura 1: Inserção da pista na faixa de terreno confinante.

Esta situação, de deficiente drenagem, conjugada com a existência de solos vegetais (apesar de, em princípio, de reduzida espessura) encostados à plataforma pavimentada (situação que se verifica, com maior incidência entre o PK 0+000 e o pk 0+500 [ver peça desenhada 01.01.01.PE (Volume IV)], conforme poderá ser analisado com maior detalhe no Volume III deste projeto, tem conduzido ao longo do tempo à contaminação da base granular que compõe a estrutura do pavimento, no troço da pista mais a Nordeste, com finos e solos orgânicos provenientes dessas camadas.

No capítulo seguinte são apresentados de forma sucinta os resultados da prospeção geotécnica realizada, a qual serviu de base ao dimensionamento do reforço de pavimento preconizado, bem como de apoio à definição dos órgãos de drenagem.



Figura 2: Deficiente drenagem conjugada com solos vegetais nos limites da pista.

Esta contaminação poderá estar na origem do abatimento localizado alvo do presente projeto, localizado ao PK 0+250.



Figura 3: Abatimento localizado registado ao PK 0+250.

2 - Prospeção geotécnica realizada

No âmbito de um estudo mais abrangente, e com o intuito de avaliar a estrutura do pavimento existente, tanto em termos de espessuras das camadas betuminosas como de espessuras e constituição das bases granulares, e caracterizar os solos de fundação, em termos de constituição e capacidade de suporte, foram realizadas 8 carotes ao longo da pista e recolhidas amostras de solo em quatro locais (fora da pista, junto à plataforma pavimentada), sobre as quais se realizou uma bateria de ensaios de caracterização.

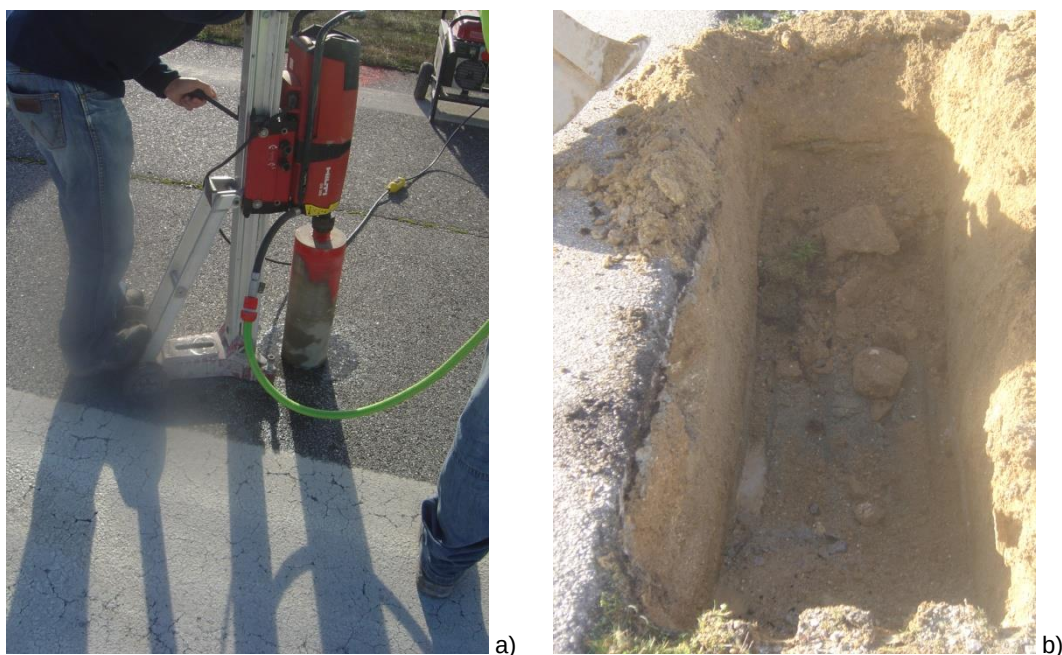


Figura 4: Prospeção geotécnica realizada: a) carotes no pavimento; b) poços junto à plataforma.

Complementarmente, e na sequência do abatimento registado ao PK 0+250, foi realizado um poço no pavimento (sobre a zona do abatimento), do qual foram recolhidas amostras, tanto da base granular como do solo de fundação para avaliação do teor de água.



Figura 5: Poço realizado no dia 14 de agosto de 2019, sobre a plataforma pavimentada da pista, na zona onde ocorreu o abatimento localizado.

As carotes de pavimento extraídas ao longo da pista, a cerca de 2 m da extremidade da plataforma pavimentada, nos locais identificados na peça desenhada 01.01.01.PE (Volume IV), conduziram aos seguintes resultados:

Tabela 1: Carotes no Pavimento – Espessuras medidas.

Medição de espessuras de camadas betuminosas (mm)			
Referência	Camada de desgaste	Camada de regularização	Espessura Total
BTM142A/11	24	48	72
BTM143A/11	37	74	111
BTM144A/11	34	59	93
BTM145A/11	40	47	87
BTM146A/11	46	51	97
BTM147A/11	35	48	83
BTM148A/11	37	40	77
BTM149A/11	38	66	104

Verifica-se desta forma a existência de duas camadas betuminosas distintas (base/regularização e desgaste), sendo a espessura média total de camadas betuminosas de, aproximadamente 90 mm. Para efeito de dimensionamento da estrutura de reforço, e apesar de se admitir que a espessura de betuminosas possa ser, na zona central da pista, superior à verificada na zona das bermas, considerou-se uma espessura efetiva de 50,8 mm, assumindo-se desta forma um fator de carga de 0,5 (que traduz a redução de espessura a considerar para efeito de dimensionamento, função do desgaste e da repetição de cargas ao longo da vida útil do pavimento, o qual foi executado nos anos 80).



a)



b)

Figura 6: Carote de pavimento – duas camadas betuminosas distintas.

No quadro seguinte apresentam-se os resultados dos ensaios realizados sobre as amostras de solo recolhidas nos poços abertos junto à berma.

Tabela 2: Quadro resumo dos resultados dos ensaios laboratoriais.

Poço / Referência	km	Ensaio							Observações
		Análise Granulométrica #10 #20 #200 (%)	Equivalente de areia médio	Teor em água (%)	Baridade seca máxima (g/cm³)	Teor em água ótimo (%)	Valor de azul de metileno (g/kg agr. 0/2mm)	CBR 5,0 (%)	
1 / SOL029A/11	0+250	21,08 12,06 0,58	17	13.4	2.07	6.5	10.1	7	Não plástico Sem expansibilidade relativa
2 / SOL030A/11	0+500	---	---	17.2	---	---	---	---	---
3 / SOL031A/11	0+950	27,86 9,24 0,51	21	11.9	---	---	6.3	---	Não plástico
4 / SOL032A/11	1+350	42,36 6,09 0,38	35	9.3	2.03	8.8	6.3	22	Não plástico Sem expansibilidade relativa

Poço no pavimento (realizado em 2019)		Teor em água (%)	Observações
Tout-Venant	AGR150A/19.1	4.2	Não plástico
Solo de fundação	SOL006A/19.1	10.4	Não plástico Sem expansibilidade relativa

Conforme se pode verificar temos duas zonas distintas, com capacidades de suporte completamente diferentes. No troço mais a Sudoeste (SOL032A/11) temos solos com maior capacidade de suporte (saibros bem calibrados), não plásticos, com teores em água próximos dos valores ótimos e, consequentemente, com um CBR de 22 %.

Já no troço mais a Nordeste (SOL029A/11), os solos apresentam uma capacidade de suporte reduzida. Trata-se de solos com alguma argila onde, apesar de serem classificados como não plásticos, apresentam alguma plasticidade (equivalente de areia menor que 20), com teores em água bastante acima do valor ótimo e, consequentemente, com um CBR de 7 %.

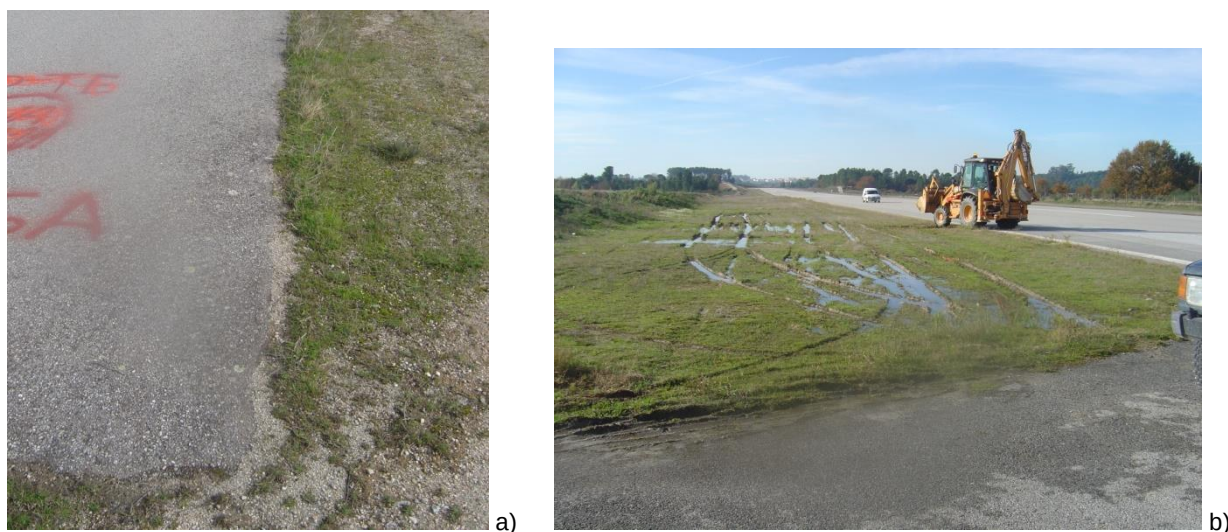


Figura 7: Troços diferentes em termos de características mecânicas da fundação: a) troço mais a Sudoeste; b) troço mais a Nordeste.

No troço com menor capacidade de suporte verifica-se ainda a existência de solos orgânicos nas camadas superficiais os quais estão ao nível da base granular do pavimento, o que, associado às deficientes condições de drenagem, não apenas da plataforma, mas também dos terrenos confinantes, conduziu já à contaminação da base granular com finos e matéria orgânica (conforme foi possível observar nas primeiras carotes extraídas – ver Figura 8, bem como no poço realizado no pavimento em 2019 – ver Figura 5 e Tabela 3), sendo esta uma das causas para o aparecimento “generalizado” de vegetação na zona das fissuras do pavimento.



Figura 8: Zona de extração de carote (PK 0+050) – Contaminação da fundação granular com finos e matéria orgânica.

A abertura dos poços junto à plataforma da pista permitiu ainda fazer uma avaliação aproximada da espessura da base granular existente sob as camadas betuminosas.

Para aferição destas espessuras, assim como para efeitos de avaliação do solo de fundação, o ideal teria sido a realização de poços no pavimento, situação esta que não foi possível, uma vez que os técnicos responsáveis pelo funcionamento do aeródromo não quiseram “rasgar” o pavimento existente.

Apenas em 2019, após a ocorrência do abatimento localizado, que conduziu ao encerramento do aeródromo, foi possível a realização de um poço no pavimento, conforme descrito anteriormente,

Apresenta-se abaixo uma tabela com a espessura aferida em cada um dos poços realizados, sendo que, para efeito de dimensionamento se considerou uma espessura de 25 cm.

Tabela 3: Quadro resumo das espessuras das camadas granulares.

Poço/ Referência	Imagem	Espessura da camada granular (cm)
1/ SOL029A/11		20
2/ SOL030A/11		25
3/ SOL031A/11		20
4/ SOL032A/11		25
Poço realizado em 2019		24

3 - Reparação da deformação localizada registada ao PK 0+250, aproximadamente

O abatimento (deformação localizada) a que se refere o presente capítulo, ocorreu ao km 0+250, aproximadamente, na zona Nordeste da pista onde, conforme referido anteriormente, “os solos apresentam uma capacidade de suporte reduzida. Trata-se de solos com alguma argila onde, apesar de serem classificados como não plásticos, apresentam alguma plasticidade (equivalente de areia menor que 20), com teores em água bastante acima do valor ótimo e, consequentemente, com um CBR de 7 %”.



Figura 1: Identificação do local onde ocorreu o abatimento (deformação localizada)..

3.1 - Solução de reparação para o caso de esta ocorrer antes da realização das restantes intervenções

A reparação desta situação implicará o saneamento da estrutura de pavimento existente e parte superior do solo de fundação, seguida de execução de uma nova estrutura de pavimento.

Havendo a intenção de executar esta reparação antes da realização das restantes intervenções (sem acautelar o correto encaminhamento das águas pluviais), a estrutura deverá ser reforçada, devendo a área de intervenção ser alargada da base para o topo das camadas a executar, de forma a existir uma transição mais suave entre as diferentes estruturas que ficarão em funcionamento.

Neste caso, o saneamento da estrutura de pavimento e fundação existentes deverá ser efetuado numa profundidade de 0.84m.

Nos primeiros 0.45 m (a contar a partir do fundo de caixa), a área mínima de intervenção será de 6.00 x 6.00 m², centrada na zona do abatimento (zona em que foi realizado o poço). Nos 0.30 m seguintes a área de intervenção deverá ser alargada para os 6.50 x 6.50 m². Nos 0.06 m seguintes (correspondentes à espessura correspondente à camada de base/regularização existente) a área de intervenção passará a ser de 7.00 x 7.00 m². Nos 0.03 m mais superficiais (correspondentes à espessura da camada de desgaste existente) a área de intervenção deverá ser de 7.25 x 7.25 m².

A nova estrutura de pavimento será constituída pelas seguintes camadas:

- a. 0.30 m de leito de pavimento em solos selecionados (numa área de 6.00 x 6.00 m²);
- b. Manta separadora, de geotêxtil não tecido termo soldado à base de polipropileno ou poliéster (numa área de 6.00 x 6.00 m²);
- c. 0.15 m de camada drenante em brita 3, isenta de pó ou argila (numa área de 6.00 x 6.00 m²);

- d. Manta separadora, de geotêxtil não tecido termo soldado à base de polipropileno ou poliéster (numa área de 6.50 x 6.50 m²);
- e. 0.15 m de camada de base granular em agregado britado de granulometria extensa (numa área de 6.50 x 6.50 m²);
- f. Manga plástica de polietileno c/ 250g/m² (numa área de 6.50 x 6.50 m²);
- g. 0.15 m de laje de betão armado com fibras (numa área de 6.00 x 6.00 m²) e 0.15 m de camada de base granular em agregado britado de granulometria extensa na restante área (até perfazer os 6.50 x 6.50 m²);
- h. 0.06 m de camada de base/regularização em mistura betuminosa densa (P-403) (numa área de 7.00 x 7.00 m²);
- i. 0.03 m de camada de desgaste em betão betuminoso (P-401) (numa área de 7.25 x 7.25 m²).

Nenhuma camada poderá ser executada antes de efetuada a devida compactação da camada inferior (incluindo o fundo de caixa, antes da execução do leito de pavimento).

O corte das camadas ligadas de pavimento nos limites de intervenção deverá ser feito com serra elétrica, devendo existir o cuidado de não danificar estas zonas durante o saneamento das camadas seguintes, sob pena de, no final, não ser possível efetuar a correta colagem das novas camadas ligadas às existentes.

Caso se verifique a degradação dos bordos do pavimento após realizado o saneamento e reposição das camadas não ligadas, deverá efetuar-se novo corte, de modo a regularizar a superfície, antes de aplicação das novas camadas betuminosas.

A cota final do pavimento após executada a reparação deverá corresponder à cota do pavimento existente (antes da ocorrência do abatimento).

4 - Peças Desenhadas

As peças desenhadas que fazem parte integrante deste estudo e que compõem Volume II, são as seguintes:

- 01.01.01.PE – Planta de localização da prospeção realizada e principais resultados (1 folha);
- 01.02.01.PE – Pavimento Tipo à escala 1:20 (1 folha).

5 - Considerações Finais

A presente memória descritiva e justificativa constitui o Volume I do Projeto de Execução. Fazem ainda parte integrante deste projeto os seguintes volumes:

- Volume II – Peças Desenhadas;

- Volume III – Caderno de Encargos;
- Volume IV – Mapa de Medições Detalhadas;
- Volume V – Mapa de Quantidades.

Coimbra, 14 de agosto de 2019

Autoria técnica

A Direção

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AERÓDROMO MUNICIPAL DE SEIA

Estudo de pavimentação e drenagem da pista principal

Projeto de Execução

II – Peças Desenhadas

Índice

- 01.01.01.PE – Planta de localização da prospeção realizada e principais resultados (escala 1:2000);
- 01.02.01.PE – Pavimento Tipo (escalas 1:20);

AERÓDROMO MUNICIPAL DE SEIA

Estudo de pavimentação e drenagem da pista principal

Projeto de Execução

III – Caderno de Encargos

CADERNO DE ENCARGOS

1 - Terraplenagem

1.1 - Leito do pavimento, incluindo tratamento ou fornecimento, e colocação dos materiais: (espessuras das camadas, após compactação).

1.1.1 Em escavações ou perfis mistos em solo:

1.1.1.1 Em solos "selecionados" (Classe S4 ou superior):

1.1.1.1.1 Com 0,30 m de espessura.

Especificações:

Esta rubrica inclui o fornecimento, a colocação dos materiais especificados e todos os ensaios previstos para a sua caracterização e trechos experimentais que se mostrem necessários para a definição e para avaliação das condições de colocação em obra.

A superfície da camada onde assenta o leito de pavimento deverá ser lisa, uniforme, isenta de fendas, ondulações ou material solto.

Os solos a aplicar em leito de pavimento deverão cumprir os seguintes requisitos:

- Dimensão máxima 75mm
- Percentagem passada no peneiro nº 200 ASTM, máxima 20%
- Limite de Liquidez, máximo 25%
- Índice de plasticidade, máximo 6%
- Equivalente de areia, máximo 30%
- Valor de Azul Metileno (material de dimensão inferior a 75µm, máximo 2,0
- CBR a 95% de compactação relativa, e teor em água (Proctor Modificado), mínimo 15%
- Expansibilidade (ensaio CBR), máxima 1,5%
- Percentagem de matéria orgânica 0%

As camadas de aterro deverão ter uma espessura máxima de 0,30m e deverão ser compactadas para valores de grau de compactação (em todas as camadas de aterro) de 95% reportados ao ensaio Proctor Modificado e não poderá definir mais de 15% do teor em água ótimo obtido no ensaio de referência.

A escolha do equipamento de compactação mais adequado e para se determinar as condições em que deverá ser executada a compactação, é aconselhável a construção de um aterro experimental com os tipos de solos exigidos, segundo as seguintes normas:

- Seleciona-se uma área no local com 30 m de comprimento por 15 m de largura, removendo-se os solos orgânicos de cobertura;
- Coloca-se os solos a usar no aterro em três faixas de 5 m de largura, com três espessuras diferentes;
- Começa-se por utilizar o solo no seu teor em humidade natural, e compacta-se com o tipo de equipamento que se projeta usar, determinando a baridade seca ao fim, por exemplo, de 2, 4 e 8 passagens;
- Repetem-se as operações precedentes, substituindo o solo e usando o teor em humidade ótimo respetivo;
- Repetem-se ainda as mesmas operações, substituindo novamente o solo, e utilizando um teor em humidade intermédio;
- No caso de o teor em humidade natural do solo ser próximo do teor ótimo, os três teores em humidade a escolher deverão ser iguais ao teor ótimo e 3% acima e abaixo desse valor;
- Com os resultados obtidos traçam-se gráficos, em presença dos quais se decidirá qual a melhor forma de compactação.

Os resultados obtidos no aterro experimental não inviabilizam condições eventualmente mais restritivas consignadas neste Caderno de Encargos, a menos que a Fiscalização expressamente admita o contrário.

O controlo de qualidade a realizar permitirá verificar a compatibilidade das características dos solos escavados com as características exigidas no Caderno de Encargos para os solos a aplicar nos aterros.

Os ensaios laboratoriais de identificação e caracterização dos solos a reutilizar nos aterros (onde inclui o leito de pavimento) serão:

- Granulometria;
- Limites de Consistência (LL e LP);
- Equivalente de Areia;
- Determinação de matéria orgânica;
- Azul Metileno;
- Proctor Modificado;
- CBR.

Este conjunto de ensaios deverá ser realizado sobre 1 amostra representativa do material por cada zona de proveniência (por cada tipo de escavação: na linha ou em empréstimo), antes da sua colocação em obra para aprovação dos materiais pela Fiscalização.

Posteriormente, dever-se-á realizar o mesmo conjunto de ensaios por cada 6.000,0m² de materiais aplicados.

Sempre que haja alteração do local de proveniência (escavação ou empréstimo), das características, ou uma significativa heterogeneidade dos materiais (ou mistura), este conjunto de ensaios deverá ser realizado com vista a atestar que as características pretendidas para estes materiais se verificam.

As normas de ensaio a adotar serão as constantes no II- Capítulo 14.00 - Controlo de Qualidade Caderno de Encargos Tipo Obra das Infraestruturas de Portugal, S.A. Em caso de impossibilidade de adoção das normas indicadas, deverá ser proposto, antes da realização dos ensaios respetivos, as normas alternativas para sua aprovação.

O controlo de qualidade a realizar em “in situ” será constituído pela realização de ensaios de determinação da baridade “in situ” e do teor em água, com recurso a gamadensímetro. Deverá ser realizado 1 ponto de medição (a 2 profundidades distintas: à superfície e a metade da espessura da camada a ensaiar) de 25 em 25m e com uma disposição em quincôncio.

Para as camadas de leito de pavimento devem ser cumpridos os critérios de aceitação, rejeição e ação corretiva a seguir expostos.

Tabela 1: Critérios de aceitação, rejeição e ação corretiva

Especificações		Critério de aceitação/rejeição	Ação Corretiva
Compactação Relativa	Média de Resultados >97%	90% de resultados individuais > 97%	Não aplicável
		10% de resultados individuais < 97%	Escarificar e refazer a camada

Critério de medição:

Unidade: metro quadrado (m²)

Corresponde à área, medida em planta, dos pavimentos betuminosos (40 cm), passadeiras (40 cm), plataforma elevada (40 cm) e passeios (20 cm) a executar, avaliada com base na cartografia disponibilizada pelo município para elaboração do projeto de execução, considerando-se a espessura indicada como o valor mínimo a garantir na camada.

1.2 - Geossintéticos em leitos do pavimento, incluindo fornecimento e colocação:

1.2.1 Geotêxteis.

Especificações:

Este artigo refere-se à aplicação de uma manta separadora, de geotêxtil não tecido Termo soldado à base de polipropileno ou poliéster, com resistência química aos ácidos e aos álcalis, de 200 gr/m², com uma sobreposição mínima de 0,30 m.

Os geotêxteis a aplicar na obra, em terraplenagem ou com outras funções, deverão ser submetidos à aprovação da Fiscalização, acompanhados de certificados de origem e ficha técnica, bem como dos resultados do controlo de fabrico e referência de obras em que tenha sido aplicado com idênticas funções.

Nenhum tipo de geotêxtil poderá ser aplicado em obra sem a prévia aprovação da Fiscalização, pelo que o seu estudo deverá ser apresentado com, pelo menos, um mês de antecedência. Deverá ser imputrescível, insensível à ação de ácidos ou bases e inatacável por microrganismos ou insetos e possuir as características mínimas estipuladas para as funções a que se destinam, definidas no projeto.

O material deverá apresentar textura e espessura homogêneas, sem defeitos, devendo ser protegido, aquando do armazenamento, dos raios solares, de sais minerais e de poeiras, chuva ou gelo.

No caso de ter havido deficiência no transporte, armazenamento ou manuseamento, ter-se-ão de eliminar as primeiras espiras do rolo com defeito.

Todas as características do geotêxtil deverão ser fixadas no projeto em função das condições de obra.

No caso dos geotêxteis a usar em terraplenagens as suas características não devem, todavia, ser inferiores às características mínimas a seguir indicadas, a não ser que o seu dimensionamento, demonstre claramente ser aconselhável, para aquelas condições específicas, adotar outros valores.

a) Solos de fundação com coesão não drenada ($C_u > 25$ kPa):

- Resistência à tração (EN ISO 10319), mínima.....10 kN/m
- Extensão na rotura (EN ISO 10319), mínima.....35%
- Resistência ao punçoamento (EN ISO 12236).....1,5 kN
- Permissividade (prEN 12040), mínima.....0,1 s⁻¹
- Porometria (O90) (Via húmida/Téc. LNEC), máxima 200 m

b) Solos de fundação muito compressíveis ($C_u < 25$ kPa):

- Resistência à tração (EN ISO 10319), mínima.....15 kN/m
- Extensão na rotura (EN ISO 10319), mínima.....40%
- Resistência ao punçoamento (EN ISO 12236).....1,5 kN
- Permissividade (prEN 12040), mínima.....0,2 s⁻¹
- Porometria (O90) (Via húmida/Téc. LNEC), máxima 150 m

MATERIAIS A APLICAR SOBRE OS GEOTÊXTEIS

Os materiais a aplicar sobre geotêxtil com função de separação, na parte inferior do aterro, serão isentos de detritos, matéria orgânica ou quaisquer outras substâncias nocivas, obedecendo ainda às seguintes características mínimas:

- Dimensão máxima..... 200 mm
- Percentagem de material passada no peneiro nº 200 ASTM 15%
- Limite de liquidez 25%
- Índice de plasticidade 6%
- Equivalente de areia..... 20%

O geotêxtil será aplicado, em princípio, segundo a direção longitudinal, com uma sobreposição mínima de 0,30 m ou 0,50 m em zonas com baixa capacidade de suporte ou preferenciais de tráfego de obra.

Em zonas localizadas, devido a uma muito baixa capacidade de suporte do solo de fundação, e caso o projeto não defina nada em contrário, poderá haver a necessidade de aumentar a sobreposição do geotêxtil para 1,0 m e/ou aplicá-lo transversalmente ao avanço dos trabalhos.

Sempre que as condições locais o aconselhem, designadamente quando o geotêxtil tiver de ser aplicado debaixo de água, poderá recorrer-se a outros processos de ligação, nomeadamente a cosedura ou soldadura, desde que autorizado previamente pela Fiscalização.

Uma vez estendido o geotêxtil, é interdita a circulação de equipamento pesado da obra (como por exemplo bulldozers, pás mecânicas, dumpers ou compactadores) enquanto não for espalhada a camada especificada para o seu recobrimento.

O transporte do material de recobrimento será efetuado por camiões basculantes, que se aproximarão sempre em "marcha-atrás", por forma a não pisar o geotêxtil, e que devem evitar fazer manobras direcionais que possam originar eventuais deslocamentos do geotêxtil.

Critério de medição:

Unidade: metro quadrado (m²)

Corresponde à área, medida em planta, da zona a sanear.

Não esquecer, contudo, que os pavimentos betuminosos (40 cm), passadeiras (40 cm), plataforma elevada (40 cm) e passeios (20 cm) a executar, avaliada com base na cartografia disponibilizada pelo município para elaboração do projeto de execução, considerando-se a espessura indicada como o valor mínimo a garantir na camada.

2 - Drenagem

2.1 - Execução de órgãos de drenagem longitudinal, incluindo todos os trabalhos necessários, e ainda, para a sua implantação, a escavação em terreno de qualquer natureza, a remoção, reposição e compactação, condução a vazadouro dos produtos sobrantes, e eventuais indemnizações por depósito:

Materiais constituintes dos betões para os órgãos de drenagem

No presente capítulo incluem-se os materiais utilizados no fabrico do betão a utilizar em peças de betão simples ou armado. Para efeitos deste Caderno de Encargos considera-se betão ciclópico o betão de cimento com 70% de pedra de enrocamento.

1 - LIGANTES HIDRÁULICOS

Os ligantes a utilizar na formulação de argamassas e betões estruturais, serão de natureza hidráulica devendo satisfazer as disposições insertas na NP2064, - Cimentos. Definições, composição, especificações e critérios de conformidade, de 1991 e sua emenda de 1993. Nestas condições os cimentos a utilizar devem subordinar-se aos tipos, composições, exigências mecânicas, físicas e químicas, estabelecidas naquela norma.

Em geral, o ligante hidráulico componente das argamassas e dos betões deve ser o cimento Portland, do tipo I das classes 32.5R ou 42.5R, e deverá obrigatoriamente conter a marca NP de conformidade com as normas dos cimentos.

Para condições ambientais agressivas deve utilizar-se um ligante do tipo IV das classes 32.5 ou 42.5, e deverá obrigatoriamente conter a marca NP de conformidade com as normas dos cimentos.

O cimento deve ser de preferência nacional, de fabrico recente e acondicionado por forma a ser bem protegido contra a humidade.

O cimento deve ser fornecido a granel e em situações específicas, em sacos. O cimento fornecido a granel deve ser armazenado em silos equipados com termómetros. Quando fornecido em sacos não será permitido o seu armazenamento a céu aberto, devendo ser guardado com todos os cuidados indicados no artigo 9.1.2.1 da NP ENV206 - Betão, comportamento, produção, colocação e critérios de conformidade, publicada ao abrigo do Decreto-Lei nº 330/95 de 14 de Dezembro.

Será rejeitado todo o cimento que se apresente endurecido, com grânulos, ou que se encontre mal-acondicionado ou armazenado. Quando em sacos, será rejeitado todo aquele que seja contido em sacos abertos ou com indícios de violação. O cimento rejeitado deve ser identificado e retirado do estaleiro em obra.

A mistura em obra de adições aos cimentos só deve ser admitida em casos excecionais devidamente justificados e quando a Indústria Cimenteira não produza, de forma corrente, cimentos certificados com características equivalentes.

Sem prejuízo do disposto no ponto anterior a junção de adições na fase de amassadura só pode ser admitida quando o cimento for do tipo I e tiver por objetivo a obtenção da durabilidade adequada para o betão dando satisfação, às Especificações e Normas em vigor.

De acordo com o ponto anterior a mistura de adições deve subordinar-se ao disposto na Especificação LNEC E378 Betões - Guia para a utilização de ligantes hidráulicos.

É vedado o recurso a qualquer adição que não esteja coberto pelas seguintes Normas ou Especificações:

NP4220 - Pozolanas para betão. Definições, especificações e verificação de conformidade.

NP EN450 - Cinzas volantes para betão. Definições, exigências e controlo de qualidade.

Especificação LNEC E375 - Escória granulada de alto forno moída para betões. Características e verificação de conformidade.

Especificação LNEC E376 - Filler calcário para betões. Características e verificação de conformidade.

Especificação LNEC E377 - Sílica de fumo para betões. Características e verificação de conformidade.

O cimento a ser empregue no betão prescrito para um dado elemento de obra deve ser sempre que possível da mesma proveniência, comprovada por certificados de origem. Caso contrário, deve o Adjudicatário demonstrar através de ensaios a equivalência das propriedades físicas, químicas e mecânicas dos cimentos empregues tendo em especial atenção a sua alcalinidade.

2 - INERTES

Os inertes para betões de ligantes hidráulicos devem obedecer, no que respeita as suas características e condições de fornecimento e armazenamento, ao estipulado na NP ENV206, e na Especificação LNEC E373 - Inertes para argamassas e betões. Características e verificação de conformidade.

O Adjudicatário apresentará para aprovação da Fiscalização o plano de obtenção de inertes, lavagem e seleção de agregados, proveniência, transporte e armazenagem, a fim de se verificar a garantia da sua produção e fornecimento com as características convenientes e constantes, nas quantidades e dimensões exigidas.

Os elementos individuais do inerte grosso devem ser de preferência isométricos, não devendo o seu coeficiente de forma exceder os 20 % do peso total:

- Uma partícula é considerada chata quando $d/b < 0,5$ e alongada quando $L/b > 1,5$, sendo "b" a largura, "d" a espessura e "L" o comprimento da partícula.

A dimensão máxima do inerte grosso não deverá exceder 1/5 da menor dimensão da peça a betonar, e nas zonas com armaduras não deverá exceder 3/4 da distância entre varões, ou entre bainhas de cabos de pré-esforço. O inerte grosso deve ser convenientemente lavado.

A areia deve ser convenientemente lavada e cirandada, se tal se mostrar necessário na opinião da Fiscalização. Sempre que a Fiscalização o exigir serão realizados os ensaios necessários para comprovar que as características dos inertes respeitam o especificado na NP ENV206.

3 – ÁGUA

A água a utilizar na obra, tanto na confeção dos betões e argamassas como para a cura do betão, deverá, na generalidade, ser doce, limpa e isenta de matérias estranhas em solução ou suspensão, aceitando-se como utilizável a água que, empregue noutras obras, não tenha produzido eflorescências nem perturbações no processo de presa e endurecimento dos betões e argamassas com ela fabricados.

De qualquer forma a água a utilizar será obrigatoriamente analisada devendo os resultados obtidos satisfazer os limites indicados no quadro 1 da especificação LNEC E372 - Água de amassadura para betões. Características e verificação da conformidade.

4 – ADJUVANTES

Os adjuvantes a incorporar nos betões com o fim de melhorarem a trabalhabilidade, manter esta reduzindo a água de amassadura, aumentarem a resistência ou com outras finalidades como acelerar ou retardar a presa, não devem conter constituintes prejudiciais em quantidades tais que possam afetar a durabilidade do betão ou provocar a corrosão das armaduras.

Os adjuvantes a incorporar nos betões de ligantes hidráulicos devem satisfazer o conjunto de exigências expressas na especificação LNEC E374 - Adjuvantes para argamassas e betões.

Características e verificação da conformidade. Assim os adjuvantes a incorporar ficam sujeitos a critérios de conformidade quanto às suas características de identificação, características de compatibilidade e características de comportamento enunciadas naquela especificação. Os adjuvantes empregues devem ainda satisfazer os critérios de conformidade e informações exigidas no ponto 6) da referida especificação.

A quantidade total de adjuvantes na composição, não deve exceder 50 g/kg de cimento e não convém que seja inferior a 2 g/kg de cimento. Só são permitidas quantidades menores de adjuvantes se estes forem dispersos em parte da água de amassadura. A quantidade de adjuvantes líquidos deve ser considerada no cálculo de relação A/C, sempre que exceda 3 litros/m³ de betão.

As condições e o tempo máximo de armazenamento dos adjuvantes em estaleiro devem observar as condições estipuladas pelo fabricante. Na ausência destas devem ser efetuados ensaios comprovativos de manutenção das características especificadas e comprovadas para os adjuvantes.

Em caso de dúvida sobre as características dos adjuvantes empregues ou a sua compatibilidade com quaisquer outros componentes do betão, pode a Fiscalização mandar efetuar os ensaios que entenda por necessários.

O Adjudicatário deverá indicar à Fiscalização os adjuvantes e as percentagens que pretende adotar na formulação dos diferentes betões, fazendo acompanhar essa indicação dos documentos de ensaio em laboratório oficial de todos os requisitos impostos na especificação LNEC E374 - Adjuvantes para argamassas e betões. Características e verificação da conformidade.

O Adjudicatário deverá contemplar a informação relativa aos adjuvantes com ensaios sobre a variabilidade da trabalhabilidade dos betões com eles produzidos na primeira hora, e das resistências aos 3, 7 e 28 dias de idade por forma a habilitar a Fiscalização com os elementos conducentes à aprovação da sua adoção.

5 - AÇO PARA BETÃO ARMADO

O aço das armaduras para betão será em varão redondo, laminado a quente, devendo satisfazer as prescrições em vigor que lhe forem aplicáveis.

O aço deve ser de um tipo homologado, e isento de zincagem, pintura, alcatroagem, argila, óleo ou ferrugem solta, obedecendo as prescrições do REBAP - Regulamento de Estruturas de Betão Armado e Pré-esforçado.

Os ensaios a realizar serão de tração sobre provetes proporcionais longos, e de dobragem, efetuados de acordo com a legislação em vigor, respetivamente a ISO 15630-1 (Secção 5), ISO 6892-1 e ISO 15630-1 (Secção 6), conforme estipulam os artigos 21 e 22 do REBAP, e ainda os necessários para satisfazer o disposto nos artigos 154 a 157, e 174, do mesmo regulamento.

No caso de se pretenderem efetuar emendas dos varões por soldadura realizar-se-ão ensaios com a finalidade a que se referem os artigos 21 e 156 do diploma citado na alínea anterior.

Materiais “pré-fabricados” para órgãos de drenagem

Os materiais “prefabricados” de betão, PP ou outros, utilizados em órgãos de drenagem, devem ser acompanhados, aquando da sua entrada em estaleiro, de certificados de origem e qualidade de fabrico, passados pelo fabricante, comprovativos das especificações constantes deste Caderno de Encargos. Devem ainda obedecer a:

- Sendo nacionais, às normas portuguesas, documentos de homologação de laboratórios oficiais, regulamentos em vigor e especificações deste Caderno de Encargos;
- Sendo estrangeiros, às normas e regulamentos em vigor no país de origem, desde que não existam normas nacionais aplicáveis. No entanto, os certificados deverão ser passados por laboratórios de reconhecida idoneidade, confirmada pelos laboratórios oficiais e/ou entidades oficiais;

- Especificações do fabricante.

As dimensões e os materiais constituintes deverão ainda apresentar as características discriminadas neste Caderno de Encargos, ou outras equivalentes, desde que patenteadas e previamente aprovadas pela Fiscalização.

2.1.1 Drenos de plataforma (longitudinais e transversais):

2.1.1.1 Drenos de plataforma transversais:

2.1.1.1.1 Camada drenante com 0.15 m de espessura.:

Material drenante

O material a utilizar na camada drenante sob o pavimento, de preferência britado, deverá obedecer às seguintes prescrições:

A granulometria deverá integra-se no seguinte fuso:

PENEIRO ASTM	PERCENTAGEM ACUMULADA DO MATERIAL QUE PASSA
37,5 mm (1 1/2")	100
31,5 mm (1 1/4")	75 - 100
19,0 mm (3/4")	55 - 85
9,51 mm (3/8")	40 - 70
4,75 mm (nº 4)	0 - 10
2,00 mm (nº 10)	0 - 8
0,075 mm (nº 200)	0 - 2

- Percentagem máxima de desgaste na máquina de Los Angeles (Granulometria F) 40%

Esta rubrica inclui o fornecimento, a colocação dos materiais especificados e todos os ensaios previstos para a sua caracterização e trechos experimentais que se mostrem necessários para a definição e para avaliação das condições de colocação em obra.

MATERIAIS A APLICAR NA CAMADA DRENANTE SOBREJACENTE AO GEOTÊXTIL

O material a aplicar sobre geotêxteis com a finalidade de constituir uma camada drenante sob aterros e/ou bases granulares em agregado britado de granulometria extensa, para escoamento das águas resultantes do processo de consolidação de formações aluvionares muito compressíveis, deverá ser de qualidade uniforme, isento de matéria orgânica ou de outras substâncias prejudiciais e obedecer às seguintes características mínimas:

AREIA

- Granulometria de dimensões nominais 0,06 / 6 mm

- Percentagem de material passada no peneiro nº 200 ASTM 6%
- Equivalente de areia 70%

MATERIAL ROCHOSO

- Dimensão máxima 200 mm
- Percentagem de material passada no peneiro nº 200 ASTM 5%
- Equivalente de areia 60%
- Desgaste de Los Angeles (Granul.F) 50%

2.1.2 Drenos de plataforma (longitudinais e transversais):

2.1.2.1 Geotêxteis

Os geotêxteis a aplicar na obra em envolvimento de materiais drenantes deverão ser imputrescíveis, insensíveis à ação de ácidos ou bases e inatacáveis por micro-organismos e deverão ser submetidos à aprovação da Fiscalização, acompanhados de certificados de origem, bem como dos resultados do controlo de fabrico. Deverão ainda conter estabilizadores e/ou inibidores adicionados à base, a fim de tornar os filamentos resistentes à deterioração por exposição aos raios ultravioletas e ao calor.

No caso de o material ser em polyester não especificamente tratado, haverá que impedir o seu contacto com betões hidráulicos frescos.

Todas as características do geotêxtil deverão ser fixadas em função das condições particulares da obra, obedecendo a um processo de dimensionamento para cada situação, mas devendo, todavia, ser balizadas pelos seguintes valores:

- Resistência à tração (EN ISO 10319), mínima 15 kN/m
- Extensão na rotura (EN ISO 10319), mínima 50%
- Resistência ao punçoamento (EN ISO 12236) 2,0 kN
- Permissividade (prEN 12040), mínima 1,0 s⁻¹
- Porometria (prEN ISO 12956), máxima 150 µm

3 - Pavimentação

3.1 - Camadas granulares:

Os agregados, provenientes da exploração de formações homogéneas, devem ser limpos, duros, pouco alteráveis sob a ação dos agentes climáticos, de qualidade uniforme e isentos de materiais decompostos, de matéria orgânica ou outras substâncias prejudiciais.

Antes da execução da camada de base do pavimento devem ser verificadas as condições em que se encontra a plataforma de apoio do pavimento - camada de leito do pavimento - nomeadamente o seu nivelamento e a sua capacidade de suporte. A superfície da camada deve ser regular, com a inclinação transversal definida em projeto para a camada de desgaste.

O controlo de qualidade das camadas de leito de pavimento deverá ser de acordo com o exposto no Artigo 5.1.

Nas situações em que não haja leito de pavimento, dever-se-á proceder à regularização da superfície e, no caso de estes se encontrarem com humidade elevada, à escarificação superficial do terreno de fundação e posterior recompactação.

Deve ser apresentado à Fiscalização para aprovação, pelo menos 30 dias antes do início da aplicação em obra, um estudo laboratorial da mistura agregados britados naturais que inclua a seguinte informação:

Requisitos relativos à mistura de agregados;

- Designação da mistura, incluindo a sua origem;
- Conteúdo máximo e mínimo de finos e percentagem de material que passa no peneiro superior D (sobretamanhos), enquadrados nos valores especificados nas tabelas de requisitos granulométricos;
- Curva granulométrica de referência (fórmula da mistura), compreendida no fuso granulométrico definido nas tabelas de requisitos granulométricos;
- Valores da baridade seca e do teor de água ótimo de laboratório, determinados pelo método de ensaio de compactação Proctor Modificado, de acordo com a EN 13286-2.

O relatório de ensaio elaborado de acordo com a EN 13286-2, incluindo a informação opcional, deve ser anexado ao estudo de caracterização laboratorial a apresentar.

As camadas granulares a compactar deverão ter uma espessura máxima de 0,15 m.

Uma vez aprovados os materiais granulares pela Fiscalização, deve ser realizado um trecho experimental em obra que permita aferir o número ótimo de passagens do cilindro compactador para o grau de compactação pretendido. O relatório do trecho experimental deve ser apresentado à Fiscalização para aprovação, pelo menos 5 dias antes do início da execução das camadas de sub-base e deverá incluir a seguinte informação:

- Localização e data de execução;
- Metodologia de execução (subdivisão do trecho em zonas, transporte e manuseamento do material, espalhamento, número de passagens dos cilindros por zona, equipamento utilizado);
- Amostragem e ensaios realizados;
- Gráfico da relação entre a variação do grau de compactação e o número ótimo de passagens dos cilindros;
- Conclusões.

Só se iniciam os trabalhos de execução em obra depois da aprovação do trecho experimental pela Fiscalização.

Antes do início do processo de fabrico e durante o período de execução dos trabalhos, é obrigatório o armazenamento dos materiais necessários à produção estimada de 15 dias.

O material deve ser armazenado de um modo controlado e os locais de armazenamento e os seus conteúdos devem estar devidamente identificados (designação da mistura, origem e tipo de agregado utilizado). Não devem ser armazenados no mesmo depósito materiais de origens e tipos diferentes. No caso de agregados reciclados no armazenamento é obrigatório separar os materiais em função da sua origem e dos seus constituintes principais.

Devem ser providenciadas as medidas necessárias para que a qualidade do material seja mantida durante o seu manuseamento e armazenamento, tendo em conta a eventual contaminação e segregação do material, a limpeza do equipamento e das áreas de armazenamento e a correta drenagem dos locais de armazenamento.

O armazenamento deve processar-se construindo um depósito com camadas de espessura não superior a 3,0 m e formando degraus nos bordos das camadas, de modo a evitar a formação de taludes contínuos. O material deve ser espalhado com trator de rastos e ser depositado na frente da camada. O carregamento para transporte deve ser feito frontalmente e com equipamento adequado. O material não deve ser armazenado em pilhas.

O armazenamento ao longo da linha poderá ser efetuado em situações excecionais, mediante a aprovação da Fiscalização. Nesses casos, deve ser feito de acordo com as necessidades de aplicação, de modo a evitar operações de carga e transporte complementares. A plataforma subjacente deve ser previamente preparada e aprovada pela Fiscalização. O transporte deve ser realizado por camiões basculantes. Antes do transporte deve ser verificado o teor de água. Se o material se encontrar excessivamente seco, deve ser feita a correção do teor de água por rega da frente de carregamento.

No espalhamento do material devem ser utilizadas motoniveladoras ou pavimentadoras adequadas, que permitam uma modelação homogénea da superfície, próxima da forma definitiva da camada, e que a sua espessura, após compactação, seja a prevista no projeto.

Se durante o espalhamento se formarem rodeiras ou vincos que não possam ser facilmente eliminados por cilindramento, deve proceder-se à escarificação e homogeneização da camada e à posterior regularização da sua superfície.

A compactação da camada deve ser efetuada por cilindro vibrador, seguida da compactação com cilindros de pneus. Antes da compactação deve ser verificado o teor de água do material e, caso se justifique, deve proceder-se à sua correção. Se o teor de água for excessivo a camada deve ser escarificada de modo a facilitar a sua secagem. Caso contrário, deve proceder-se a uma distribuição uniforme e rápida de água, empregando-se para tal carros tanques de pressão cujo jato deverá cobrir a largura total da área a tratar.

Atendendo ao facto que o trabalho decorrerá em zona urbana consolidada e em que existirão, certamente, infraestruturas enterradas, a escolha dos equipamentos de espalhamento e compactação a afetar à obra deverá ter em conta estes aspetos.

O controlo de qualidade a realizar permitirá verificar a compatibilidade das características dos materiais a colocar em obra com as características exigidas no Caderno de Encargos para os materiais a aplicar.

Os ensaios laboratoriais de identificação e caracterização dos materiais serão:

- Granulometria;
- Equivalente de Areia;
- Los Angeles e Micro Deval;
- Azul Metileno;
- Proctor Modificado;
- Massa Volúmica e Absorção de água.

O adjudicatário deverá apresentar, para cada fornecimento de material, certificados de origem e ficha técnica, bem como, os resultados do controlo de fabrico. Após a aprovação dos materiais a utilizar, o adjudicatário deverá enviar 1 amostra representativa a um laboratório certificado, com o objetivo de comprovar as características constantes no certificado e previstas no Caderno de Encargos, e de acordo com o conjunto de ensaios mencionado anteriormente.

As normas de ensaio a adotar serão as constantes no Volume II- Capítulo 14.00 - Controlo de Qualidade Caderno de Encargos Tipo Obra das Infraestruturas de Portugal, S.A. Em caso de impossibilidade de adoção das normas indicadas, deverá ser proposto, antes da realização dos ensaios respetivos, as normas alternativas para sua aprovação.

O controlo de qualidade dos materiais aplicados durante a execução da obra consistirá na realização do conjunto de ensaios laboratoriais mencionados anteriormente e por cada 2.500 m de extensão de faixa.

Sempre que haja alteração do local de proveniência dos materiais (pedreira ou de lote de fabrico), das características, ou uma significativa heterogeneidade dos materiais, este conjunto de ensaios deverá

ser realizado sobre uma amostra representativa com vista a atestar que as características pretendidas para estes materiais se verificam. O adjudicatário deverá apresentar os certificados de origem e ficha técnica, bem como, os resultados do controlo de fabrico dos novos materiais.

O controlo de qualidade a realizar em obra será constituído pela realização de ensaios de determinação da baridade “in situ” e do teor em água, com recurso a gamadensímetro. Deverá ser realizado 1 ponto de medição (à superfície da camada a ensaiar) em cada camada, de 25 em 25m, e em quincêncio.

Para a camada de base, devem ser cumpridos os critérios de aceitação, rejeição e ação corretiva apresentados na Tabela 3.

Tabela 2: Critérios de aceitação/rejeição e ação corretiva

Especificações		Critério de aceitação/rejeição	Ação Corretiva
Compactação Relativa	Média de Resultados $\geq 98\%$	90% de resultados individuais $\geq 98\%$	Não aplicável
		10% de resultados individuais $< 97\%$	Escarificar e refazer a camada

Antes da execução das camadas do pavimento sobrejacentes às camadas de sub-base e base, a Fiscalização pode solicitar a execução de “ensaios de carga” expeditos, por exemplo recorrendo à passagem de um camião carregado e observando os efeitos, que permitam detetar eventuais zonas instáveis.

3.1.1 Camada de base:

Esta rubrica inclui o fornecimento a carga, o transporte, espalhamento e compactação dos materiais especificados e todos os ensaios previstos para a sua caracterização e trechos experimentais que se mostrem necessários para a definição e avaliação das condições de colocação em obra.

Os requisitos dos agregados para camadas granulares com características de base encontram-se especificadas no quadro abaixo.

Tabela 3: Requisitos/Propriedades dos agregados para camadas granulares com características de base

Requisitos/Propriedades	Referência Normativa	Unidade	Camada de Base
			ABGE
Forma do Agregado grosso	NP EN933-3	%	30
% de partículas esmagadas ou partidas e de partículas totalmente roladas nos agregados grossos	NP EN 933-5	%	C _{90/3}
Qualidade dos finos – Valor de Equivalente de Areia, mínimo e Valor de Azul Metileno, máximo	NP EN 933-8, NP EN 933-9	% g/kg	Se a % de passados no peneiro de 0,063mm for inferior a 3% os finos poderão ser considerados não prejudiciais. Se o teor total de finos for superior a 3%, então $SE \geq 50$. Caso $SE < 50$ então $MB \leq 2,0$

Requisitos/Propriedades	Referência Normativa	Unidade	Camada de Base
			ABGE
Resistência à fragmentação do agregado grosso, coeficiente de Los Angeles	NP EN 1097-2	%	LA ₄₀
Resistência por desgaste por atrito do agregado grosso, coeficiente micro-deval	NP EN 1097-1	%	M _{DE25}
Massa Volúmica das partículas	NP EN 1097-6	Mg/m ³	A declarar
Absorção de Água	NP EN 1097-6	%	A declarar
“Sonnembrand” do basalto	NP EN1367-3 E NP EN 1097-2	%	
Resistência ao gelo e degelo (valor de absorção de água (wa) como ensaio de triagem e valor de sulfato de magnésio (MS)) (d)	NP EN1097-6 NPEN1367-2	%	Se absorção de água for superior a WA ₂₄ 2 o valor de sulfato de magnésio deve estar enquadrado em MS ₃₅
NA - Não Aplicável (a) – Como a Norma NP EN 13242 não possui as categorias FI ₃₀ e LA ₄₅ são indicados os valores requeridos. (b) - Para agregados suscetíveis de degradação pela ação do gelo-degelo, expostos a ambientes sujeitos ao gelo e ao degelo, a situações de humidade elevada ou à água do mar, o ensaio de absorção de água deve ser utilizado como ensaio de triagem. Se a absorção de água não for superior ao valor especificado na categoria WA ₂₄ 2 ou W _{cm} 0,5, o agregado deve ser considerado como resistente ao gelo-degelo.			

Quanto aos requisitos granulométricos, os materiais granulares deverão respeitar o exposto no quadro seguinte.

Tabela 4: Requisitos granulométricos dos materiais granulares

Requisitos/Propriedades	Referência Normativa	Unidade	Camada de Base	
			ABGE	
Designação agregado/mistura	NP EN 13242	-	Mistura 0/31,5	
Teor de Finos	NP EN 13242, NP EN 933-1	%	NA	
Conteúdo de Finos, máximo	NP EN 13285 NP EN 933-1	%	UF ₇	
Conteúdo de Finos, mínimo			LF ₂	
Sobretamanhos			OC ₈₀	
Curva granulométrica	EN 13285 (G _B) NP EN 13242 (G _F)		G _B	
Dimensão dos peneiros de referência			Fuso Granulométrico - % de material acumulada de material passado	
40	NP EN 13242 EN 13285 NP EN 933-2	mm		100
31.5			D	80-99
22.4			A	-
16			B	63-77
8				43-60
6.3	NP EN 13242 EN 13285 NP EN 933-2	mm	C	-
5.6			E	-
4			F	30-52

Requisitos/Propriedades	Referência Normativa	Unidade	Camada de Base	
			ABGE	
2			G	23-40
1				14-35
0.5				10-30
0.25				-
0.125				-
0.063				2-7
D – Abertura do Peneiro superior que pode reter material, em milímetros. A,B,C,E,F,G – Peneiros para granulometria de acordo com a EN13285, secção 4.4.1				

3.2 - Camadas de misturas com ligantes hidráulicos

3.2.1 Com características de base:

3.2.1.1 Em laje de betão com fibras metálicas:

3.2.1.2 Com 0,15 m de espessura.

Fabricação do betão com características e composição específica para receber, sem segregação, fibras metálicas devendo ser seguidas as recomendações do respetivo fornecedor de fibras. A resistência mecânica deverá corresponder à classe C25/30.

Adição de fibras metálicas tipo HE 1/50 da “Arcelor Mittal”, ou equivalente, ao betão, numa dosagem de 30 kg/m³. A mistura deverá garantir a distribuição uniforme das fibras no betão.

Espalhamento, regularização e compactação do betão com vibradores de agulha e régua vibradora. A espessura da camada será de 0.10 m.

3.3 - Camadas de misturas betuminosas a quente

Seguidamente são apresentadas as características dos materiais a utilizar na realização das camadas betuminosas previstas, sendo que estes elementos foram transcritos da Advisory Circular n.º 150/5370-10F – “Standards for Specifying Construction of Airports”, da FAA (Federal Aviation Administration – U.S. Department of Transportation).

Surface Preparation

ITEM P-101 SURFACE PREPARATION

DESCRIPTION

101-1.1 This item shall consist of preparation of existing pavement surfaces for overlay, removal of existing pavement, and other miscellaneous items. The work shall be accomplished in accordance with these specifications and the applicable drawings.

For projects that involve preparing and repairing the existing pavement to accommodate an overlay, add the following Item P-101: Surface Preparation.

EQUIPMENT

101-2.1 All equipment shall be specified hereinafter or as approved by the Engineer. The equipment shall not cause damage to the pavement to remain in place.

CONSTRUCTION

101-3.1 REMOVAL OF EXISTING PAVEMENT

a. Concrete: The existing concrete to be removed shall be freed from the pavement to remain unless jackhammers are used for the complete removal. This shall be accomplished by line drilling or sawing through the complete depth of the slab 1 ft inside the perimeter of the final removal limits or outside the load transfer devices, whichever is greater. In this case, the limits of removal would be located on joints. If line drilling is used, the distance between holes shall not exceed the diameter of the hole. The pavement between the perimeter of the pavement removal and the saw cut or line-drilled holes shall be removed with a jackhammer. Where the perimeter of the removal limits is not located on the joint, the perimeter shall be saw cut 2 in in depth or 1/4 the slab thickness, whichever is less. Again, the concrete shall be line drilled or saw cut the full depth of the pavement 6 in inside the removal limits. The pavement inside the saw cut or line shall be broken by methods suitable to the Contractor; however, if the material is to be wasted on the airport site, it shall be reduced to a maximum size designated by the airport owner. The Contractor's removal operation shall not cause damage to cables, utility ducts, pipelines, or drainage structures under the pavement. Any damage shall be repaired by the Contractor at no expense to the airport owner.

b. Asphaltic Concrete: Asphaltic concrete pavement to be removed shall be cut to the full depth of the bituminous material around the perimeter of the area to be removed. The pavement shall be removed in such a manner that the joint for each layer of pavement replacement is offset 1 ft from the joint in the preceding layer. This does not apply if the removed pavement is to be replaced with concrete or soil. If the material is to be wasted on the airport site, it shall be broken to a maximum size as designated by the airport owner.

101-3.2 PREPARATION OF JOINTS AND CRACKS.

All joints and cracks in bituminous and concrete pavements to be overlaid with asphaltic concrete shall be cleaned of joint and crack sealer, debris, and vegetation. Any excess joint or crack sealer on the surface of the pavement shall also be removed from the pavement surface. If vegetation is a problem a soil sterilant shall be applied. Cracks and joints wider than 3/8 in shall be filled with a mixture of emulsified asphalt and

aggregate. The aggregate shall consist of limestone, volcanic ash, sand, or other material that will cure to form a hard substance. The combined gradation shall be as shown in Table 1.

Table 1

Sieve Size	Percent Passing
No. 4	100
No. 8	90-100
No. 16	65-90
No. 30	40-60
No. 50	25-42
No. 100	15-30
No. 200	10-20

Up to 3% cement can be added to accelerate the set time. The mixture shall not contain more than 20% natural sand without approval in writing from the Engineer.

The proportions of asphalt emulsion and aggregate shall be determined in the field and may be varied to facilitate construction requirements. Normally, these proportions will be approximately one part asphalt emulsion to five parts aggregate by volume. The material shall be poured into the joints or cracks or shall be placed in the joint or crack and compacted to form a voidless mass. The joint or crack shall be filled within 0 to 1/8 in of the surface. Any material spilled outside the width of the joint shall be removed from the surface prior to constructing the overlay. Where concrete overlays are to be constructed, only the excess joint material on the surface and vegetation in the joints need to be removed.

101-3.3 REMOVAL OF PAINT AND RUBBER.

All paint and rubber over 1 ft wide that will affect the bond of the new overlay shall be removed from the surface of the existing pavement. Chemicals, high-pressure water, heater scarifier (asphaltic concrete only), cold milling, or sandblasting may be used. Any methods used shall not cause major damage to the pavement. Major damage is defined as changing the properties of the pavement or removing pavement over 1/8 in deep. If chemicals are used, they shall comply with the state's environmental protection regulations. No material shall be deposited on the runway shoulders. All wastes shall be disposed of in areas indicated in this specification or shown on the plans. This specification shall not be used for removal of rubber deposits to improve skid resistance or obliterate traffic markings where a new overlay is not to be constructed.

101-3.4 CONCRETE SPALL OR FAILED ASPHALTIC CONCRETE PAVEMENT REPAIR.

a. Repair of Concrete Spalls in Areas to be overlaid with Asphalt: The Contractors shall repair all spalled concrete as shown on the plans or as directed by the Resident Engineer. The perimeter of the repair shall be sawed a minimum of 1 in deep or shall be cut with approved tools to this depth. The deteriorated material shall be removed to a depth where the existing material is firm or cannot be easily removed with a geologist pick. The removed area shall be filled with asphaltic concrete with a minimum Marshall stability of 1,200 lbs. and maximum flow of 20. The material shall be compacted with equipment approved by the Resident Engineer until the material is dense and no movement or marks can be noted. The material shall not be placed in lifts over 4 in in depth. This method of repair applies only to pavement to be overlaid.

b. Asphaltic Concrete Pavement Repair: The failed areas shall be removed as specified in paragraph 101-3.1b. All failed material including surface, base course, subbase course, and subgrade shall be removed. The base course and subbase shall be replaced if it has been infiltrated with clay, silt, or other material affecting the load-bearing capacity. Materials and methods of construction shall comply with the other applicable sections of this specification.

101-3.5 COLD PLANING.

a. Patching: The machine shall be capable of cutting a vertical edge without chipping or spalling the edges of the pavement to remain. The machine shall have a positive method of controlling the depth of cut. The Engineer shall layout the area to be milled. The area shall be laid out with straightedges in increments of 1 ft widths. The area to be milled shall cover only the failed area. Any excessive area that is milled because the Contractor doesn't have the appropriate machine, or areas that are damaged because of his negligence, shall not be included in the measurement for payment.

b. Profiling, Grade Correction, or Surface Correction: The machine shall have a minimum width of 10 feet. It shall be equipped with electronic grade control devices on both sides that will cut the surface to the grade and tolerances specified. The machine shall cut vertical edges. A positive method of dust control shall be provided. The machine shall be capable of discharging the millings in a truck or leaving them in a defined windrow.

METHOD OF MEASUREMENT

101-4.1 MEASUREMENT.

a. General: If there is no quantity shown in the bidding schedule, the work covered by this section shall be considered as a subsidiary obligation of the Contractor covered under the other contract items. Only accepted work will be measured.

b. Pavement Removal: The unit of measurement for pavement removal shall be the number of square yards removed by the Contractor. Any pavement removed outside the limits of removal because the pavement was damaged by negligence on the part of the Contractor shall not be included in the measurement for payment.

c. Joint and Crack Repair: The unit of measurement for joint and crack repair shall be the linear foot of joint.

d. Paint and Rubber Removal: The unit of measurement for paint and rubber removal shall be the square foot.

e. Spall and Failed Asphaltic Concrete Pavement Repair:

(1) The unit of measure for concrete spall repair shall be the number of square feet. The average depth of the patch shall be agreed upon by the Contractor and the Resident Engineer. The quantity shall be divided in the following categories:

- (a) 0 to 4 in in average depth
- (b) 4 to 8 in in average depth
- (c) Greater than 8 in in average depth

(2) The unit of measure for failed asphaltic concrete pavement shall be as follow:

- (a) Asphaltic concrete sq yd
- (b) Base course sq yd
- (c) Subbase course square yd
- (d) Subgrade sq yd

f. Cold Planing: The unit of measure for cold planing shall be the number of square yards. The average depth of the cold planing shall be determined by the Engineer and the Contractor prior to accomplishment of the work. When surface correction is required, if the initial cut doesn't correct the condition, the Contractor shall re-plane the area and will be paid only once for the total depth of planning. The quantity shall be divided into the following categories:

- (a) 0 to 2 in
- (b) 0 to 3 in
- (c) 0 to 4 in
- (d) 0 to 5 in
- (e) 0 to 6 in

BASIS OF PAYMENT

101-5.1 PAYMENT. Payment shall be made at contract unit price for the unit of measurement as specified hereinbefore. This price shall be full compensation for furnishing all materials and for all preparation, hauling, and placing of the material and for all labor, equipment, tools, and incidentals necessary to complete this item.

END OF ITEM P-101

3.3.1 Com características de regularização

3.3.1.1 P-403 Base and Leveling (Mistura Betuminosa Densa)

3.3.1.1.1 Com 0,06 m de espessura.

PLANT MIX BITUMINOUS PAVEMENTS (BASE, LEVELING OR SURFACE COURSE)

DESCRIPTION

403-1.1 This item shall consist of a [] course composed of mineral aggregate and bituminous material mixed in a central mixing plant and placed on a prepared course in accordance with these specifications and shall conform to the lines, grades, thicknesses, and typical cross sections shown on the plans. Each course shall be constructed to the depth, typical section, and elevation required by the plans and shall be rolled, finished, and approved before the placement of the next course.

Specify base and/or leveling course. Surface course may also be specified but only for those pavements designed to accommodate aircraft of gross weights less than or equal to 12,500 pounds (5,670 kg) or for surface course of shoulders, blast pads, service roads, etc. Item P-401 is to be specified for surface courses for pavements designed to accommodate aircraft gross weights greater than 12,500 pounds (5,670 kg).

This specification is to be used as a base or leveling course for pavements designed to accommodate aircraft of gross weights greater than 12,500 pounds (5,670 kg). State highway department specifications may be used in lieu of this specification for access roads, perimeter roads, stabilized base courses under Item P-501, and other pavements not subject to aircraft loading, or for pavements designed for aircraft gross weights of 12,500 pounds (5,670 kg) or less.

Where a state highway department specification is to be used in lieu of this specification, the state specification must have a demonstrated satisfactory performance record under equivalent loadings and exposure. When a density requirement is not specified by a state specification, it is to be modified to incorporate the language found in paragraphs 403-5.1, 403-5.2 and 403-5.3. When state highway specification are approved, include all applicable/approved state specifications in the contract documents.

MATERIALS

403-2.1 AGGREGATE. Aggregates shall consist of crushed stone, crushed gravel, or crushed slag with or without natural sand or other inert finely divided mineral aggregate. The portion of combined materials retained on the No. 4 (4.75 mm) sieve is coarse aggregate. The portion of combined materials passing the No. 4 (4.75 mm) sieve and retained on the No. 200 (0.075 mm) sieve is fine aggregate, and the portion passing the No. 200 (0.075 mm) sieve is mineral filler.

a. Coarse Aggregate. Coarse aggregate shall consist of sound, tough, durable particles, free from adherent films of matter that would prevent thorough coating and bonding with the bituminous material and be free from organic matter and other deleterious substances. The percentage of wear shall not be greater than [] percent when tested in accordance with ASTM C 131. The sodium sulfate soundness loss shall not exceed 10 percent, or the magnesium sulfate soundness loss shall not exceed 13 percent, after five cycles, when tested in accordance with ASTM C 88.

Percentage of wear shall not exceed 40 for surface, binder, and leveling courses and 50 for base course. Aggregates with a higher percentage loss of wear or soundness may be specified in lieu of those indicated, provided a satisfactory service record under similar conditions of service and exposure has been demonstrated.

Aggregate shall contain at least [] percent by weight of individual pieces having two or more fractured faces and [] percent by weight having at least one fractured face. The area of each face shall be equal to at least 75 percent of the smallest midsectional area of the piece. When two fractured faces are contiguous, the angle between the planes of fractures shall be at least 30 degrees to count as two fractured faces. Fractured faces shall be obtained by crushing.

For pavement courses designed for aircraft gross weights of 60,000 pounds (27 200 kg) or more, the Engineer shall specify 70 percent for two fractured faces and 85 percent for one fractured face. For pavement courses designed for aircraft gross weights less than 60,000 pounds (27 200 kg), the Engineer shall specify 50 percent for two fractured faces and 65 percent for one fractured face.

In areas where slag is not available or desired, the references to it should be deleted from all aggregate paragraphs.

The aggregate shall not contain more than a total of 8 percent, by weight, of flat particles, elongated particles, and flat and elongated particles, when tested in accordance with ASTM D 4791 with a value of 5:1.

The Engineer may specify ASTM D 4791 with a ratio of 3:1. If so, replace the above paragraph as follows: “The aggregate shall not contain more than a total of 20 percent by weight of flat particles, elongated particles, and flat and elongated particles when tested in accordance with ASTM D 4791 with a value of 3:1.”

Slag shall be air-cooled, blast furnace slag, and shall have a compacted weight of not less than 70 pounds per cubic foot (1.12 mg/cubic meter) when tested in accordance with ASTM C 29.

b. Fine Aggregate. Fine aggregate shall consist of clean, sound, durable, angular shaped particles produced by crushing stone, slag, or gravel that meets the requirements for wear and soundness specified for coarse aggregate. The aggregate particles shall be free from coatings of clay, silt, or other objectionable matter and shall contain no clay balls. The fine aggregate, including any blended material for the fine aggregate, shall have a plasticity index of not more than 6 and a liquid limit of not more than 25 when tested in accordance with ASTM D 4318.

Natural (non-manufactured) sand may be used to obtain the gradation of the aggregate blend or to improve the workability of the mix. The amount of sand to be added will be adjusted to produce mixtures conforming to requirements of this specification. [The fine aggregate shall not contain more than 15 percent natural sand by weight of total aggregates.] If used, the natural sand shall meet the requirements of ASTM D 1073 and shall have a plasticity index of not more than 6 and a liquid limit of not more than 25 when tested in accordance with ASTM D 4318.

The aggregate shall have sand equivalent values of [] or greater when tested in accordance with ASTM D 2419.

Typically the sand equivalent value should be 45, unless local conditions require lower value.

The addition of natural sand to a mix containing all crushed coarse and fine aggregates will normally increase its workability and compactability. However, the addition of excessive amounts of natural sand tends to decrease the stability of the mixture. The requirement for a sand equivalent value of 45 usually limits the use of natural sand; however, the maximum of 15 percent natural sand may be included for locations where low stabilities are a chronic problem.

c. Sampling. ASTM D 75 shall be used in sampling coarse and fine aggregate, and ASTM C 183 shall be used in sampling mineral filler.

403-2.2 MINERAL FILLER. If filler, in addition to that naturally present in the aggregate, is necessary, it shall meet the requirements of ASTM D 242.

403-2.3 BITUMINOUS MATERIAL. Bituminous material shall conform to the following requirements: [].

Asphalt cement binder shall conform to [AASHTO MP1 Performance Grade (PG) [____]] [ASTM D 3381 Table 1, 2, or 3 Viscosity Grade] [ASTM D 946 Penetration Grade [____]]. Test data indicating grade certification shall be provided by the supplier at the time of delivery of each load to the mix plant. Copies of these certifications shall be submitted to the Engineer. The Engineer shall specify the grade of bituminous material, based on geographical location and climatic conditions. Asphalt Institute Superpave Series No. 1 (SP-1) provides guidance on the selection of performance graded binders. Table VI-1, Selecting Asphalt Grade, contained in the Asphalt Institute's Manual Series-1 (MS-1) provides guidance on the selection of asphalt type. For cold climates, Table 2 of ASTM D 3381 may be specified to minimize the susceptibility for thermal cracking. The Engineer should be aware that PG asphalt binders may contain modifiers that require elevated mixing and compaction temperatures that exceed the temperatures specified in Item P-403.

Grades of some materials are listed below:

NOTE: Performance Graded (PG) asphalt binders should be specified wherever available. The same grade PG binder used by the state highway department in the area should be considered as the base grade for the project (for example, the grade typically specified in that specific location for dense graded mixes on highways with

design ESAL less than 10 million). The exception would be that grades with a low temperature higher than PG XX-22 should not be used (for example, PG XX-16 or PG XX-10), unless the Engineer has had successful experience with them. Typically, rutting is not a problem on airport runways. However, at airports with a history of stacking on end of runways and taxiway areas, rutting has accrued due to the slow speed of loading on the pavement.

If there has been rutting on the project or it is anticipated that stacking may accrue during the design life of the project, then the following grade “bumping” should be applied for the top 125 mm (5 in) of paving in the end of runway and taxiway areas: for aircraft tire pressure between 100 and 200 psi, increase the high temperature one grade; for aircraft tire pressure greater than 200 psi, increase the high temperature two grades. Each grade adjustment is 6 °C. Polymer Modified Asphalt, PMA, has shown to perform very well in these areas. The low temperature grade should remain the same.

Additional grade bumping and grade selection information is given in Table A.

Table A. Binder Grade Selection and Grade Bumping Based on Gross Aircraft Weight

Aircraft Gross Weight (pounds)	High Temperature Adjustment to Base Binder Grade	
	Pavement Type	
	Runway	Taxiway/Apron
Less than 12,500	--	--
Less than 60,000	--	1
Less than 100,000	--	1
Greater than 100,000	1	2
1. PG grades above a -22 on the low end (for example, 64-16) are not recommended. Limited experience has shown this to be a poor performer. 2. PG grades below a 64 on the high end (for example, 58-22) are not recommended. These binders often provide tender tendencies. 3. PG grades above a 76 on the high end (for example, 82-22) are very stiff and may be difficult to work and compact.		

Grade Specification			
Penetration Grade ASTM D 946	Viscosity Grade ASTM D 3381		Performance Graded Asphalt Institute Superpave Series No. 1(SP-1)
40-50	AC-5	AR-1000	In general, the Engineer should choose a PG-asphalt binder that has been approved for use in the vicinity by the State DOT, and is locally available. In general, a high reliability (98 percent) on both the high and low temperature categories is sufficiently conservative.
60-70	AC-10	AR-2000	
85-100	AC-15	AR-4000	
100-120	AC-20	AR-8000	
120-150	AC-30		
	AC-40		

The Contractor shall furnish vendor's certified test reports for each lot of bituminous material shipped to the project. The vendor's certified test report for the bituminous material can be used for acceptance or tested independently by the Engineer.

403-2.4 PRELIMINARY MATERIAL ACCEPTANCE. Prior to delivery of materials to the job site, the Contractor shall submit certified test reports to the Engineer for the following materials:

a. Coarse Aggregate.

- (1) Percent of wear.
- (2) Soundness.
- (3) Unit weight of slag.
- (4) Percent fractured faces

b. Fine Aggregate.

- (1) Liquid limit.
- (2) Plasticity index.
- (3) Sand equivalent.

c. Mineral Filler.

d. Bituminous Material. Test results for bituminous material shall include temperature/viscosity charts for mixing and compaction temperatures.

The certifications shall show the appropriate ASTM tests for each material, the test results, and a statement that the material meets the specification requirement.

The Engineer may request samples for testing, prior to and during production, to verify the quality of the materials and to ensure conformance with the applicable specifications.

403-2.5 ANTI-STRIPPING AGENT. Any anti-stripping agent or additive if required shall be heat stable, shall not change the asphalt cement viscosity beyond specifications, shall contain no harmful ingredients, shall be added in recommended proportion by approved method, and shall be a material approved by the Department of Transportation of the State in which the project is located.

COMPOSITION

403-3.1 COMPOSITION OF MIXTURE. The bituminous plant mix shall be composed of a mixture of well-graded aggregate, filler and anti-strip agent if required, and bituminous material. The several aggregate fractions shall be sized, handled in separate size groups, and combined in such proportions that the resulting mixture meets the grading requirements of the job mix formula (JMF).

403-3.2 JOB MIX FORMULA. No bituminous mixture for payment shall be produced until a job mix formula has been approved in writing by the Engineer. The bituminous mixture shall be designed using procedures contained in Chapter 5, MARSHALL METHOD OF MIX DESIGN, of the Asphalt Institute's Manual Series No. 2 (MS-2), Mix Design Methods for Asphalt Concrete, sixth edition, and shall meet the requirements of Tables 1, 2 and 3.

Tensile Strength Ratio (TSR) of the composite mixture, as determined by ASTM D 4867, shall not be less than 75. Anti-stripping agent shall be added to the asphalt, as necessary, to produce a TSR of not less than 75. If an anti-strip agent is required, it will be provided by the Contractor at no additional cost to the Owner.

Engineer may specify a TSR of not less than 80 in areas that are prone to stripping at a TSR of 75.

The job mix formula shall be submitted in writing by the Contractor to the Engineer at least [] days prior to the start of paving operations and shall include as a minimum:

- a. Percent passing each sieve size for total combined gradation, individual gradation of all aggregate stockpiles and percent by weight of each stockpile used in the job mix formula.
- b. Percent of asphalt cement.
- c. Asphalt performance, viscosity or penetration grade, and type of modifier if used.
- d. Number of blows of hammer compaction per side of molded specimen.
- e. Mixing temperature.
- f. Compaction temperature.
- g. Temperature of mix when discharged from the mixer.
- h. Temperature-viscosity relationship of the asphalt cement.
- i. Plot of the combined gradation on the Federal Highway Administration (FHWA) 45 power gradation curve.
- j. Graphical plots of stability, flow, air voids, voids in the mineral aggregate, and unit weight versus asphalt content.
- k. Percent natural sand.
- l. Percent fractured faces.
- m. Percent by weight of flat particles, elongated particles, and flat and elongated particles (and criteria).
- n. Tensile Strength Ratio (TSR).
- o. Anti-strip agent (if required).

The Contractor shall submit to the Engineer the results of verification testing of three (3) asphalt samples prepared at the optimum asphalt content. The average of the results of this testing shall indicate conformance with the job mix formula requirements specified in Tables 1, 2 and 3.

When the project requires asphalt mixtures of differing aggregate gradations, a separate job mix formula and the results of job mix formula verification testing must be submitted for each mix.

The job mix formula for each mixture shall be in effect until a modification is approved in writing by the Engineer. Should a change in sources of materials be made, a new job mix formula must be submitted within [] days and approved by the Engineer in writing before the new material is used. After the initial production job mix formula has been approved by the Engineer and a new or modified job mix formula is required for whatever reason, the subsequent cost of the Engineer's approval of the new or modified job mix formula will be borne by the Contractor. There will be no time extension given or considerations for extra costs associated with the stoppage of production paving or restart of production paving due to the time needed for the Engineer to approve the initial, new or modified job mix formula.

The Engineer shall specify the number of days. A minimum of 10 days is recommended.

For mixes with maximum size aggregate of 1" or less, the Marshall Design Criteria applicable to the project shall be specified by the Engineer from the information shown below and inserted into Table 1. Asterisks denote insert points.

Test Property	Pavements Designed for Aircraft Gross Weights of 60,000 Lb or More or Tire Pressures of 100 PSI or More	Pavements Designed for Aircraft Gross Weights Less Than 60,000 Lb or Tire Pressures Less Than 100 PSI
Number of Blows	75	50
Stability, pounds (Newtons)	1800 (8006)	1000 (4448)

Test Property	Pavements Designed for Aircraft Gross Weights of 60,000 Lb or More or Tire Pressures of 100 PSI or More	Pavements Designed for Aircraft Gross Weights Less Than 60,000 Lb or Tire Pressures Less Than 100 PSI
Flow, 0.01 in. (0.25 mm)	8-16	8-20
Air Voids (percent)	2-5	2-5
Percent Voids in Mineral Aggregate (minimum)	See Table 2.	See Table 2.

For mixes with maximum size aggregate greater than 1 in up to a maximum of 1-½ in, the Marshall Design Criteria shall be modified by the Engineer per the guidance found in Asphalt Institute Manual Series No. 2 (MS-2), Chapter 5 and the test method specified shall be ASTM D 5581 in lieu of ASTM D 6926. Modifications to the flow criteria may be required for modified asphalt cement binders.

Table 1. Marshall Design Criteria

Test Property	*
Number of blows	*
Stability, pounds (Newtons) minimum	*
Flow, 0.01 in. (0.25 mm)	*
Air voids (percent)	*
Percent voids in mineral aggregate, minimum	See Table 2.

Table 2. Minimum Percent Voids In Mineral Aggregate

Maximum Particle Size		Minimum Voids in Mineral Aggregate, percent
in	mm	Percent
½	12.5	16
¾	19.0	15
1	25.0	14
1 ½	37.5	13

Modifications to the minimum VMA as found in Table 2 may be made depending on the definition of maximum particle size and/or local conditions.

The mineral aggregate shall be of such size that the percentage composition by weight, as determined by laboratory sieves, will conform to the gradation or gradations specified in Table 3 when tested in accordance with ASTM C 136 and C 117.

The gradations in Table 3 represent the limits that shall determine the suitability of aggregate for use from the sources of supply. The aggregate, as selected (and used in the JMF), shall have a gradation within the limits designated in Table 3 and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve, or vice versa, but shall be well graded from coarse to fine.

Deviations from the final approved mix design for bitumen content and gradation of aggregates shall be within the action limits for individual measurements as specified in paragraph 403-6.5a. The limits still will apply if they fall outside the master grading band in Table 3.

The maximum size aggregate used shall not be more than one-half of the thickness of the course being constructed except where otherwise shown on the plans or ordered by the Engineer.

Table 3. Aggregate - Bituminous Pavements Sieve Size	Percentage by Weight Passing Sieve
1 ½ in. (37.50 mm)	*
1 in. (25.0 mm)	*
¾ in. (19.0 mm)	*
½ in. (12.5 mm)	*
⅜ in. (9.5 mm)	*
No. 4 (4.75 mm)	*
No. 8 (2.36 mm)	*
No. 16 (1.18 mm)	*
No. 30 (0.60 mm)	*
No. 50 (0.30 mm)	*
No. 100 (0.15 mm)	*
No. 200 (0.075 mm)	*
Asphalt Percent:	
Stone or gravel	*
Slag	*

The aggregate gradations shown are based on aggregates of uniform specific gravity. The percentages passing the various sieves shall be corrected when aggregates of varying specific gravities are used, as indicated in the Asphalt Institute Manual Series No. 2 (MS-2), Chapter 3.

The aggregate gradation shall be specified by the Engineer from the gradations shown in this note. The gradation shall be inserted into Table 3. Asterisks denote insert points.

Where locally-available aggregates cannot be economically blended to meet the grading requirements of the gradations shown, the gradations may be modified to fit the characteristics of such local aggregates with approval of the FAA. The modified gradation must produce a paving mixture that satisfies the mix design requirements.

Aggregate - Bituminous Pavements

Sieve Size	Percentage by Weight Passing Sieves			
	1-½" max	1" max	¾" max	½" max
1-½ in. (37.5 mm)	100	--	--	--

Sieve Size	Percentage by Weight Passing Sieves			
	1-½" max	1" max	¾" max	½" max
1 in. (24.0 mm)	86-98	100	--	--
¾ in. (19.0 mm)	68-93	76-98	100	--
½ in. (12.5 mm)	57-81	66-86	79-99	100
⅜ in. (9.5 mm)	49-69	57-77	68-88	79-99
No. 4 (4.75 mm)	34-54	40-60	48-68	58-78
No. 8 (2.36 mm)	22-42	26-46	33-53	39-59
No. 16 (1.18 mm)	13-33	17-37	20-40	26-46
No. 30 (0.600 mm)	8-24	11-27	14-30	19-35
No. 50 (0.300 mm)	6-18	7-19	9-21	12-24
No. 100 (0.150 mm)	4-12	6-16	6-16	7-17
No. 200 (0.075 mm)	3-6	3-6	3-6	3-6
Asphalt Percent:				
Stone or gravel	4.5-7.0	4.5-7.0	5.0-7.5	5.5-8.0
Slag	5.0-7.5	5.0-7.5	6.5-9.5	7.0-10.5

403-3.3 RECYCLED ASPHALT CONCRETE. Recycled HMA shall consist of reclaimed asphalt pavement (RAP), coarse aggregate, fine aggregate, mineral filler, and asphalt cement. The RAP shall be of a consistent gradation and asphalt content and properties. When RAP is fed into the plant, the maximum RAP chunk size shall not exceed 2 in. The recycled HMA mix shall be designed using procedures contained in AI MS-02. The recycled asphalt concrete mix shall be designed using procedures contained in the Asphalt Institute's Manual Series Number 2 (MS-2). The percentage of asphalt in the RAP shall be established for the mixture design according to ASTM D 2172 using the appropriate dust correction procedure. The job mix shall meet the requirements of paragraph 403-3.2 RAP should only be used for shoulder surface course mixes and for any intermediate courses. The amount of RAP shall be limited to [] percent.

Reclaimed Asphalt Pavement (RAP) should not be used for surface mixes, except on shoulders. It can be used very effectively in lower layers or for shoulders. Engineer to specify the maximum percentage of reclaimed asphalt allowed in the mix. The amount of RAP shall be limited to 30 percent, as long as the resulting recycled mix meets all requirements that are specified for virgin mixtures. The Contractor may obtain the RAP from the job site or an existing source.

In addition to the requirements of paragraph 403-3.2, the job mix formula shall indicate the percent of reclaimed asphalt pavement and the percent and viscosity grade of new asphalt. The Contractor shall submit documentation to the Engineer, indicating that the mixing equipment proposed for use is adequate to mix the percent of RAP shown in the job mix formula and meet all local and national environmental regulations.

The appropriate test should be selected to conform to the grade of new asphalt specified. If a penetration grade is specified, use penetration test. If a viscosity grade is specified, use a viscosity test. If a PG asphalt binder is specified, use the dynamic shear rheometer and bending beam tests. RAP containing coal tars may be require additional precautions during production and may be excluded.

The blend of new asphalt cement and the RAP asphalt binder shall meet the requirements in paragraph 403-2.3. The virgin asphalt cement shall not be more than two standard asphalt material grades different than that specified in paragraph 403-2.3

Delete paragraph 403-3.3 in its entirety if recycled asphalt pavement is not to be allowed and include a sentence that RAP will not be permitted to be used.

403-3.4 TEST SECTION. Prior to full production, the Contractor shall prepare and place a quantity of bituminous mixture according to the job mix formula. The amount of mixture shall be sufficient to construct a test section [] long and [] wide, placed in two lanes, with a longitudinal cold joint, and shall be of the same depth specified for the construction of the course which it represents. A cold joint is an exposed construction joint at least 4 hours old or whose mat has cooled to less than 160 °F. The underlying grade or pavement structure upon which the test section is to be constructed shall be the same as the remainder of the course represented by the test section. The equipment used in construction of the test section shall be the same type and weight to be used on the remainder of the course represented by the test section. The test section shall be evaluated for acceptance as a single lot in accordance with the acceptance criteria in paragraph 403-5.1 and 403-6.3. The test section shall be divided into equal sublots. As a minimum the test section shall consist of 3 sublots.

The test section shall be considered acceptable if the average mat density of the test section cores is greater than or equal to 98 percent and the average joint density of the test section cores is greater than or equal to 95 percent. If the initial test section should prove to be unacceptable, the necessary adjustments to the job mix formula, plant operation, placing procedures, and/or rolling procedures shall be made. A second test section shall then be placed. If the second test section also does not meet specification requirements, both sections shall be removed at the Contractor's expense. Additional test sections, as required, shall be constructed and evaluated for conformance to the specifications. Any additional sections that are not acceptable shall be removed at the Contractor's expense. Full production shall not begin until an acceptable section has been constructed and accepted in writing by the Engineer. Once an acceptable test section has been placed, payment for the initial test section and the section that meets specification requirements shall be made in accordance with paragraph 403-8.1.

Job mix control testing shall be performed by the Contractor at the start of plant production and in conjunction with the calibration of the plant for the job mix formula. If the aggregates produced by the plant do not satisfy the gradation requirements or produce a mix that meets the JMF, it will be necessary to reevaluate and redesign the mix using plant-produced aggregates. Specimens shall be prepared and the optimum bitumen content determined in the same manner as for the original design tests.

The test section should be a minimum of 300 feet (90 m) long and 20 to 30 feet (6 to 9 m) wide. The test section affords the Contractor and the Engineer an opportunity to determine the quality of the mixture in place, as well as performance of the plant and laydown equipment.

403-3.5 JOB MIX (JMF) FORMULA LABORATORY. The Contractor's laboratory used to develop the job mix formula (JMF) shall meet the requirements of ASTM D 3666. The laboratory accreditation must be current and listed on the accrediting authority's website. All test methods required for developing the JMF must be listed on the lab accreditation. A copy of the laboratory's current accreditation and accredited test methods shall be submitted to the Engineer prior to start of construction.

CONSTRUCTION METHODS

403-4.1 WEATHER LIMITATIONS. The bituminous mixture shall not be placed upon a wet surface or when the surface temperature of the underlying course is less than specified in Table 4. The temperature

requirements may be waived by the Engineer, if requested; however, all other requirements including compaction shall be met.

Table 4. Base Temperature Limitations

Mat Thickness	Base Temperature (Minimum)	
	Deg. F	Deg. C
3 in. (7.5 cm) or greater	40	4
Greater than 1 in. (2.5 cm) but less than 3 in. (7.5 cm)	45	7
1 in. (2.5 cm) or less	50	10

403-4.2 BITUMINOUS MIXING PLANT. Plants used for the preparation of bituminous mixtures shall conform to the requirements of ASTM D 995 with the following changes:

a. Requirements for all plants include:

(1) Truck Scales. The bituminous mixture shall be weighed on approved scales furnished by the Contractor, or on certified public scales at the Contractor's expense. Scales shall be inspected and sealed as often as the Engineer deems necessary to assure their accuracy. Scales shall conform to the requirements of the General Provisions, Section 90-01.

In lieu of scales, and as approved by the Engineer, asphalt mixture weights may be determined by the use of an electronic weighing system equipped with an automatic printer that weighs the total paving mixture. Contractor must furnish calibration certification of the weighing system prior to mix production and as often thereafter as requested by the Engineer.

(2) Testing Facilities. The Contractor shall provide laboratory facilities at the plant for the use of the Engineer's acceptance testing and the Contractor's quality control testing. The Engineer will always have priority in the use of the laboratory. The lab shall have sufficient space and equipment so that both testing representatives (Engineer's and Contractor's) can operate efficiently. The lab shall also meet the requirements of ASTM D 3666. The plant testing laboratory shall have a floor space area of not less than 150 sq ft, with a ceiling height of not less than 7-½ feet. The laboratory shall be weather tight, sufficiently heated in cold weather, air-conditioned in hot weather to maintain temperatures for testing purposes of 70 °F +/- 5 °F. The plant testing laboratory shall be located on the plant site to provide an unobstructed view, from one of its windows, of the trucks being loaded with the plant mix materials.

Laboratory facilities shall be kept clean, and all equipment shall be maintained in proper working condition. The Engineer shall be permitted unrestricted access to inspect the Contractor's laboratory facility and witness quality control activities. The Engineer will advise the Contractor in writing of any noted deficiencies concerning the laboratory facility, equipment, supplies, or testing personnel and procedures. When the deficiencies are serious enough to be adversely affecting the test results, the incorporation of the materials into the work shall be suspended immediately and will not be permitted to resume until the deficiencies are satisfactorily corrected.

As a minimum, the plant testing laboratory shall have:

- a. Adequate artificial lighting
- b. Electrical outlets sufficient in number and capacity for operating the required testing equipment and drying samples
- c. Fire extinguishers (2), Underwriter's Laboratories approved

- d. Work benches for testing, minimum 2-½ feet by 10 feet
- e. Desk with 2 chairs
- f. Sanitary facilities convenient to testing laboratory
- g. Exhaust fan to outside air, minimum 12 in blade diameter
- h. A direct telephone line and telephone including a FAX machine operating 24 hours per day, seven days per week
- i. File cabinet with lock for Engineer
- j. Sink with running water, attached drain board and drain capable of handling separate material
- k. Metal stand for holding washing sieves
- l. Two element hot plate or other comparable heating device, with dial type thermostatic controls for drying aggregates
- m. Mechanical shaker and appropriate sieves (listed in JMF, Table 3) meeting the requirements of ASTM E-11 for determining the gradation of coarse and fine aggregates in accordance with ASTM C 136
- n. Marshall testing equipment meeting ASTM D 6926, ASTM D 6927, or ASTM D 5581 as necessary, automatic compaction equipment capable of compacting three specimens at once and other apparatus as specified in ASTM C 127, D 2172, D 2726, and D 2041
- o. Oven, thermostatically controlled, inside minimum 1 cubic foot
- p. Two volumetric specific gravity flasks, 500 CC
- q. Other necessary hand tools required for sampling and testing
- r. Library containing contract specifications, latest ASTM volumes 4.01, 4.02, 4.03 and 4.09, AASHTO standard specification parts I and II, and Asphalt Institute Publication MS-2
- s. Equipment for Theoretical Specific Gravity testing including a 4,000 cc pycnometer, vacuum pump capable of maintaining 30 ml mercury pressure and a balance, 16-20 gm with accuracy of 0.5 grams
- t. Extraction equipment, centrifuge and reflux types and Rotoflex equipment
- u. A masonry saw with diamond blade for trimming pavement cores and samples
- v. Telephone

Approval of the plant and testing laboratory by the Engineer requires all facilities and equipment to be in good working order during production, sampling and testing. Failure to provide the specified facilities shall be sufficient cause for disapproving bituminous plant operations.

The Owner shall have access to the lab and at the plant whenever Contractor is producing asphalt for the project.

(3) Inspection of Plant. The Engineer, or Engineer's authorized representative, shall have access, at all times, to all areas of the plant for checking adequacy of equipment; inspecting operation of the plant; verifying weights, proportions, and material properties; and checking the temperatures maintained in the preparation of the mixtures.

(4) Storage Bins and Surge Bins. Use of surge bins or storage bins for temporary storage of hot bituminous mixtures will be permitted as follows:

- a. The bituminous mixture may be stored in surge bins for a period of time not to exceed 3 hours.
- b. The bituminous mixture may be stored in insulated storage bins for a period of time not to exceed 24 hours.

The bins shall be such that mix drawn from them meets the same requirements as mix loaded directly into trucks.

If the Engineer determines that there is an excessive amount of heat loss, segregation or oxidation of the mixture due to temporary storage, no temporary storage will be allowed.

403-4.3 HAULING EQUIPMENT. Trucks used for hauling bituminous mixtures shall have tight, clean, and smooth metal beds. To prevent the mixture from adhering to them, the truck beds shall be lightly coated with a minimum amount of an approved asphalt release agent. Petroleum products shall not be used for coating truck beds. Each truck shall have a suitable cover to protect the mixture from adverse weather. When necessary, to ensure that the mixture will be delivered to the site at the specified temperature, truck beds shall be insulated or heated and covers shall be securely fastened.

403-4.4 BITUMINOUS PAVERS. Bituminous pavers shall be self-propelled with an activated heated screed, capable of spreading and finishing courses of bituminous plant mix material that will meet the specified thickness, smoothness, and grade. The paver shall have sufficient power to propel itself and the hauling equipment without adversely affecting the finished surface.

The paver shall have a receiving hopper of sufficient capacity to permit a uniform spreading operation. The hopper shall be equipped with a distribution system to place the mixture uniformly in front of the screed without segregation. The screed shall effectively produce a finished surface of the required evenness and texture without tearing, shoving, or gouging the mixture.

The paver shall be equipped with a control system capable of automatically maintaining the specified screed elevation. The control system shall be automatically actuated from either a reference line and/or through a system of mechanical sensors or sensor-directed mechanisms or devices that will maintain the paver screed at a predetermined transverse slope and at the proper elevation to obtain the required surface. The transverse slope controller shall be capable of maintaining the screed at the desired slope within plus or minus 0.1 percent.

The controls shall be capable of working in conjunction with any of the following attachments:

- a. Ski-type device of not less than 30 feet (9.14 m) in length
- b. Taut stringline (wire) set to grade
- c. Short ski or shoe
- d. Laser control

If, during construction, it is found that the spreading and finishing equipment in use leaves tracks or indented areas, or produces other blemishes in the pavement and/or base course that are not satisfactorily corrected by the scheduled operations, the use of such equipment shall be discontinued and satisfactory equipment shall be provided by the Contractor.

403-4.5 ROLLERS. Rollers of the vibratory, steel wheel, and pneumatic-tired type shall be used. They shall be in good condition, capable of operating at slow speeds to avoid displacement of the bituminous mixture. The number, type, and weight of rollers shall be sufficient to compact the mixture to the required density while it is still in a workable condition.

All rollers shall be specifically designed and suitable for compacting hot mix bituminous concrete and shall be properly used. Rollers that impair the stability of any layer of a pavement structure or underlying soils shall not be used. Depressions in pavement surfaces caused by rollers shall be repaired by the Contractor at its own expense.

The use of equipment that causes crushing of the aggregate will not be permitted.

a. Nuclear Densometer. The Contractor shall have on site a nuclear densometer during all paving operations in order to assist in the determination of the optimum rolling pattern, type of roller and frequencies, as well as to monitor the effect of the rolling operations during production paving. The Contractor shall also supply a qualified technician during all paving operations to calibrate the nuclear densometer and obtain accurate density readings for all new bituminous concrete. These densities shall be supplied to the Engineer upon request at any time during construction. No separate payment will be made for supplying the density gauge and technician.

403-4.6 PREPARATION OF BITUMINOUS MATERIAL. The bituminous material shall be heated in a manner that will avoid local overheating and provide a continuous supply of the bituminous material to the mixer at a uniform temperature. The temperature of the bituminous material delivered to the mixer shall be sufficient to provide a suitable viscosity for adequate coating of the aggregate particles, but shall not exceed 325 °F (160 °C), unless otherwise required by the manufacturer.

403-4.7 PREPARATION OF MINERAL AGGREGATE. The aggregate for the mixture shall be heated and dried prior to introduction into the mixer. The maximum temperature and rate of heating shall be such that

no damage occurs to the aggregates. The temperature of the aggregate and mineral filler shall not exceed 350 °F (175 °C) when the asphalt is added. Particular care shall be taken that aggregates high in calcium or magnesium content are not damaged by overheating. The temperature shall not be lower than is required to obtain complete coating and uniform distribution on the aggregate particles and to provide a mixture of satisfactory workability.

403-4.8 PREPARATION OF BITUMINOUS MIXTURE. The aggregates and the bituminous material shall be weighed or metered and introduced into the mixer in the amount specified by the job mix formula.

The combined materials shall be mixed until the aggregate obtains a uniform coating of bitumen and is thoroughly distributed throughout the mixture. Wet mixing time shall be the shortest time that will produce a satisfactory mixture, but not less than 25 seconds for batch plants. The wet mixing time for all plants shall be established by the Contractor, based on the procedure for determining the percentage of coated particles described in ASTM D 2489, for each individual plant and for each type of aggregate used. The wet mixing time will be set to achieve 95 percent of coated particles. For continuous mix plants, the minimum mixing time shall be determined by dividing the weight of its contents at operating level by the weight of the mixture delivered per second by the mixer. The moisture content of all bituminous mixtures upon discharge shall not exceed 0.5 percent.

For batch plants, wet mixing time begins with the introduction of bituminous material into the mixer and ends with the opening of the mixer discharge gate. Distribution of aggregate and bituminous material as they enter the pugmill, speed of mixer shafts, and arrangement and pitch of paddles are factors governing efficiency of mixing. Prolonged exposure to air and heat in the pugmill hardens the asphalt film on the aggregate. Mixing time, therefore, should be the shortest time required to obtain uniform distribution of aggregate sizes and thorough coating of aggregate particles with bituminous material.

403-4.9 PREPARATION OF THE UNDERLYING SURFACE. Immediately before placing the bituminous mixture, the underlying course shall be cleaned of all dust and debris. A prime coat or tack coat shall be applied in accordance with Item P-602 or P-603, if shown on the plans.

Engineer should evaluate the presence of paint and rubber deposits on the existing pavement and, if needed, may specify milling, grinding or other suitable means to remove same prior to placement of new bituminous material.

403-4.10 LAYDOWN PLAN, TRANSPORTING, PLACING, AND FINISHING. Prior to the placement of the bituminous mixture, the Contractor shall prepare a laydown plan for approval by the Engineer. This is to minimize the number of cold joints in the pavement. The laydown plan shall include the sequence of paving laydown by stations, width of lanes, temporary ramp locations, and laydown temperature. The laydown plan shall also include estimated time of completion for each portion of the work (that is, milling, paving, rolling, cooling, etc.). Modifications to the laydown plan shall be approved by the Engineer.

The bituminous mixture shall be transported from the mixing plant to the site in vehicles conforming to the requirements of paragraph 403-4.3. Deliveries shall be scheduled so that placing and compacting of mixture is uniform with minimum stopping and starting of the paver. Hauling over freshly placed material shall not be permitted until the material has been compacted, as specified, and allowed to cool to atmospheric temperature.

[The Contractor may elect to use a material transfer vehicle to deliver mix to the paver.]

Use of a material transfer vehicle allows the paver to be operated almost continuously without stopping between truckloads of mix, if a continuous supply of

mix is available from the asphalt plant. The use of a transfer vehicle is recommended on long paving lanes.

Paving during nighttime construction shall require the following:

a. All paving machines, rollers, distribution trucks and other vehicles required by the Contractor for his operations shall be equipped with artificial illumination sufficient to safely complete the work.

b. Minimum illumination level shall be twenty (20) horizontal foot candles and maintained in the following areas:

(1) An area of 30 feet wide by 30 feet long immediately behind the paving machines during the operations of the machines.

(2) An area 15 feet wide by 30 feet long immediately in front and back of all rolling equipment, during operation of the equipment.

(3) An area 15 feet wide by 15 feet long at any point where an area is being tack coated prior to the placement of pavement.

c. As partial fulfillment of the above requirements, the Contractor shall furnish and use, complete artificial lighting units with a minimum capacity of 3,000 watt electric beam lights, affixed to all equipment in such a way to direct illumination on the area under construction.

d. In addition, the Contractor shall furnish [] portable floodlight units similar or equal to [].

Engineer to specify the minimum number of floodlighting units and may elect to specify a particular manufacturer's lighting unit "or equal".

If nighttime paving requires the critical re-opening of airfield facilities, the following additional language should be added:

"If the Contractor places any out of specification mix in the project work area, the Contractor is required to remove it at its own expense, to the satisfaction of the Engineer. If the Contractor has to continue placing non-payment bituminous concrete, as directed by the Engineer, to make the surfaces safe for aircraft operations, the Contractor shall do so to the satisfaction of the Engineer. It is the Contractor's responsibility to leave the facilities to be paved in a safe condition ready for aircraft operations. No consideration for extended closure time of the area being paved will be given. As a first order of work for the next paving shift, the Contractor shall remove all out of specification material and replace with approved material to the satisfaction of the Engineer. When the above situations occur, there will be no consideration given for additional construction time or payment for extra costs."

The initial placement and compaction of the mixture shall occur at a temperature suitable for obtaining density, surface smoothness, and other specified requirements but not less than 250 °F (121 °C). Edges of existing bituminous pavement abutting the new work shall be saw cut and carefully removed as shown on the drawings and painted with bituminous tack coat before new material is placed against it. Upon arrival, the mixture shall be placed to the full width by a bituminous paver. It shall be struck off in a uniform layer of such depth that, when the work is completed, it shall have the required thickness and conform to the grade and contour indicated. The speed of the paver shall be regulated to eliminate pulling and tearing of the bituminous mat. Unless otherwise permitted, placement of the mixture shall begin along the centerline of a crowned section or on the high side of areas with a one-way slope. The mixture shall be placed in consecutive adjacent strips having a minimum width of [] except where edge lanes require less width to complete the area. Additional screed sections shall not be attached to widen paver to meet the

minimum lane width requirements specified above unless additional auger sections are added to match. The longitudinal joint in one course shall offset the longitudinal joint in the course immediately below by at least 1 ft (30 cm); however, the joint in the surface top course shall be at the centerline of crowned pavements. Transverse joints in one course shall be offset by at least 10 feet (3 m) from transverse joints in the previous course.

Transverse joints in adjacent lanes shall be offset a minimum of 10 feet (3 m).

On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impractical, the mixture may be spread and luted by hand tools. Areas of segregation in the course, as determined by the Engineer, shall be removed and replaced at the Contractor's expense. The area shall be removed by saw cutting and milling a minimum of 2 in deep. The area to be removed and replaced shall be a minimum width of the paver and a minimum of 10 feet long.

The Engineer should specify the widest paving lane practicable in an effort to hold the number of longitudinal joints to a minimum.

403-4.11 COMPACTION OF MIXTURE. After placing, the mixture shall be thoroughly and uniformly compacted by power rollers. The surface shall be compacted as soon as possible when the mixture has attained sufficient stability so that the rolling does not cause undue displacement, cracking or shoving. The sequence of rolling operations and the type of rollers used shall be at the discretion of the Contractor. The speed of the roller shall, at all times, be sufficiently slow to avoid displacement of the hot mixture and be effective in compaction. Any displacement occurring as a result of reversing the direction of the roller, or from any other cause, shall be corrected at once.

Sufficient rollers shall be furnished to handle the output of the plant. Rolling shall continue until the surface is of uniform texture, true to grade and cross section, and the required field density is obtained.

To prevent adhesion of the mixture to the roller, the wheels shall be equipped with a scraper and kept properly moistened using a water soluble asphalt release agent approved by the engineer.

In areas not accessible to the roller, the mixture shall be thoroughly compacted with approved power driven tampers. Tampers shall weigh not less than 275 pounds, have a tamping plate width not less than 15 in, be rated at not less than 4,200 vibrations per minute, and be suitably equipped with a standard tamping plate wetting device.

Any mixture that becomes loose and broken, mixed with dirt, contains check-cracking, or in any way defective shall be removed and replaced with fresh hot mixture and immediately compacted to conform to the surrounding area. This work shall be done at the Contractor's expense. Skin patching shall not be allowed.

403-4.12 JOINTS. The formation of all joints shall be made in such a manner as to ensure a continuous bond between the courses and obtain the required density. All joints shall have the same texture as other sections of the course and meet the requirements for smoothness and grade.

The roller shall not pass over the unprotected end of the freshly laid mixture except when necessary to form a transverse joint. When necessary to form a transverse joint, it shall be made by means of placing a bulkhead or by tapering the course. The tapered edge shall be cut back to its full depth and width on a straight line to expose a vertical face prior to placing the adjacent lane. In both methods, all contact surfaces shall be given a tack coat of bituminous material before placing any fresh mixture against the joint.

Longitudinal joints which are irregular, damaged, uncompacted, or otherwise defective [or which have been left exposed for more than 4 hours, or whose surface temperature has cooled to less than 160°F] shall be cut back [specify cutback] to expose a clean, sound surface for the full depth of the course. All contact surfaces shall be cleaned and dry and given a tack coat of bituminous material prior to placing any fresh mixture against the joint. The cost of this work and tack coat shall be considered incidental to the cost of the bituminous course.

Engineer may retain the bracketed language regarding the treatment of "cold joints" when considered necessary. The cutback should be no more than 6 in.

MATERIAL ACCEPTANCE

403-5.1 ACCEPTANCE SAMPLING AND TESTING. Unless otherwise specified, all acceptance sampling and testing necessary to determine conformance with the requirements specified in this section will be performed by the Engineer at no cost to the Contractor. Testing organizations performing these tests shall meet the requirements of ASTM D 3666. The laboratory accreditation must be current and listed on the accrediting authority's website. All test methods required for acceptance sampling and testing must be listed on the lab accreditation. A copy of the laboratory's current accreditation and accredited test methods shall be submitted to the Engineer prior to start of construction. All equipment in Contractor furnished laboratories shall be calibrated by an independent testing organization prior to the start of operations.

a. Field Placed Material. Material placed in the field shall be tested for mat and joint density on a lot basis. A lot will consist of:

- One day or shift's production not to exceed 2,000 tons (1,814 t), or
- A half day or shift's production where a day's production is expected to consist of between 2,000 and 4,000 tons (1,814 and 3,628 t), or similar subdivisions for tonnages over 4,000 tons (3,628 t).

Where more than one plant is simultaneously producing material for the job, the lot sizes shall apply separately for each plant.

(1) Mat Density. The lot shall be divided into four equal sublots. One core of finished, compacted materials shall be taken by the Contractor from each subplot. Core locations will be determined by the Engineer on a random basis in accordance with procedures contained in ASTM D 3665. Cores shall not be taken closer than 1 ft from a transverse or longitudinal joint.

(2) Joint Density. The lot shall be divided into four equal sublots. One core of finished, compacted materials shall be taken by the Contractor from each subplot. Core locations will be determined by the Engineer on a random basis in accordance with procedures contained in ASTM D 3665. Edge of cores will be taken within 6 in of the joint of the same lot material but not directly on the joint.

(3) Sampling. Samples shall be neatly cut with a core drill. The cutting edge of the core drill bit shall be of hardened steel or other suitable material with diamond chips embedded in the metal cutting edge. The minimum diameter of the sample shall be 5 in. Samples that are clearly defective, as a result of sampling, shall be discarded and another sample taken. The Contractor shall furnish all tools, labor, and materials for cutting samples, cleaning, and filling the cored pavement. Cored pavement shall be cleaned and core holes shall be filled in a manner acceptable to the Engineer and within one day after sampling.

(4) Testing. The bulk specific gravity of each cored sample will be measured by the Engineer in accordance with ASTM D 2726 or ASTM D 1188, whichever is applicable. The percent compaction (density) of each sample will be determined by dividing the bulk specific gravity of each subplot sample by the average bulk specific gravity of all laboratory prepared specimens for the lot, as determined as follows:

(a) Sufficient material for preparation of test specimens for all testing will be sampled by the Engineer on a random basis, in accordance with the procedures contained in ASTM D 3665. One set of laboratory compacted specimens will be prepared for each subplot in accordance with ASTM D 6926, at the number of blows required by paragraph 403-3.2, Table 1. Each set of laboratory compacted specimens will consist of three test portions prepared from the same sample increment. The sample of bituminous mixture may be put in a covered metal tin and placed in an oven for not less than 30 minutes or more than 60 minutes to stabilize to compaction temperature. The compaction temperature of the specimens shall be as specified in the job mix formula.

Engineer should increase hold times to not less than 60 minutes and not more than 90 minutes when absorptive aggregates are used,

(b) The bulk specific gravity of each test specimen shall be measured by the Engineer in accordance with ASTM D 2726 using the procedure for laboratory-prepared thoroughly dry specimens, or ASTM D 1188, whichever is applicable, for use in computing pavement density.

(c) The bulk specific gravity used to determine the joint density at joints formed between different lots shall be the lowest of the bulk specific gravity values from the two different lots.

(5) Acceptance. Acceptance of field placed material for mat and joint density will be determined by the Engineer in accordance with the requirements of paragraph 403-5.2b.

d. Partial Lots - Field Placed Material. When operational conditions cause a lot to be terminated before the specified number of tests have been made for the lot, or when the Contractor and Engineer agree in writing to allow overages or other minor tonnage placements to be considered as partial lots, the following procedure will be used to adjust the lot size and the number of tests for the lot.

The last batch produced where production is halted will be sampled, and its properties shall be considered as representative of the particular subplot from which it was taken. In addition, an agreed to minor placement will be sampled, and its properties shall be considered as representative of the particular subplot from which it was taken. Where three sublots are produced, they shall constitute a lot. Where one or two sublots are produced, they shall be incorporated into the next lot, and the total number of sublots shall be used in the acceptance plan calculation, that is, $n = 5$ or $n = 6$, for example. Partial lots at the end of asphalt production on the project shall be included with the previous lot.

403-5.2 ACCEPTANCE CRITERIA.

a. General. Acceptance will be based on the following characteristics of the bituminous mixture and completed pavement and test results:

- (1) Mat density
- (2) Joint density
- (3) Thickness
- (4) Smoothness
- (5) Grade

Mat density will be evaluated for acceptance in accordance with paragraph 403-5.2b(1). Joint density will be evaluated for acceptance in accordance with paragraph 403-5.2b(2).

Thickness will be evaluated by the Engineer for compliance in accordance with paragraph 403-5.2b(3). Acceptance for smoothness will be based on the criteria contained in paragraph 403-5.2b(4). Acceptance for grade will be based on the criteria contained in paragraph 403-5.2b(5).

The Engineer may at any time, notwithstanding previous plant acceptance, reject and require the Contractor to dispose of any batch of bituminous mixture which is rendered unfit for use due to contamination, segregation, incomplete coating of aggregate, or improper mix temperature. Such rejection may be based on only visual inspection or temperature measurements. In the event of such rejection, the Contractor may take a representative sample of the rejected material in the presence of the Engineer, and if it can be demonstrated in the laboratory, in the presence of the Engineer, that such material was erroneously rejected, payment will be made for the material at the contract unit price.

b. Acceptance Criteria.

(1) Mat Density. Acceptance of each lot of plant produced material for mat density shall be based on the average of all of the densities taken from the sublots. If the average mat density of the lot so established equals or exceeds 96 percent, the lot shall be acceptable. If the average mat density of the lot is below 96 percent, the lot shall be removed and replaced at the Contractor's expense.

(2) Joint Density. Acceptance of each lot of plant produced material for joint density shall be based on the average of all of the joint densities taken from the sublots. If the average joint density of the lot so

established equals or exceeds 94 percent, the lot shall be acceptable. If the average joint density of the lot is less than 94 percent, the Contractor shall stop production and evaluate the method of compacting joints. Production may resume once the reason for poor compaction has been determined and appropriate measures have been taken to ensure proper compaction.

(3) Thickness. Thickness of each course shall be evaluated by the Engineer for compliance to the requirements shown on the plans. Measurements of thickness shall be made by the Engineer using the cores extracted for each subplot for density measurement. The maximum allowable deficiency at any point shall not be more than $\frac{1}{4}$ in less than the thickness indicated for the lift. Average thickness of lift, or combined lifts, shall not be less than the indicated thickness. Where thickness deficiency exceeds the specified tolerances, the lot or subplot shall be corrected by the Contractor at his expense by removing the deficient area and replacing with new pavement. The Contractor, at his expense, may take additional cores as approved by the Engineer to circumscribe the deficient area.

(4) Smoothness. The final surface shall be free from roller marks. The finished surfaces of each course of the pavement, except the finished surface of the final surface course, shall not vary more than $\frac{3}{8}$ in when evaluated with a 16 ft straightedge. The finished surface of the final surface course shall not vary more than $\frac{1}{4}$ in when evaluated with a 16 ft straightedge. The lot size shall be [] square yards (sq m). Smoothness measurements shall be made at 50 ft intervals and as determined by the Engineer. In the longitudinal direction, a smoothness reading shall be made at the center of each paving lane. In the transverse direction, smoothness readings shall be made continuously across the full width of the pavement. However, transverse smoothness readings shall not be made across designed grade changes. At warped transition areas, straightedge position shall be adjusted to measure surface smoothness and not design grade transitions. When more than 15 percent of all measurements within a lot exceed the specified tolerance, the Contractor shall remove the deficient area to the depth of the course of pavement and replace with new material. Skin patching shall not be permitted. Isolated high points may be ground off providing the course thickness complies with the thickness specified on the plans. High point grinding will be limited to 15 sq yd. Areas in excess of 15 sq yd will require removal and replacement of the course in accordance with the limitations noted above.

The Engineer shall specify the lot size. A minimum of 2,000 sq yd (1,650 sq m) is recommended.

(5) Grade. The finished surface of the pavement shall not vary from the gradeline elevations and cross sections shown on the plans by more than $\frac{1}{2}$ in (12.70 mm). The finished grade of each lot will be determined by running levels at intervals of 50 feet (15.2 m) or less longitudinally and all breaks in grade transversely (not to exceed 50 feet) to determine the elevation of the completed pavement. The Contractor shall pay the cost of surveying of the level runs that shall be performed by a licensed surveyor. The documentation, stamped and signed by a licensed surveyor, shall be provided by the Contractor to the Engineer. The lot size shall be [] square yards (square meters). When more than 15 percent of all the measurements within a lot are outside the specified tolerance, or if any one shot within the lot deviates $\frac{3}{4}$ in or more from planned grade, the Contractor shall remove the deficient area to the depth of the final course of pavement and replace with new material. Skin patching shall not be permitted. Isolated high points may be ground off providing the course thickness complies with the thickness specified on the plans. High point grinding will be limited to 15 sq yd. The surface of the ground pavement shall have a texture consisting of grooves between 0.090 and 0.130 in wide. The peaks and ridges shall be approximately $\frac{1}{32}$ in higher than the bottom of the grooves. The pavement shall be left in a clean condition. The removal of all of the slurry resulting from the grinding operation shall be continuous. The grinding operation should be controlled so the residue from the operation does not flow across other lanes of pavement. Areas in excess of 15 sq yd will require removal and replacement of the pavement in accordance with the limitations noted above.

c. Density Outliers. If the tests within a lot include a very large or a very small value that appears to be outside the normal limits of variation, check for an outlier in accordance with ASTM E 178, at a significance level of 5 percent, to determine if this value should be discarded.

A minimum of 2,000 sq yd (1,650 sq m) is recommended.

403-5.3 RESAMPLING PAVEMENT FOR MAT DENSITY.

a. General. Resampling of a lot of pavement will only be allowed for mat density and then, only if the Contractor requests same in writing, within 48 hours after receiving the written test results from the Engineer. A retest will consist of all the sampling and testing procedures contained in paragraphs 403-5.1b(1). Only one resampling per lot will be permitted.

(1) A redefined mat density shall be calculated for the resampled lot. The number of tests used to calculate the redefined mat density shall include the initial tests made for that lot plus the retests.

(2) The cost for resampling and retesting shall be borne by the Contractor.

b. Payment for Resampled Lots. The redefined mat density for a resampled lot shall be used to evaluate the acceptance of that lot in accordance with Paragraph 403-5.2.

403-5.4 LEVELING COURSE. Any course used for truing and leveling shall meet the requirements of paragraph 403-3.2, but shall not be subject to the density requirements of paragraph 403-5.1. The leveling course shall be compacted with the same effort used to achieve density of the test section. The truing and leveling course shall not exceed a nominal thickness of 1-½ in (37.5 mm). The leveling course is the first variable thickness lift of an overlay placed prior to subsequent courses.]

Use this paragraph only when there is a need to restore proper cross-section prior to overlaying. Areas of the pavement requiring a leveling course shall be shown on the plans.

CONTRACTOR QUALITY CONTROL

403-6.1 GENERAL. The Contractor shall perform quality control sampling, testing, and inspection during all phases of the work and shall perform them at a rate sufficient to ensure that the work conforms to the contract requirements, and at minimum test frequencies required by paragraph 403-6.3, including but not limited to:

- a.** Mix Design
- b.** Aggregate Grading
- c.** Quality of Materials
- d.** Stockpile Management
- e.** Proportioning
- f.** Mixing and Transportation
- g.** Placing and Finishing
- h.** Joints
- i.** Compaction
- j.** Surface smoothness

403-6.2 TESTING LABORATORY. The Contractor shall provide a fully equipped asphalt laboratory meeting the requirements of paragraph 403-3.5 and 403-4.2a(2) located at the plant or job site. The Contractor shall provide the Engineer with certification stating that all of the testing equipment to be used is properly calibrated and will meet the specifications applicable for the specified test procedures.

403-6.3 QUALITY CONTROL TESTING. The Contractor shall perform all quality control tests necessary to control the production and construction processes applicable to these specifications and as set forth in the approved Quality Control Program. The testing program shall include, but not necessarily be limited to, tests for the control of asphalt content, aggregate gradation, temperatures, aggregate moisture, field compaction, and surface smoothness.

a. Asphalt Content. A minimum of two tests shall be performed per lot in accordance with ASTM D 2172 for determination of asphalt content. The weight of ash portion of the test, as described in ASTM D 2172, shall be determined as part of the first test performed at the beginning of plant production; and as part of every tenth test performed thereafter, for the duration of plant production. The last weight of ash value obtained shall be used in the calculation of the asphalt content for the mixture. The asphalt content for the lot will be determined by averaging the test results.

The use of the nuclear method for determining asphalt content in accordance with ASTM D 4125 is permitted, provided that it is calibrated for the specific mix being used.

b. Gradation. Aggregate gradations shall be determined a minimum of twice per lot from mechanical analysis of extracted aggregate in accordance with ASTM D 5444 and ASTM C 136 (dry sieve). When asphalt content is determined by the nuclear method, aggregate gradation shall be determined from hot bin samples on batch plants, or from the cold feed on drum mix or continuous mix plants, and tested in accordance with ASTM C 136 (dry sieve) using actual batch weights to determine the combined aggregate gradation of the mixture.

c. Moisture Content of Aggregate. The moisture content of aggregate used for production shall be determined a minimum of once per lot in accordance with ASTM C 566.

d. Moisture Content of Mixture. The moisture content of the mixture shall be determined once per lot in accordance with ASTM D 1461 [or AASHTO T 110].

ASTM D 1461 may be replaced with an AASHTO moisture content testing procedure using a conventional oven or microwave. The frequency can also change in the specification depending on the probability of incurring a moisture problem.

e. Temperatures. Temperatures shall be checked, at least four times per lot, at necessary locations to determine the temperatures of the dryer, the bitumen in the storage tank, the mixture at the plant, and the mixture at the job site.

f. In-Place Density Monitoring. The Contractor shall conduct any necessary testing to ensure that the specified density is being achieved. A nuclear gauge may be used to monitor the pavement density in accordance with ASTM D 2950.

g. Additional Testing. Any additional testing that the Contractor deems necessary to control the process may be performed at the Contractor's option.

h. Monitoring. The Engineer reserves the right to monitor any or all of the above testing.

403-6.4 SAMPLING. When directed by the Engineer, the Contractor shall sample and test any material that appears inconsistent with similar material being sampled, unless such material is voluntarily removed and replaced or deficiencies corrected by the Contractor. All sampling shall be in accordance with standard procedures specified.

403-6.5 CONTROL CHARTS. The Contractor shall maintain linear control charts both for individual measurements and range (that is, difference between highest and lowest measurements) for aggregate gradation and asphalt content.

Control charts shall be posted in a location satisfactory to the Engineer and shall be kept current. As a minimum, the control charts shall identify the project number, the contract item number, the test number, each test parameter, the Action and Suspension Limits applicable to each test parameter, and the Contractor's test results. The Contractor shall use the control charts as part of a process control system for identifying potential problems and assignable causes before they occur. If the Contractor's projected data during production indicates a problem and the Contractor is not taking satisfactory corrective action, the Engineer may suspend production or acceptance of the material.

- a. Individual Measurements.** Control charts for individual measurements shall be established to maintain process control within tolerance for aggregate gradation and asphalt content. The control charts shall use the job mix formula target values as indicators of central tendency for the following test parameters with associated Action and Suspension Limits:

Control Chart Limits For Individual Measurements		
Sieve	Action Limit	Suspension Limit
¾ in (19.0 mm)	0%	0%
½ in (12.5 mm)	+/-6%	+/-9%
¾ in (9.5 mm)	+/-6%	+/-9%
No. 4 (4.75 mm)	+/-6%	+/-9%
No. 16 (1.18 mm)	+/-5%	+/-7.5%
No. 50 (0.30 mm)	+/-3%	+/-4.5%
No. 200 (0.075 mm)	+/-2%	+/-3%
Asphalt Content	+/-0.45%	+/-0.70%

- b. Range.** Control charts for range shall be established to control process variability for the test parameters and Suspension Limits listed below. The range shall be computed for each lot as the difference between the two test results for each control parameter. The Suspension Limits specified below are based on a sample size of $n = 2$. Should the Contractor elect to perform more than two tests per lot, the Suspension Limits shall be adjusted by multiplying the Suspension Limit by 1.18 for $n = 3$ and by 1.27 for $n = 4$.

Control Chart Limits Based On Range (Based On $n = 2$)	
Sieve	Suspension Limit
½ in (12.5 mm)	11 percent
¾ in (9.5 mm)	11 percent
No. 4 (4.75 mm)	11 percent
No. 16 (1.18 mm)	9 percent
No. 50 (0.30 mm)	6 percent
No. 200 (0.075 mm)	3.5 percent
Asphalt Content	0.8 percent

- c. Corrective Action.** The Contractor Quality Control Program shall indicate that appropriate action shall be taken when the process is believed to be out of tolerance. The Plan shall contain sets of rules to gauge when a process is out of control and detail what action will be taken to bring the process into control.

As a minimum, a process shall be deemed out of control and production stopped and corrective action taken, if:

- (1) One point falls outside the Suspension Limit line for individual measurements or range; or
- (2) Two points in a row fall outside the Action Limit line for individual measurements.

The aggregate control chart parameters and Suspension and Action Limits contained in the above paragraphs are based on $\frac{3}{4}$ in (19.0 mm) maximum size aggregate gradation. When 1 in (25.0 mm) or 1 $\frac{1}{4}$ in (31.2 mm) maximum size aggregate greater than $\frac{3}{4}$ in is specified, the Individual Measurements Chart requirements should be amended as follows:

Sieve	Action Limit	Suspension Limit
1 in or greater or 1 $\frac{1}{2}$ in	0%	0%
$\frac{3}{4}$ in	6%	11%

When $\frac{1}{2}$ in (12.5 mm) maximum size aggregate is specified, the $\frac{3}{4}$ in (19.0 mm) and 1 in (25.0 mm) sieves should be deleted from the Individual Measurements Chart and the $\frac{1}{2}$ in (12.5 mm) sieve Action and Suspension Limits should be changed to 0%. For the $\frac{1}{2}$ in (12.5 mm) gradation, the $\frac{1}{2}$ in sieve should be deleted from the Range Chart.

403-6.6 QUALITY CONTROL REPORTS. The Contractor shall maintain records and shall submit reports of quality control activities daily.

METHOD OF MEASUREMENT

403-7.1 MEASUREMENT. Plant mix bituminous concrete pavement shall be measured by the number of tons (kg) of bituminous mixture used in the accepted work. Recorded batch weights or truck scale weights will be used to determine the basis for the tonnage.

BASIS OF PAYMENT

403-8.1 PAYMENT. Payment for a lot of bituminous concrete pavement meeting all acceptance criteria as specified in paragraph 403-5.2 shall be made at the contract unit price per ton (kg) for bituminous mixture. The price shall be compensation for furnishing all materials, for all preparation, mixing, and placing of these materials, and for all labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

Item P-403-8.1a Bituminous [] [Surface] [Base] [Binder] [Leveling] Course - per ton (kg)

TESTING REQUIREMENTS

ASTM C 29	Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C 88	Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C 117	Materials Finer than 75 μ m (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C 127	Specific Gravity and Absorption of Coarse Aggregate
ASTM C 131	Resistance to Degradation of Small Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 136	Sieve Analysis of Fine and Coarse Aggregates
ASTM C 183	Sampling and the Amount of Testing of Hydraulic Cement
ASTM C 566	Total Evaporable Moisture Content of Aggregate by Drying
ASTM D 75	Sampling Aggregates
ASTM D 979	Sampling Bituminous Paving Mixtures

ASTM D 995	Mixing Plants for Hot-Mixed Hot-Laid Bituminous Paving Mixtures
ASTM D 1073	Fine Aggregate for Bituminous Paving Mixtures
ASTM D 1074	Compressive Strength of Bituminous Mixtures
ASTM D 1188	Bulk Specific Gravity and Density of Compacted Bituminous Mixtures Using Paraffin-Coated Specimens
ASTM D 1461	Moisture or Volatile Distillates in Bituminous Paving Mixtures
ASTM D 2041	Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
ASTM D 2172	Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
ASTM D 2419	Sand Equivalent Value of Soils and Fine Aggregate
ASTM D 2489	Estimating Degree of Particle Coating of Bituminous-Aggregate Mixtures
ASTM D 2726	Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures
ASTM D 2950	Density of Bituminous Concrete in Place by Nuclear Methods
ASTM D 3203	Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures
ASTM D 3665	Random Sampling of Construction Materials
ASTM D 3666	Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials
ASTM D 4125	Asphalt Content of Bituminous Mixtures by the Nuclear Method
ASTM D 4318	Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D 4791	Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D 4867	Effect of Moisture on Asphalt Concrete Paving Mixtures
ASTM D 5444	Mechanical Size Analysis of Extracted Aggregate
ASTM D 5581	Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus (6" Diameter Specimen)
ASTM D 6926	Preparation of Bituminous Specimens Using MARSHALL Apparatus
ASTM D 6927	MARSHALL Stability and Flow of Bituminous Mixtures
ASTM E 11	Wire-Cloth Sieves for Testing Purposes
ASTM E 178	Dealing with Outlying Observations
AASHTO T 30	Mechanical Analysis of Extracted Aggregate
[AASHTO T 110	Moisture or Volatile Distillates in Bituminous Paving Mixtures]
The Asphalt	Mix Design Methods for Asphalt Concrete
Institute's Manual	
No. 2 (MS-2)	

MATERIAL REQUIREMENTS

ASTM D 242	Mineral Filler for Bituminous Paving Mixtures
ASTM D 946	Penetration Graded Asphalt Cement for Use in Pavement Construction
ASTM D 3381	Viscosity-Graded Asphalt Cement for Use in Pavement Construction
ASTM D 4552	Classifying Hot-Mix Recycling Agents
AASHTO MP1	Performance Graded Binder Designation

END OF ITEM P-403

3.3.2 Com características de desgaste, na faixa de rodagem:

3.3.2.1 Em P-401 PLANT MIX BITUMINOUS PAVEMENTS (betão Betuminoso)

3.3.2.1.1 Com 0,03 m de espessura

DESCRIPTION

401-1.1 This item shall consist of pavement courses composed of mineral aggregate and bituminous material mixed in a central mixing plant and placed on a prepared course in accordance with these specifications and shall conform to the lines, grades, thicknesses, and typical cross sections shown on the plans. Each course shall be constructed to the depth, typical section, and elevation required by the plans and shall be rolled, finished, and approved before the placement of the next course.

This specification is intended to be used for the surface course for airfield flexible pavements subject to aircraft loadings of gross weights greater than 12,500 pounds (5670 kg) and is to apply within the limits of the pavement designed for full load bearing capacity.

The dimensions and depth of the “surface course” for which this specification applies shall be that as is defined by the Engineer’s pavement design as performed in accordance with FAA Advisory Circular 150/5320-6, current edition.

For courses other than the surface course, such as stabilized base courses, binder courses and/or truing and leveling courses; for pavements designed to accommodate aircraft gross weights of 12,500 pounds (5670 kg) or less; and for pavements intended to be used for roads, shoulder pavements, blast pads, and other pavements not subject to full aircraft loading, specification Item P-403 may be used.

State highway department specifications may be used for shoulders, access roads, perimeter roads, stabilized base courses under Item P-501, and other pavements not subject to aircraft loading. When state highway specification are approved, include all applicable/approved state specifications in the contract documents.

MATERIALS

401-2.1 AGGREGATE. Aggregates shall consist of crushed stone, crushed gravel, or crushed slag with or without natural sand or other inert finely divided mineral aggregate. The portion of combined materials retained on the No. 4 (4.75 mm) sieve is coarse aggregate. The portion of combined materials passing the No. 4 (4.75 mm) sieve and retained on the No. 200 (0.075 mm) sieve is fine aggregate, and the portion passing the No. 200 (0.075 mm) sieve is mineral filler.

a. Coarse Aggregate. Coarse aggregate shall consist of sound, tough, durable particles, free from adherent films of matter that would prevent thorough coating and bonding with the bituminous material and be free from organic matter and other deleterious substances. The percentage of wear shall not be greater than 40 percent when tested in accordance with ASTM C 131. The sodium sulfate soundness loss shall not exceed 10 percent, or the magnesium sulfate soundness loss shall not exceed 13 percent, after five cycles, when tested in accordance with ASTM C 88.

Aggregates with a higher percentage loss of wear or soundness may be specified in lieu of those above, provided a satisfactory service record under similar conditions of service and exposure has been demonstrated.

Aggregate shall contain at least [] percent by weight of individual pieces having two or more fractured faces and [] percent by weight having at least one fractured face. The area of each face shall be equal to at least 75 percent of the smallest midsectional area of the piece. When two fractured faces are contiguous, the angle between the planes of fractures shall be at least 30 degrees to count as two fractured faces. Fractured faces shall be obtained by crushing.

For pavements designed for aircraft gross weights of 60,000 pounds (27 200 kg) or more, the Engineer shall specify 70 percent for two fractured faces and 85 percent for one fractured face. For pavements designed for aircraft gross weights less than 60,000 pounds (27 200 kg), the Engineer shall specify 50 percent for two fractured faces and 65 percent for one fractured face.

In areas where slag is not available or desired, the references to it should be deleted from all aggregate paragraphs.

The aggregate shall not contain more than a total of 8 percent, by weight, of flat particles, elongated particles, and flat and elongated particles, when tested in accordance with ASTM D 4791 with a value of 5:1.

The Engineer may specify ASTM D 4791 with a ratio of 3:1. If so, replace the above paragraph as follows: “The aggregate shall not contain more than a total of 20 percent by weight of flat particles, elongated particles, and flat and elongated particles when tested in accordance with ASTM D 4791 with a value of 3:1.”

Slag shall be air-cooled, blast furnace slag, and shall have a compacted weight of not less than 70 pounds per cubic foot (1.12 mg/cubic meter) when tested in accordance with ASTM C 29.

b. Fine Aggregate. Fine aggregate shall consist of clean, sound, durable, angular shaped particles produced by crushing stone, slag, or gravel that meets the requirements for wear and soundness specified for coarse aggregate. The aggregate particles shall be free from coatings of clay, silt, or other objectionable matter and shall contain no clay balls. The fine aggregate, including any blended material for the fine aggregate, shall have a plasticity index of not more than 6 and a liquid limit of not more than 25 when tested in accordance with ASTM D 4318.

Natural (nonmanufactured) sand may be used to obtain the gradation of the aggregate blend or to improve the workability of the mix. The amount of sand to be added will be adjusted to produce mixtures conforming to requirements of this specification. **[The fine aggregate shall not contain more than 15 percent natural sand by weight of total aggregates.]** If used, the natural sand shall meet the requirements of ASTM D 1073 and shall have a plasticity index of not more than 6 and a liquid limit of not more than 25 when tested in accordance with ASTM D 4318.

The aggregate shall have sand equivalent values of [] or greater when tested in accordance with ASTM D 2419.

Typically the sand equivalent value should be 45, unless local conditions require lower value.

The addition of natural sand to a mix containing all crushed coarse and fine aggregates will normally increase its workability and compactability. However, the addition of excessive amounts of natural sand tends to decrease the stability of the mixture. The requirement for a sand equivalent value of 45 usually limits the use of

natural sand; however, the maximum of 15 percent natural sand may be included for locations where low stabilities are a chronic problem.

c. **Sampling.** ASTM D 75 shall be used in sampling coarse and fine aggregate, and ASTM C 183 shall be used in sampling mineral filler.

401-2.2 MINERAL FILLER. If filler, in addition to that naturally present in the aggregate, is necessary, it shall meet the requirements of ASTM D 242.

401-2.3 BITUMINOUS MATERIAL. Bituminous material shall conform to the following requirements: [].

Asphalt cement binder shall conform to [AASHTO M320 Performance Grade (PG) [____]] [ASTM D 3381 Table 1, 2, or 3 Viscosity Grade] [ASTM D 946 Penetration Grade [____]]. Test data indicating grade certification shall be provided by the supplier at the time of delivery of each load to the mix plant. Copies of these certifications shall be submitted to the Engineer. The Engineer shall specify the grade of bituminous material, based on geographical location and climatic conditions. Asphalt Institute Superpave Series No. 1 (SP-1) provides guidance on the selection of performance graded binders. Table VI-1, Selecting Asphalt Grade, contained in the Asphalt Institute Manual Series-1 (MS-1) provides guidance on the selection of asphalt type. For cold climates, Table 2 of ASTM D 3381 may be specified to minimize the susceptibility for thermal cracking. The Engineer should be aware that PG asphalt binders may contain modifiers that require elevated mixing and compaction temperatures that exceed the temperatures specified in Item P-401.

Grades of some materials are listed below:

NOTE: Performance Graded (PG) asphalt binders should be specified wherever available. The same grade PG binder used by the state highway department in the area should be considered as the base grade for the project (for example, the grade typically specified in that specific location for dense graded mixes on highways with design Equivalent Standard Axle Loads (ESAL) less than 10 million). The exception would be that grades with a low temperature higher than PG XX-22 should not be used (for example, PG XX-16 or PG XX-10), unless the Engineer has had successful experience with them. Typically, rutting is not a problem on airport runways. However, at airports with a history of stacking on end of runways and taxiway areas, rutting has accrued due to the slow speed of loading on the pavement.

If there has been rutting on the project or it is anticipated that stacking may accrue during the design life of the project, then the following grade “bumping” should be applied for the top 125 mm (5 in) of paving in the end of runway and taxiway areas: for aircraft tire pressure between 100 and 200 psi, increase the high temperature one grade; for aircraft tire pressure greater than 200 psi, increase the high temperature two grades. Each grade adjustment is 6 °C. Polymer Modified Asphalt, (PMA) has shown to perform very well in these areas. The low temperature grade should remain the same.

Additional grade bumping and grade selection information is given in Table A.

Table A. Binder Grade Selection and Grade Bumping Based on Gross Aircraft Weight.

Aircraft Gross Weight (pounds)	High Temperature Adjustment to Base Binder Grade	
	Pavement Type	
	Runway	Taxiway/Apron
Less than 12,500	--	--
Less than 60,000	--	1
Less than 100,000	--	1
Greater than 100,000	1	2

NOTES:

1. PG grades above a -22 on the low end (for example, 64-16) are not recommended. Limited experience has shown this to be a poor performer.
2. PG grades below a 64 on the high end (for example, 58-22) are not recommended. These binders often provide tender tendencies.
3. PG grades above a 76 on the high end (for example, 82-22) are very stiff and may be difficult to work and compact.

Penetration Grade ASTM D 946	Viscosity Grade ASTM D 3381		Performance Graded Asphalt Institute Superpave Series No. 1 (SP-1)
40-50	AC-5	AR-1000	In general, the Engineer should choose a PG-asphalt binder that has been approved for use in the vicinity by the State DOT, and is locally available. In general, a high reliability (98 percent) on both the high and low temperature categories is sufficiently conservative.
60-70	AC-10	AR-2000	
85-100	AC-15	AR-4000	
100-120	AC-20	AR-8000	
120-150	AC-30		
	AC-40		

The Contractor shall furnish vendor's certified test reports for each lot of bituminous material shipped to the project. The vendor's certified test report for the bituminous material can be used for acceptance or tested independently by the Engineer.

401-2.4 PRELIMINARY MATERIAL ACCEPTANCE. Prior to delivery of materials to the job site, the Contractor shall submit certified test reports to the Engineer for the following materials:

a. Coarse Aggregate.

- (1). Percent of wear.
- (2). Soundness.
- (3). Unit weight of slag.
- (4). Percent fractured faces.

b. Fine Aggregate.

- (1) Liquid limit.
- (2) Plasticity index.
- (3) Sand equivalent.

c. Mineral Filler.

d. Bituminous Material. Test results for bituminous material shall include temperature/viscosity charts for mixing and compaction temperatures.

The certifications shall show the appropriate ASTM tests for each material, the test results, and a statement that the material meets the specification requirement.

The Engineer may request samples for testing, prior to and during production, to verify the quality of the materials and to ensure conformance with the applicable specifications.

401-2.5 ANTI-STRIPPING AGENT. Any anti-stripping agent or additive if required shall be heat stable, shall not change the asphalt cement viscosity beyond specifications, shall contain no harmful ingredients, shall be added in recommended proportion by approved method, and shall be a material approved by the Department of Transportation of the State in which the project is located.

COMPOSITION

401-3.1 COMPOSITION OF MIXTURE. The bituminous plant mix shall be composed of a mixture of well-graded aggregate, filler and anti-strip agent if required, and bituminous material. The several aggregate fractions shall be sized, handled in separate size groups, and combined in such proportions that the resulting mixture meets the grading requirements of the job mix formula (JMF).

401-3.2 JOB MIX FORMULA. No bituminous mixture for payment shall be produced until a job mix formula has been approved in writing by the Engineer. The bituminous mixture shall be designed using procedures contained in Chapter 5, Marshall Method of Mix Design, of the Asphalt Institute's Manual Series No. 2 (MS-2), Mix Design Methods for Asphalt Concrete, sixth edition.

The design criteria in Table 1 are target values necessary to meet the acceptance requirements contained in paragraph 401-5.2b. The criteria is based on a production process which has a material variability with the following standard deviations:

Stability = 270 lb

Flow (0.01 in) = 1.5 in

Air Voids = 0.65%

If material variability exceeds the standard deviations indicated, the job mix formula and subsequent production targets shall be based on a stability greater than shown in Table 1 and the flow and air voids shall be targeted close to the mid-range of the criteria in order to meet the acceptance requirements.

Tensile Strength Ratio (TSR) of the composite mixture, as determined by ASTM D 4867, shall not be less than 75. Anti-stripping agent shall be added to the asphalt, as necessary, to produce a TSR of not less than 75. If an anti-strip agent is required, it will be provided by the Contractor at no additional cost to the Owner.

Engineer may specify a TSR of not less than 80 in areas that are prone to stripping at a TSR of 75. Engineer may specify one or more freeze-thaw conditioning cycles in areas that are prone to stripping at a TSR of 75.

The job mix formula shall be submitted in writing by the Contractor to the Engineer at least [] days prior to the start of paving operations and shall include as a minimum:

a. Percent passing each sieve size for total combined gradation, individual gradation of all aggregate stockpiles and percent by weight of each stockpile used in the job mix formula.

b. Percent of asphalt cement.

c. Asphalt performance, viscosity or penetration grade, and type of modifier if used.

d. Number of blows of hammer compaction per side of molded specimen.

e. Mixing temperature.

f. Compaction temperature.

g. Temperature of mix when discharged from the mixer.

- h.** Temperature-viscosity relationship of the asphalt cement.
- i.** Plot of the combined gradation on the Federal Highway Administration (FHWA) 45 power gradation curve.
- j.** Graphical plots of stability, flow, air voids, voids in the mineral aggregate, and unit weight versus asphalt content.
- k.** Percent natural sand.
- l.** Percent fractured faces.
- m.** Percent by weight of flat particles, elongated particles, and flat and elongated particles (and criteria).
- n.** Tensile Strength Ratio (TSR).
- o.** Anti-strip agent (if required).
- p.** Date the job mix formula was developed.

The Contractor shall submit to the Engineer the results of verification testing of three (3) asphalt samples prepared at the optimum asphalt content. The average of the results of this testing shall indicate conformance with the job mix formula requirements specified in Tables 1, 2, and 3.

When the project requires asphalt mixtures of differing aggregate gradations, a separate job mix formula and the results of job mix formula verification testing must be submitted for each mix.

The job mix formula for each mixture shall be in effect until a modification is approved in writing by the Engineer. Should a change in sources of materials be made, a new job mix formula must be submitted within [] days and approved by the Engineer in writing before the new material is used. After the initial production job mix formula has been approved by the Engineer and a new or modified job mix formula is required for whatever reason, the subsequent cost of the Engineer's approval of the new or modified job mix formula will be borne by the Contractor. There will be no time extension given or considerations for extra costs associated with the stoppage of production paving or restart of production paving due to the time needed for the Engineer to approve the initial, new or modified job mix formula.

The Engineer shall specify the number of days. A minimum of 10 days is recommended.

Job mix formula not developed within the previous 90 days are not recommended.

The Marshall Design Criteria applicable to the project shall be specified by the Engineer from the information shown below and inserted into Table 1. Asterisks denote insert points.

Test Property	Pavements Designed for Aircraft Gross Weights of 60,000 Lb or More or Tire Pressures of 100 PSI or More	Pavements Designed for Aircraft Gross Weights Less Than 60,000 Lb or Tire Pressures Less Than 100 PSI
Number of Blows	75	50
Stability, pounds (Newtons)	2150 (9564)	1350 (6005)
Flow, 0.01 in. (0.25 mm)	10-14	10-18
Air Voids (percent)	2.8-4.2	2.8-4.2
Percent Voids in Mineral Aggregate (minimum)	See Table 2.	See Table 2

Table 1. Marshall Design Criteria

Test Property	*
Number of blows	*
Stability, pounds (Newtons) minimum	*
Flow, 0.01 in. (0.25 mm)	*
Air voids (%)	*
Percent voids in mineral aggregate, minimum	See Table 2.

Table 2. Minimum Percent Voids In Mineral Aggregate

Maximum Particle Size		Minimum Voids in Mineral Aggregate
½ in	12.5 mm	16%
¾ in	19.0 mm	15%
1 in	25.0 mm	14%
1 ½ in	37.5 mm	13%

Modifications to the minimum Voids in Mineral Aggregate (VMA) as found in Table 2 may be made depending on the definition of maximum particle size and/or local conditions. Modifications to the flow criteria may be required for modified asphalt cement binders.

The mineral aggregate shall be of such size that the percentage composition by weight, as determined by laboratory sieves, will conform to the gradation or gradations specified in Table 3 when tested in accordance with ASTM C 136 and C 117.

The gradations in Table 3 represent the limits that shall determine the suitability of aggregate for use from the sources of supply. The aggregate, as selected (and used in the JMF), shall have a gradation within the limits designated in Table 3 and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve, or vice versa, but shall be well graded from coarse to fine.

Deviations from the final approved mix design for bitumen content and gradation of aggregates shall be within the action limits for individual measurements as specified in paragraph 401-6.5a. The limits still will apply if they fall outside the master grading band in Table 3.

The maximum size aggregate used shall not be more than one-half of the thickness of the course being constructed except where otherwise shown on the plans or ordered by the Engineer.

Table 3 Aggregate - Bituminous Pavements

Sieve Size	Percentage by Weight Passing Sieve
1 ½ in. (37.50 mm)	*
1 in. (25.0 mm)	*
¾ in. (19.0 mm)	*
½ in. (12.5 mm)	*
⅜ in. (9.5 mm)	*
No. 4 (4.75 mm)	*
No. 8 (2.36 mm)	*

Sieve Size	Percentage by Weight Passing Sieve
No. 16 (1.18 mm)	*
No. 30 (0.60 mm)	*
No. 50 (0.30 mm)	*
No. 100 (0.15 mm)	*
No. 200 (0.075 mm)	*
Asphalt Percent:	
Stone or gravel	*
Slag	*

The aggregate gradations shown are based on aggregates of uniform specific gravity. The percentages passing the various sieves shall be corrected when aggregates of varying specific gravities are used, as indicated in the Asphalt Institute Manual Series No. 2 (MS-2), Chapter 3.

The aggregate gradation shall be specified by the Engineer from the gradations shown in this note. The gradation shall be inserted into Table 3. Asterisks denote insert points.

Where locally-available aggregates cannot be economically blended to meet the grading requirements of the gradations shown, the gradations may be modified to fit the characteristics of such local aggregates with approval of the FAA. The modified gradation must produce a paving mixture that satisfies the mix design requirements.

Aggregate - Bituminous Pavements

Sieve Size	Percentage by Weight Passing Sieves			
	1-½" max	1" max	¾" max	½" max
1-½ in. (37.5 mm)	100	--	--	--
1 in. (24.0 mm)	86-98	100	--	--
¾ in. (19.0 mm)	68-93	76-98	100	--
½ in. (12.5 mm)	57-81	66-86	79-99	100
⅜ in. (9.5 mm)	49-69	57-77	68-88	79-99
No. 4 (4.75 mm)	34-54	40-60	48-68	58-78
No. 8 (2.36 mm)	22-42	26-46	33-53	39-59
No. 16 (1.18 mm)	13-33	17-37	20-40	26-46
No. 30 (0.600 mm)	8-24	11-27	14-30	19-35
No. 50 (0.300 mm)	6-18	7-19	9-21	12-24
No. 100 (0.150 mm)	4-12	6-16	6-16	7-17
No. 200 (0.075 mm)	3-6	3-6	3-6	3-6
Asphalt percent:				
Stone or gravel	4.5-7.0	4.5-7.0	5.0-7.5	5.5-8.0
Slag	5.0-7.5	5.0-7.5	6.5-9.5	7.0-10.5

401-3.3 RECYCLED ASPHALT CONCRETE. Recycled HMA shall consist of reclaimed asphalt pavement (RAP), coarse aggregate, fine aggregate, mineral filler, and asphalt cement. The RAP shall be of a consistent gradation and asphalt content and properties. When RAP is fed into the plant, the maximum

RAP chunk size shall not exceed 2 in. The recycled HMA mix shall be designed using procedures contained in AI MS-02. The recycled asphalt concrete mix shall be designed using procedures contained in the Asphalt Institute's Manual Series Number 2 (MS-2). The percentage of asphalt in the RAP shall be established for the mixture design according to ASTM D 2172 using the appropriate dust correction procedure. The job mix shall meet the requirements of paragraph 401-3.2 RAP should only be used for shoulder surface course mixes and for any intermediate courses. The amount of RAP shall be limited to [] percent.

Reclaimed Asphalt Pavement (RAP) should not be used for surface mixes, except on shoulders. It can be used very effectively in lower layers or for shoulders. Engineer to specify the maximum percentage of reclaimed asphalt allowed in the mix. The amount of RAP shall be limited to 30 percent, as long as the resulting recycled mix meets all requirements that are specified for virgin mixtures. The Contractor may obtain the RAP from the job site or an existing source.

In addition to the requirements of paragraph 401-3.2, the job mix formula shall indicate the percent of reclaimed asphalt pavement and the percent and viscosity grade of new asphalt. The Contractor shall submit documentation to the Engineer, indicating that the mixing equipment proposed for use is adequate to mix the percent of RAP shown in the job mix formula and meet all local and national environmental regulations.

The appropriate test should be selected to conform to the grade of new asphalt specified. If a penetration grade is specified, use penetration test. If a viscosity grade is specified, use a viscosity test. If a PG asphalt binder is specified, use the dynamic shear rheometer and bending beam tests.

The blend of new asphalt cement and the RAP asphalt binder shall meet the requirements in paragraph 401-2.3. The virgin asphalt cement shall not be more than two standard asphalt material grades different than that specified in paragraph 401-2.3

Delete paragraph 401-3.3 in its entirety if recycled asphalt pavement is not to be allowed and include a sentence that RAP will not be permitted to be used. RAP containing coal tars may require additional precautions during production and may be excluded.

401-3.4 TEST SECTION. Prior to full production, the Contractor shall prepare and place a quantity of bituminous mixture according to the job mix formula. The amount of mixture shall be sufficient to construct a test section [] long and [] wide, placed in two lanes, with a longitudinal cold joint, and shall be of the same depth specified for the construction of the course which it represents. A cold joint is an exposed construction joint at least 4 hours old or whose mat has cooled to less than 160 °F. The underlying grade or pavement structure upon which the test section is to be constructed shall be the same as the remainder of the course represented by the test section. The equipment used in construction of the test section shall be the same type and weight to be used on the remainder of the course represented by the test section. The test section shall be evaluated for acceptance as a single lot in accordance with the acceptance criteria in paragraph 401-5.1 and 401-6.3. The test section shall be divided into equal sublots. As a minimum the test section shall consist of 3 sublots.

The test section shall be considered acceptable if; 1) stability, flow, mat density, air voids, and joint density are 90 percent or more within limits, 2) gradation and asphalt content are within the action limits specified in paragraphs 401-6.5a and 5b, and 3) the voids in the mineral aggregate are within the limits of Table 2. If the initial test section should prove to be unacceptable, the necessary adjustments to the job mix formula, plant operation, placing procedures, and/or rolling procedures shall be made. A second test section shall

then be placed. If the second test section also does not meet specification requirements, both sections shall be removed at the Contractor's expense. Additional test sections, as required, shall be constructed and evaluated for conformance to the specifications. Any additional sections that are not acceptable shall be removed at the Contractor's expense. Full production shall not begin until an acceptable section has been constructed and accepted in writing by the Engineer. Once an acceptable test section has been placed, payment for the initial test section and the section that meets specification requirements shall be made in accordance with paragraph 401-8.1.

Job mix control testing shall be performed by the Contractor at the start of plant production and in conjunction with the calibration of the plant for the job mix formula. If aggregates produced by the plant do not satisfy the gradation requirements or produce a mix that meets the JMF. It will be necessary to reevaluate and redesign the mix using plant-produced aggregates. Specimens shall be prepared and the optimum bitumen content determined in the same manner as for the original design tests.

The test section should be a minimum of 300 feet (90 m) long and 20 to 30 feet (6 to 9 m) wide. The test section affords the Contractor and the Engineer an opportunity to determine the quality of the mixture in place, as well as performance of the plant and laydown equipment.

Contractor will not be allowed to place the test section until the Contractor Quality Control Program, showing conformance with the requirements of Paragraph 401-6.1, has been approved, in writing, by the Engineer.

401-3.5 Job Mix Formula (JMF) Laboratory. The Contractor's laboratory used to develop the job mix formula shall meet the requirements of ASTM D 3666. The laboratory accreditation must be current and listed on the accrediting authority's website. All test methods required for developing the JMF must be listed on the lab accreditation. A copy of the laboratory's current accreditation and accredited test methods shall be submitted to the Engineer prior to start of construction.

CONSTRUCTION METHODS

401-4.1 WEATHER LIMITATIONS. The bituminous mixture shall not be placed upon a wet surface or when the surface temperature of the underlying course is less than specified in Table 4. The temperature requirements may be waived by the Engineer, if requested; however, all other requirements including compaction shall be met.

Table 4. Base Temperature Limitations

Mat Thickness	Base Temperature (Minimum)	
	Deg. F	Deg. C
3 in. (7.5 cm) or greater	40	4
Greater than 1 in. (2.5 cm) but less than 3 in. (7.5 cm)	45	7
1 in. (2.5 cm) or less	50	10

401-4.2 BITUMINOUS MIXING PLANT. Plants used for the preparation of bituminous mixtures shall conform to the requirements of ASTM D 995 with the following changes:
Requirements for all plants include:

(1) Truck Scales. The bituminous mixture shall be weighed on approved scales furnished by the Contractor, or on certified public scales at the Contractor's expense. Scales shall be inspected and sealed as often as the Engineer deems necessary to assure their accuracy. Scales shall conform to the requirements of the General Provisions, Section 90-01.

In lieu of scales, and as approved by the Engineer, asphalt mixture weights may be determined by the use of an electronic weighing system equipped with an automatic printer that weighs the total paving mixture. Contractor must furnish calibration certification of the weighing system prior to mix production and as often thereafter as requested by the Engineer.

(2) Testing Facilities. The Contractor shall provide laboratory facilities at the plant for the use of the Engineer's acceptance testing and the Contractor's quality control testing. The Engineer will always have priority in the use of the laboratory. The lab shall have sufficient space and equipment so that both testing representatives (Engineer's and Contractor's) can operate efficiently. The lab shall also meet the requirements of ASTM D 3666.

The plant testing laboratory shall have a floor space area of not less than 150 sq ft, with a ceiling height of not less than 7-½ feet. The laboratory shall be weather tight, sufficiently heated in cold weather, air-conditioned in hot weather to maintain temperatures for testing purposes of 70 °F +/- 5 °F. The plant testing laboratory shall be located on the plant site to provide an unobstructed view, from one of its windows, of the trucks being loaded with the plant mix materials.

Laboratory facilities shall be kept clean, and all equipment shall be maintained in proper working condition. The Engineer shall be permitted unrestricted access to inspect the Contractor's laboratory facility and witness quality control activities. The Engineer will advise the Contractor in writing of any noted deficiencies concerning the laboratory facility, equipment, supplies, or testing personnel and procedures. When the deficiencies are serious enough to be adversely affecting the test results, the incorporation of the materials into the work shall be suspended immediately and will not be permitted to resume until the deficiencies are satisfactorily corrected.

As a minimum, the plant testing laboratory shall have:

- a. Adequate artificial lighting
- b. Electrical outlets sufficient in number and capacity for operating the required testing equipment and drying samples.
- c. Fire extinguishers (2), Underwriter's Laboratories approved
- d. Work benches for testing, minimum 2-½ feet by 10 feet.
- e. Desk with 2 chairs
- f. Sanitary facilities convenient to testing laboratory
- g. Exhaust fan to outside air, minimum 12 in blade diameter
- h. A direct telephone line and telephone including a FAX machine operating 24 hours per day, seven days per week
- i. File cabinet with lock for Engineer
- j. Sink with running water, attached drain board and drain capable of handling separate material
- k. Metal stand for holding washing sieves
- l. Two element hot plate or other comparable heating device, with dial type thermostatic controls for drying aggregates
- m. Mechanical shaker and appropriate sieves (listed in JMF, Table 3) meeting the requirements of ASTM E-11 for determining the gradation of coarse and fine aggregates in accordance with ASTM C 136
- n. Marshall testing equipment meeting ASTM D 6926, ASTM D 6927, automatic compaction equipment capable of compacting three specimens at once and other apparatus as specified in ASTM C 127, D 2172, D 2726, and D 2041
- o. Oven, thermostatically controlled, inside minimum 1 cubic foot
- p. Two volumetric specific gravity flasks, 500 cc
- q. Other necessary hand tools required for sampling and testing
- r. Library containing contract specifications, latest ASTM volumes 4.01, 4.02, 4.03 and 4.09, AASHTO standard specification parts I and II, and Asphalt Institute Publication MS-2.
- s. Equipment for Theoretical Specific Gravity testing including a 4,000 cc pycnometer, vacuum pump capable of maintaining 30 ml mercury pressure and a balance, 16-20 gm with accuracy of 0.5 grams

- t. Extraction equipment, centrifuge and reflux types and Rotoflex equipment
- u. A masonry saw with diamond blade for trimming pavement cores and samples
- v. Telephone

Approval of the plant and testing laboratory by the Engineer requires all facilities and equipment to be in good working order during production, sampling and testing. Failure to provide the specified facilities shall be sufficient cause for disapproving bituminous plant operations.

The Owner shall have access to the lab and the plant whenever Contractor is in production.

(3) Inspection of Plant. The Engineer, or Engineer's authorized representative, shall have access, at all times, to all areas of the plant for checking adequacy of equipment; inspecting operation of the plant; verifying weights, proportions, and material properties; and checking the temperatures maintained in the preparation of the mixtures.

(4) Storage Bins and Surge Bins. Use of surge and storage bins for temporary storage of hot bituminous mixtures will be permitted as follows:

- a. The bituminous mixture may be stored in surge bins for a period of time not to exceed 3 hours.
- b. The bituminous mixture may be stored in insulated storage bins for a period of time not to exceed 24 hours.

The bins shall be such that mix drawn from them meets the same requirements as mix loaded directly into trucks.

If the Engineer determines that there is an excessive amount of heat loss, segregation, or oxidation of the mixture due to temporary storage, no temporary storage will be allowed.

401-4.3 HAULING EQUIPMENT. Trucks used for hauling bituminous mixtures shall have tight, clean, and smooth metal beds. To prevent the mixture from adhering to them, the truck beds shall be lightly coated with a minimum amount of paraffin oil, lime solution, or other approved material. Petroleum products shall not be used for coating truck beds. Each truck shall have a suitable cover to protect the mixture from adverse weather. When necessary, to ensure that the mixture will be delivered to the site at the specified temperature, truck beds shall be insulated or heated and covers shall be securely fastened.

401-4.4 BITUMINOUS PAVERS. Bituminous pavers shall be self-propelled with an activated heated screed, capable of spreading and finishing courses of bituminous plant mix material that will meet the specified thickness, smoothness, and grade. The paver shall have sufficient power to propel itself and the hauling equipment without adversely affecting the finished surface.

The paver shall have a receiving hopper of sufficient capacity to permit a uniform spreading operation. The hopper shall be equipped with a distribution system to place the mixture uniformly in front of the screed without segregation. The screed shall effectively produce a finished surface of the required evenness and texture without tearing, shoving, or gouging the mixture.

The paver shall be equipped with a control system capable of automatically maintaining the specified screed elevation. The control system shall be automatically actuated from either a reference line and/or through a system of mechanical sensors or sensor-directed mechanisms or devices that will maintain the paver screed at a predetermined transverse slope and at the proper elevation to obtain the required surface. The transverse slope controller shall be capable of maintaining the screed at the desired slope within plus or minus 0.1 percent.

The controls shall be capable of working in conjunction with any of the following attachments:

- a. Ski-type device of not less than 30 feet (9.14 m) in length.
- b. Taut stringline (wire) set to grade.
- c. Short ski or shoe.
- d. Laser control.

If, during construction, it is found that the spreading and finishing equipment in use leaves tracks or indented areas, or produces other blemishes in the pavement that are not satisfactorily corrected by the scheduled operations, the use of such equipment shall be discontinued and satisfactory equipment shall be provided by the Contractor.

401-4.5 ROLLERS. Rollers of the vibratory, steel wheel, and pneumatic-tired type shall be used. They shall be in good condition, capable of operating at slow speeds to avoid displacement of the bituminous mixture. The number, type, and weight of rollers shall be sufficient to compact the mixture to the required density while it is still in a workable condition.

All rollers shall be specifically designed and suitable for compacting hot mix bituminous concrete and shall be properly used. Rollers that impair the stability of any layer of a pavement structure or underlying soils shall not be used. Depressions in pavement surfaces caused by rollers shall be repaired by the Contractor at its own expense.

The use of equipment that causes crushing of the aggregate will not be permitted.

a. Nuclear Densometer. The Contractor shall have on site a nuclear densometer during all paving operations in order to assist in the determination of the optimum rolling pattern, type of roller and frequencies, as well as to monitor the effect of the rolling operations during production paving. The Contractor shall also supply a qualified technician during all paving operations to calibrate the nuclear densometer and obtain accurate density readings for all new bituminous concrete. These densities shall be supplied to the Engineer upon request at any time during construction. No separate payment will be made for supplying the density gauge and technician.

401-4.6 PREPARATION OF BITUMINOUS MATERIAL. The bituminous material shall be heated in a manner that will avoid local overheating and provide a continuous supply of the bituminous material to the mixer at a uniform temperature. The temperature of the bituminous material delivered to the mixer shall be sufficient to provide a suitable viscosity for adequate coating of the aggregate particles, but shall not exceed 325 °F (160 °C), unless otherwise required by the manufacturer.

401-4.7 PREPARATION OF MINERAL AGGREGATE. The aggregate for the mixture shall be heated and dried prior to introduction into the mixer. The maximum temperature and rate of heating shall be such that no damage occurs to the aggregates. The temperature of the aggregate and mineral filler shall not exceed 350 °F (175 °C) when the asphalt is added. Particular care shall be taken that aggregates high in calcium or magnesium content are not damaged by overheating. The temperature shall not be lower than is required to obtain complete coating and uniform distribution on the aggregate particles and to provide a mixture of satisfactory workability.

401-4.8 PREPARATION OF BITUMINOUS MIXTURE. The aggregates and the bituminous material shall be weighed or metered and introduced into the mixer in the amount specified by the job mix formula. The combined materials shall be mixed until the aggregate obtains a uniform coating of bitumen and is thoroughly distributed throughout the mixture. Wet mixing time shall be the shortest time that will produce a satisfactory mixture, but not less than 25 seconds for batch plants. The wet mixing time for all plants shall be established by the Contractor, based on the procedure for determining the percentage of coated particles described in ASTM D 2489, for each individual plant and for each type of aggregate used. The wet mixing time will be set to achieve 95 percent of coated particles. For continuous mix plants, the minimum mixing time shall be determined by dividing the weight of its contents at operating level by the weight of the mixture delivered per second by the mixer. The moisture content of all bituminous mixtures upon discharge shall not exceed 0.5 percent.

For batch plants, wet mixing time begins with the introduction of bituminous material into the mixer and ends with the opening of the mixer discharge gate. Distribution of aggregate and bituminous material as they enter the pugmill, speed of mixer shafts, and arrangement and pitch of paddles are factors governing efficiency of mixing. Prolonged exposure to air and heat in the pugmill harden the asphalt film on the aggregate. Mixing time, therefore, should be the shortest time required to obtain uniform distribution of aggregate sizes and thorough coating of aggregate particles with bituminous material.

401-4.9 PREPARATION OF THE UNDERLYING SURFACE. Immediately before placing the bituminous mixture, the underlying course shall be cleaned of all dust and debris. A prime coat or tack coat shall be applied in accordance with Item P-602 or P-603, if shown on the plans.

Engineer should evaluate the presence of paint and/or rubber deposits on the existing pavement and, if needed, may specify milling, grinding or other suitable means to remove same prior to placement of new bituminous material.

401-4.10 LAYDOWN PLAN, TRANSPORTING, PLACING, AND FINISHING. Prior to the placement of the bituminous mixture, the Contractor shall prepare a laydown plan for approval by the Engineer. This is to minimize the number of cold joints in the pavement. The laydown plan shall include the sequence of paving laydown by stations, width of lanes, temporary ramp locations, and laydown temperature. The laydown plan shall also include estimated time of completion for each portion of the work (that is, milling, paving, rolling, cooling, etc.). Modifications to the laydown plan shall be approved by the Engineer. The bituminous mixture shall be transported from the mixing plant to the site in vehicles conforming to the requirements of paragraph 401-4.3. Deliveries shall be scheduled so that placing and compacting of mixture is uniform with minimum stopping and starting of the paver. Hauling over freshly placed material shall not be permitted until the material has been compacted, as specified, and allowed to cool to atmospheric temperature.

Engineer may, at his option, add the following language:

“For all runway, taxiway and apron pavements, Contractor shall use a stringline to place each lane of each lift of bituminous surface course. However, at the Contractor’s option, Contractor shall use stringline for first lift of bituminous surface course and then survey the grade of that lift. Provided grades of that lift of bituminous surface course meet the tolerances of paragraphs 401-5.2b(6), then Contractor may place successive lifts of bituminous surface course using a long ski, or laser control per paragraph 401-4.4. However, Contractor shall survey each lift of bituminous surface course and certify to Engineer that every lot of each lift meets the grade tolerances of paragraph 401-5.2b(6) before the next lift can be placed without a stringline. If the grades of a single lot do not meet the tolerances of 401-5.2b(6), then the Contractor shall use a stringline for each entire lift. Corrective action in paragraph 401-5.2b(6) applies to the final lift of surface course; however, for multiple lift construction, the Contractor shall correct to ensure the final lift of surface course is a minimum of [] inches and a maximum of [] inches.” (Engineer to specify minimum and maximum tolerances for final lift of surface course)

The Contractor may elect to use a material transfer vehicle to deliver mix to the paver.

Use of a material transfer vehicle allows the paver to be operated almost continuously without stopping between truckloads of mix, if a continuous supply of mix is available from the asphalt plant. The use of a transfer vehicle is recommended on long paving lanes.

Paving during nighttime construction shall require the following:

- a.** All paving machines, rollers, distribution trucks and other vehicles required by the Contractor for his operations shall be equipped with artificial illumination sufficient to safely complete the work.

b. Minimum illumination level shall be twenty (20) horizontal foot candles and maintained in the following areas:

(1) An area of 30 feet wide by 30 feet long immediately behind the paving machines during the operations of the machines.

(2) An area 15 feet wide by 30 feet long immediately in front and back of all rolling equipment, during operation of the equipment.

(3) An area 15 feet wide by 15 feet long at any point where an area is being tack coated prior to the placement of pavement.

c. As partial fulfillment of the above requirements, the Contractor shall furnish and use, complete artificial lighting units with a minimum capacity of 3,000 watt electric beam lights, affixed to all equipment in such a way to direct illumination on the area under construction.

d. In addition, the Contractor shall furnish [] portable floodlight units similar or equal to [].

Engineer to specify the minimum number of floodlighting units and may elect to specify a particular manufacturer's lighting unit "or equal".

If nighttime paving requires the critical re-opening of airfield facilities, the following additional language should be added:

"If the Contractor places any out of specification mix in the project work area, the Contractor is required to remove it at its own expense, to the satisfaction of the Engineer. If the Contractor has to continue placing non-payment bituminous concrete, as directed by the Engineer, to make the surfaces safe for aircraft operations, the Contractor shall do so to the satisfaction of the Engineer. It is the Contractor's responsibility to leave the facilities to be paved in a safe condition ready for aircraft operations. No consideration for extended closure time of the area being paved will be given. As a first order of work for the next paving shift, the Contractor shall remove all out of specification material and replace with approved material to the satisfaction of the Engineer. When the above situations occur, there will be no consideration given for additional construction time or payment for extra costs."

The initial placement and compaction of the mixture shall occur at a temperature suitable for obtaining density, surface smoothness, and other specified requirements but not less than 250 °F (121 °C).

Edges of existing bituminous pavement abutting the new work shall be saw cut and carefully removed as shown on the drawings and painted with bituminous tack coat before new material is placed against it.

Upon arrival, the mixture shall be placed to the full width by a bituminous paver. It shall be struck off in a uniform layer of such depth that, when the work is completed, it shall have the required thickness and conform to the grade and contour indicated. The speed of the paver shall be regulated to eliminate pulling and tearing of the bituminous mat. Unless otherwise permitted, placement of the mixture shall begin along the centerline of a crowned section or on the high side of areas with a one-way slope. The mixture shall be placed in consecutive adjacent strips having a minimum width of [] except where edge lanes require less width to complete the area. Additional screed sections shall not be attached to widen paver to meet the minimum lane width requirements specified above unless additional auger sections are added to match. The longitudinal joint in one course shall offset the longitudinal joint in the course immediately below by at least 1 ft (30 cm); however, the joint in the surface top course shall be at the centerline of crowned pavements. Transverse joints in one course shall be offset by at least 10 feet (3 m) from transverse joints in the previous course.

Transverse joints in adjacent lanes shall be offset a minimum of 10 feet (3 m).

On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impractical, the mixture may be spread and luted by hand tools. Areas of segregation in the surface course, as determined by the Engineer, shall be removed and replaced at the Contractor's expense.

The area shall be removed by saw cutting and milling a minimum of 2 in deep. The area to be removed and replaced shall be a minimum width of the paver and a minimum of 10 feet long.

The Engineer should add more detail as appropriate to areas that require removal and replacements. The Engineer should specify the widest paving lane practicable in an effort to hold the number of longitudinal joints to a minimum.

401-4.11 COMPACTION OF MIXTURE. After placing, the mixture shall be thoroughly and uniformly compacted by power rollers. The surface shall be compacted as soon as possible when the mixture has attained sufficient stability so that the rolling does not cause undue displacement, cracking or shoving. The sequence of rolling operations and the type of rollers used shall be at the discretion of the Contractor. The speed of the roller shall, at all times, be sufficiently slow to avoid displacement of the hot mixture and be effective in compaction. Any displacement occurring as a result of reversing the direction of the roller, or from any other cause, shall be corrected at once.

Sufficient rollers shall be furnished to handle the output of the plant. Rolling shall continue until the surface is of uniform texture, true to grade and cross section, and the required field density is obtained.

To prevent adhesion of the mixture to the roller, the wheels shall be equipped with a scraper and kept properly moistened but excessive water will not be permitted.

In areas not accessible to the roller, the mixture shall be thoroughly compacted with approved power driven tampers. Tampers shall weigh not less than 275 pounds, have a tamping plate width not less than 15 in, be rated at not less than 4,200 vibrations per minute, and be suitably equipped with a standard tamping plate wetting device.

Any mixture that becomes loose and broken, mixed with dirt, contains check-cracking, or in any way defective shall be removed and replaced with fresh hot mixture and immediately compacted to conform to the surrounding area. This work shall be done at the Contractor's expense. Skin patching shall not be allowed.

401-4.12 JOINTS. The formation of all joints shall be made in such a manner as to ensure a continuous bond between the courses and obtain the required density. All joints shall have the same texture as other sections of the course and meet the requirements for smoothness and grade.

The roller shall not pass over the unprotected end of the freshly laid mixture except when necessary to form a transverse joint. When necessary to form a transverse joint, it shall be made by means of placing a bulkhead or by tapering the course. The tapered edge shall be cut back to its full depth and width on a straight line to expose a vertical face prior to placing the adjacent lane. In both methods, all contact surfaces shall be given a tack coat of bituminous material before placing any fresh mixture against the joint.

Longitudinal joints which are irregular, damaged, uncompacted, or otherwise defective [or which have been left exposed for more than 4 hours, or whose surface temperature has cooled to less than 160 °F] shall be cut back [specify cutback] to expose a clean, sound surface for the full depth of the course. All contact surfaces shall be cleaned and dry prior and given a tack coat of bituminous material prior to placing any fresh mixture against the joint. The cost of this work and tack coat shall be considered incidental to the cost of the bituminous course.

Engineer may retain the bracketed language regarding the treatment of “cold joints” when considered necessary. The cutback should be no more than 6 in.

401-4.13 SKID RESISTANT SURFACES/SAW-CUT GROOVING. If shown on the plans, skid resistant surfaces for asphalt pavements shall be provided by construction of saw-cut grooves. Saw-cut grooves must meet the requirements of Item P-621.

MATERIAL ACCEPTANCE

401-5.1 ACCEPTANCE SAMPLING AND TESTING. Unless otherwise specified, all acceptance sampling and testing necessary to determine conformance with the requirements specified in this section will be

performed by the Engineer at no cost to the Contractor except that coring [and profilograph testing] as required in this section shall be completed and paid for by the Contractor.

Testing organizations performing these tests [except profilograph] shall meet the requirements of ASTM D 3666. The laboratory accreditation must be current and listed on the accrediting authority's website. All test methods required for acceptance sampling and testing must be listed on the lab accreditation. A copy of the laboratory's current accreditation and accredited test methods shall be submitted to the Engineer prior to start of construction. All equipment in Contractor furnished laboratories shall be calibrated by an independent testing organization prior to the start of operations at the Contractor's expense.

**See note to Engineer in section 401-5.2b(5) regarding the use of profilograph testing.
If this testing is specified, it is performed and paid for by the Contractor.**

a. Plant-Produced Material. Plant-produced material shall be tested for stability, flow, and air voids on a lot basis. Sampling shall be from material deposited into trucks at the plant or from trucks at the job site. Samples shall be taken in accordance with ASTM D 979. A lot will consist of:

- One day or shift's production not to exceed 2,000 tons (1,814 t), or half day or shift's production where a day's production is expected to consist of between 2,000 and 4,000 tons (1,814 t and 3,628 t), or Similar subdivisions for tonnages over 4,000 tons (3,628, t).

Where more than one plant is simultaneously producing material for the job, the lot sizes shall apply separately for each plant.

(1) Sampling. Each lot will consist of four equal sublots. Sufficient material for preparation of test specimens for all testing will be sampled by the Engineer on a random basis, in accordance with the procedures contained in ASTM D 3665. One set of laboratory compacted specimens will be prepared for each subplot in accordance with ASTM D 6926, at the number of blows required by paragraph 401-3.2, Table 1. Each set of laboratory compacted specimens will consist of three test portions prepared from the same sample increment.

The sample of bituminous mixture may be put in a covered metal tin and placed in an oven for not less than 30 minutes nor more than 60 minutes to stabilize to compaction temperature. The compaction temperature of the specimens shall be as specified in the job mix formula.

Engineer should increase hold times to not less than 60 minutes and not more than 90 minutes when absorptive aggregates are used,

(2) Testing. Sample specimens shall be tested for stability and flow in accordance with ASTM D 6927. Air voids will be determined by the Engineer in accordance with ASTM D 3203.

Prior to testing, the bulk specific gravity of each test specimen shall be measured by the Engineer in accordance with ASTM D 2726 using the procedure for laboratory-prepared thoroughly dry specimens, or ASTM D 1188, whichever is applicable, for use in computing air voids and pavement density.

For air voids determination, the theoretical maximum specific gravity of the mixture shall be measured one time for each subplot in accordance with ASTM D 2041, Type C, D or E container. The value used in the air voids computation for each subplot shall be based on theoretical maximum specific gravity measurement for the subplot.

The stability and flow for each subplot shall be computed by averaging the results of all test specimens representing that subplot.

(3) Acceptance. Acceptance of plant produced material for stability, flow, and air voids shall be determined by the Engineer in accordance with the requirements of paragraph 401-5.2b.

b. Field Placed Material. Material placed in the field shall be tested for mat and joint density on a lot basis.

(1) Mat Density. The lot size shall be the same as that indicated in paragraph 401-5.1a and shall be divided into four equal sublots. One core of finished, compacted materials shall be taken by the Contractor from each subplot. Core locations will be determined by the Engineer on a random basis in accordance with procedures contained in ASTM D 3665. Cores shall not be taken closer than 1 ft from a transverse or longitudinal joint.

(2) Joint Density. The lot size shall be the total length of longitudinal joints constructed by a lot of material as defined in paragraph 401-5.1a. The lot shall be divided into four equal sublots. One core of finished, compacted materials shall be taken by the Contractor from each subplot. Core locations will be determined by the Engineer on a random basis in accordance with procedures contained in ASTM D 3665. All coring shall be centered on the joint. The minimum core diameter for joint density determination shall be 5 in.

(3) Sampling. Samples shall be neatly cut with a core drill. The cutting edge of the core drill bit shall be of hardened steel or other suitable material with diamond chips embedded in the metal cutting edge. The minimum diameter of the sample shall be 5 in. Samples that are clearly defective, as a result of sampling, shall be discarded and another sample taken. The Contractor shall furnish all tools, labor, and materials for cutting samples, cleaning, and filling the cored pavement. Cored pavement shall be cleaned and core holes shall be filled in a manner acceptable to the Engineer and within one day after sampling.

(4) Testing. The bulk specific gravity of each cored sample will be measured by the Engineer in accordance with ASTM D 2726 or ASTM D 1188, whichever is applicable. The percent compaction (density) of each sample will be determined by dividing the bulk specific gravity of each subplot sample by the average bulk specific gravity of all laboratory prepared specimens for the lot, as determined in paragraph 401-5.1a(2). The bulk specific gravity used to determine the joint density at joints formed between different lots shall be the lowest of the bulk specific gravity values from the two different lots.

(5) Acceptance. Acceptance of field placed material for mat density will be determined by the Engineer in accordance with the requirements of paragraph 401-5.2b(1). Acceptance for joint density will be determined in accordance with the requirements of paragraph 401-5.2b(3).

c. Partial Lots - Plant-Produced Material. When operational conditions cause a lot to be terminated before the specified number of tests have been made for the lot, or when the Contractor and Engineer agree in writing to allow overages or other minor tonnage placements to be considered as partial lots, the following procedure will be used to adjust the lot size and the number of tests for the lot.

The last batch produced where production is halted will be sampled, and its properties shall be considered as representative of the particular subplot from which it was taken. In addition, an agreed to minor placement will be sampled, and its properties shall be considered as representative of the particular subplot from which it was taken. Where three sublots are produced, they shall constitute a lot. Where one or two sublots are produced, they shall be incorporated into the next lot, and the total number of sublots shall be used in the acceptance plan calculation, that is, $n = 5$ or $n = 6$, for example. Partial lots at the end of asphalt production on the project shall be included with the previous lot.

d. Partial Lots - Field Placed Material. The lot size for field placed material shall correspond to that of the plant material, except that, in no cases, shall less than three (3) cored samples be obtained, that is, $n = 3$.

401-5.2 ACCEPTANCE CRITERIA.

a. General. Acceptance will be based on the following characteristics of the bituminous mixture and completed pavement as well as the implementation of the Contractor Quality Control Program and test results:

- (1) Stability
- (2) Flow
- (3) Air voids
- (4) Mat density
- (5) Joint density
- (6) Thickness
- (7) Smoothness
- (8) Grade

Mat density and air voids will be evaluated for acceptance in accordance with paragraph 401-5.2b(1). Stability and flow will be evaluated for acceptance in accordance with paragraph 401-5.2b(2). Joint density will be evaluated for acceptance in accordance with paragraph 401-5.2b(3).

Thickness will be evaluated by the Engineer for compliance in accordance with paragraph 401-5.2b(4). Acceptance for smoothness will be based on the criteria contained in paragraph 401-5.2b(5). Acceptance for grade will be based on the criteria contained in paragraph 401-5.2b(6).

The Engineer may at any time, notwithstanding previous plant acceptance, reject and require the Contractor to dispose of any batch of bituminous mixture which is rendered unfit for use due to contamination, segregation, incomplete coating of aggregate, or improper mix temperature. Such rejection may be based on only visual inspection or temperature measurements. In the event of such rejection, the Contractor may take a representative sample of the rejected material in the presence of the Engineer, and if it can be demonstrated in the laboratory, in the presence of the Engineer, that such material was erroneously rejected, payment will be made for the material at the contract unit price.

b. Acceptance Criteria.

(1) Mat Density and Air Voids. Acceptance of each lot of plant produced material for mat density and air voids shall be based on the percentage of material within specification limits (PWL). If the PWL of the lot equals or exceeds 90 percent, the lot shall be acceptable. Acceptance and payment shall be determined in accordance with paragraph 401-8.1.

(2) Stability and Flow. Acceptance of each lot of plant produced material for stability and flow shall be based on the percentage of material within specification limits (PWL). If the PWL of the lot equals or exceeds 90 percent, the lot shall be acceptable. If the PWL is less than 90 percent, the Contractor shall determine the reason and take corrective action. If the PWL is below 80 percent, the Contractor must stop production until the reason for poor stability and/or flow has been determined and adjustments to the mix are made

(3) Joint Density. Acceptance of each lot of plant produced material for joint density shall be based on the percentage of material within specification limits (PWL). If the PWL of the lot is equal to or exceeds 90 percent, the lot shall be considered acceptable. If the PWL is less than 90 percent, the Contractor shall evaluate the reason and act accordingly. If the PWL is less than 80 percent, the Contractor shall cease operations and until the reason for poor compaction has been determined. If the PWL is less than 71 percent, the pay factor for the lot used to complete the joint shall be reduced by 5 percentage points. This lot pay factor reduction shall be incorporated and evaluated in accordance with paragraph 401-8.1.

(4) Thickness. Thickness of each lift of surface course shall be evaluated by the Engineer for compliance to the requirements shown on the plans. Measurements of thickness shall be made by the Engineer using the cores extracted for each subplot for density measurement. The maximum allowable deficiency at any point shall not be more than $\frac{1}{4}$ in less than the thickness indicated for the lift. Average

thickness of lift, or combined lifts, shall not be less than the indicated thickness. Where the thickness tolerances are not met, the lot or subplot shall be corrected by the Contractor at his expense by removing the deficient area and replacing with new pavement. The Contractor, at his expense, may take additional cores as approved by the Engineer to circumscribe the deficient area.

(5) Smoothness. The final surface shall be free from roller marks. The finished surfaces of each course of the pavement, except the finished surface of the final course, shall not vary more than $\frac{3}{8}$ in when evaluated with a 16 ft straightedge. The finished surface of the final course of pavement shall not vary more than $\frac{1}{4}$ in when evaluated with a 16 ft straightedge. The lot size shall be [] square yards (sq m). Smoothness measurements shall be made at 50 ft intervals and as determined by the Engineer. In the longitudinal direction, a smoothness reading shall be made at the center of each paving lane. In the transverse direction, smoothness readings shall be made continuously across the full width of the pavement. However, transverse smoothness readings shall not be made across designed grade changes. At warped transition areas, straightedge position shall be adjusted to measure surface smoothness and not design grade transitions. When more than 15 percent of all measurements within a lot exceed the specified tolerance, the Contractor shall remove the deficient area to the depth of the final course of pavement and replace with new material. Skin patching shall not be permitted. Isolated high points may be ground off providing the course thickness complies with the thickness specified on the plans. High point grinding will be limited to 15 sq yd. Areas in excess of 15 sq yd will require removal and replacement of the pavement in accordance with the limitations noted above.

The Engineer shall specify the lot size. A minimum of 2,000 sq yd (1,650 sq m) is recommended.

Use of a profilograph can be included in the specifications for surface smoothness for runways and taxiways on a case by case basis provided it is approved by the FAA. Use of a profilograph may not be practical for all asphalt construction. Thin lift overlays and other minimum resurfacing may not allow for removal of existing pavement roughness. However, the use of the profilograph is recommended for new construction or overlays designed to correct grade and smoothness deficiencies.

If the profilograph is to be included, straightedge requirements need only apply to the perpendicular direction. To include profilograph requirements, add ASTM E 1274 to the referenced testing list and add the following:

(a) Profilograph. The Contractor shall furnish a 25 ft wheel base California type profilograph and competent operator to measure pavement surface deviations. The profilograph shall be operated in accordance with the manufacturer's instructions and at a speed no greater than 3 mph. Original profilograms for the appropriate locations interpreted in accordance with ASTM E 1274 shall be furnished to the Engineer. The profilograms shall be recorded on a scale of 1 inch equal to 25 feet longitudinally and 1 inch equal to 1 inch (or full scale) vertically. Profilographs shall be calibrated prior to testing.

The surface of the runway and/or taxiway pavements of continuous placement of 50 feet or more shall be tested and evaluated as described herein. One pass along the centerline shall be required for each paving lane. Runs shall be continuous through a day's production. Each trace shall be completely labeled to show paving lane and stationing.

The Contractor shall furnish paving equipment and employ methods that produce a riding surface for each section of pavement having an average profile index meeting the requirements of Table 7. A typical section will be considered to be the width of the paving lane and 1/10 of a mile long. The profile index will be determined in accordance with ASTM E 1274. A blanking band of 0.2 in shall be used. Within each

1/10 mile section, all areas represented by high points having a deviation in excess of 0.4 inches in 25 feet or less shall be removed by the Contractor using an approved method. After removing all individual deviations in excess of 0.4 inches, additional corrective work shall be performed if necessary to achieve the required ride quality. All corrective work shall be completed prior to determination of pavement thickness.

On pavement sections where corrections were necessary, second profilograph runs shall be performed to verify that the corrections have produced an average profile index of 15 in per mile or less. If the initial average profile index was less than 15, only those areas representing greater than 0.4 inch deviation will be re-profiled for correction verification.

Individual sections shorter than 50 feet and the last 15 feet of any section where the Contractor is not responsible for the adjoining section shall be straightedged in accordance with paragraph 401-5.2b(5).

If there is a section of 250 feet or less, the profilogram for the section shall be included in the evaluation of the previous section. If there is an independently placed section of 50 to 250 feet in length, a profilogram shall be made for that section and the pay adjustment factors for short section of Table 7 shall apply.

All costs necessary to provide the profilograph and related to furnishing the appropriate profilograms as required in this provision are incidental to pavement construction and no direct compensation will be made therefore.

(6) Grade. The finished surface of the pavement shall not vary from the gradeline elevations and cross sections shown on the plans by more than ½ in (12.70 mm). The finished grade of each lot will be determined by running levels at intervals of 50 feet (15.2 m) or less longitudinally and all breaks in grade transversely (not to exceed 50 feet) to determine the elevation of the completed pavement. The Contractor shall pay the cost of surveying of the level runs that shall be performed by a licensed surveyor. The documentation, stamped and signed by a licensed surveyor, shall be provided by the Contractor to the Engineer. The lot size shall be [] square yards (square meters). When more than 15 percent of all the measurements within a lot are outside the specified tolerance, or if any one shot within the lot deviates ¾ in or more from planned grade, the Contractor shall remove the deficient area to the depth of the final course of pavement and replace with new material. Skin patching shall not be permitted. Isolated high points may be ground off providing the course thickness complies with the thickness specified on the plans. The surface of the ground pavement shall have a texture consisting of grooves between 0.090 and 0.130 in wide. The peaks and ridges shall be approximately 1/32 in higher than the bottom of the grooves. The pavement shall be left in a clean condition. The removal of all of the slurry resulting from the grinding operation shall be continuous. The grinding operation should be controlled so the residue from the operation does not flow across other lanes of pavement. High point grinding will be limited to 15 sq yd. Areas in excess of 15 sq yd will require removal and replacement of the pavement in accordance with the limitations noted above.

A minimum of 2,000 sq yd (1,650 sq m) is recommended.

c. Percentage of Material Within Specification Limits (PWL). The percentage of material within specification limits (PWL) shall be determined in accordance with procedures specified in Section 110 of the General Provisions. The specification tolerance limits (L) for lower and (U) for upper are contained in Table 5.

d. Outliers. All individual tests for mat density and air voids shall be checked for outliers (test criterion) in accordance with ASTM E 178, at a significance level of 5 percent. Outliers shall be discarded, and the PWL shall be determined using the remaining test values.

The specification tolerance limits applicable to the project, based on design criteria specified in Table 1, shall be specified by the Engineer from the information shown below and inserted into Table 5. Asterisks denote insert points.

Table 5 Marshall Acceptance Limits For Stability, Flow, Air Voids, Density

TEST PROPERTY	Pavements Designed for Aircraft Gross Weights of 60,000 Lb or More or Tire Pressures of 100 PSI or More		Pavements Designed for Aircraft Gross Weights Less Than 60,000 Lb or Tire Pressures Less Than 100 PSI	
Number of Blows	75 blows		50 blows	
	Specification Tolerance Limits		Specification Tolerance Limits	
	L	U	L	U
Stability, minimum (pounds)	1800	--	1000	--
Flow, 0.01-inch	8	16	8	20
Air Voids Total Mix (%)	2	5	2	5
Surface Course Mat Density (%)	96.3	[101.3]	96.3	[101.3]
Base Course Mat Density (%)	95.5	[101.3]	95.5	[101.3]
Joint density (%)	93.3	--	93.3	--

NOTE TO ENGINEER. The Engineer may specify both upper and lower PWL acceptance criteria (two-sided) for density. Use 101.3 as the Upper tolerance limits when two-sided density acceptance criteria is specified AND insert edit paragraph 401-8.1. See Notes to Engineer following paragraph 401-8.1.

Table 5. Marshall Acceptance Limits For Stability, Flow, Air Voids, Density

TEST PROPERTY	*	
Number of Blows	* blows	
	Specification Tolerance	
	L	U
Stability, minimum (pounds)	*	*
Flow, 0.01-inch	*	*
Air Voids Total Mix (%)	*	*
Mat Density (%)	*	*
Joint Density (%)	*	*

The criteria in Table 5 is based on production processes which have a variability with the following standard deviations:

Surface Course Mat Density (%), 1.30

Base Course Mat Density (%), 1.55

Joint Density (%), 2.1

The Contractor should note that (1) 90 PWL is achieved when consistently producing a surface course with an average mat density of at least 98 percent with 1.30% or less variability, (2) 90 PWL is achieved when consistently producing a base course with an average mat density of at least 97.5 percent with 1.55% or less variability, and (3) 90 PWL is achieved when consistently producing joints with an average joint density of at least 96 percent with 2.1% or less variability.

A lot is the quantity of material to be controlled and may represent a specified tonnage or a specified number of truckloads. The lot size, to be determined by the Engineer, should, for the most part, depend on the operational capacity of the plant, but shall in no case exceed 2,000 tons (1,814 kg) in accordance with paragraph 401-5.1a.

401-5.3 RESAMPLING PAVEMENT FOR MAT DENSITY.

a. General. Resampling of a lot of pavement will only be allowed for mat density, and then, only if the Contractor requests same, in writing, within 48 hours after receiving the written test results from the Engineer. A retest will consist of all the sampling and testing procedures contained in paragraphs 401-5.1b and 401-5.2b(1). Only one resampling per lot will be permitted.

(1) A redefined PWL shall be calculated for the resampled lot. The number of tests used to calculate the redefined PWL shall include the initial tests made for that lot plus the retests.

(2) The cost for resampling and retesting shall be borne by the Contractor.

b. Payment for Resampled Lots. The redefined PWL for a resampled lot shall be used to calculate the payment for that lot in accordance with Table 6.

c. Outliers. Check for outliers in accordance with ASTM E 178, at a significance level of 5 percent.

[401-5.4 LEVELING COURSE. Any course used for truing and leveling shall meet the requirements of paragraph 401-3.2, 401-5.2b(1) for air voids and 401-5.2b(2), but shall not be subject to the density requirements of paragraph 401-5.2b(1) for mat density and 401-5.2b(3). The leveling course shall be compacted with the same effort used to achieve density of the test section. The truing and leveling course shall not exceed a nominal thickness of 1-½ in (37.5 mm). The leveling course is the first variable thickness lift of an overlay placed prior to subsequent courses.]

Use this paragraph only when there is a need to restore proper cross-section prior to overlaying. Areas of the pavement requiring a leveling course shall be shown on the plans.

CONTRACTOR QUALITY CONTROL

401-6.1 GENERAL. The Contractor shall develop a Quality Control Program in accordance with Section 100 of the General Provisions. The program shall address all elements that affect the quality of the pavement including, but not limited to:

a. Mix Design

- b. Aggregate Grading
- c. Quality of Materials
- d. Stockpile Management
- e. Proportioning
- f. Mixing and Transportation
- g. Placing and Finishing
- h. Joints
- i. Compaction
- j. Surface Smoothness
- k. Personnel
- l. Laydown Plan

The Contractor shall perform quality control sampling, testing, and inspection during all phases of the work and shall perform them at a rate sufficient to ensure that the work conforms to the contract requirements, and at minimum test frequencies required by paragraph 401-6.3 and Section 100 of the General Provisions. As a part of the process for approving the Contractor's plan, the Engineer may require the Contractor's technician to perform testing of samples to demonstrate an acceptable level of performance.

No partial payment will be made for materials that are subject to specific quality control requirements without an approved plan.

401-6.2 TESTING LABORATORY. The Contractor shall provide a fully equipped asphalt laboratory meeting the requirements of paragraph 401-3.5 and 401-4.2a(2) located at the plant or job site. The Contractor shall provide the Engineer with certification stating that all of the testing equipment to be used is properly calibrated and will meet the specifications applicable for the specified test procedures.

401-6.3 QUALITY CONTROL TESTING. The Contractor shall perform all quality control tests necessary to control the production and construction processes applicable to these specifications and as set forth in the approved Quality Control Program. The testing program shall include, but not necessarily be limited to, tests for the control of asphalt content, aggregate gradation, temperatures, aggregate moisture, field compaction, and surface smoothness. A Quality Control Testing Plan shall be developed as part of the Quality Control Program.

a. Asphalt Content. A minimum of two tests shall be performed per lot in accordance with ASTM D 6307 or ASTM D 2172 for determination of asphalt content. The weight of ash portion of the test, as described in ASTM D 2172, shall be determined as part of the first test performed at the beginning of plant production; and as part of every tenth test performed thereafter, for the duration of plant production. The last weight of ash value obtained shall be used in the calculation of the asphalt content for the mixture. The asphalt content for the lot will be determined by averaging the test results.

The use of the nuclear method for determining asphalt content in accordance with ASTM D 4125 is permitted, provided that it is calibrated for the specific mix being used.

b. Gradation. Aggregate gradations shall be determined a minimum of twice per lot from mechanical analysis of extracted aggregate in accordance with ASTM D 5444 and ASTM C 136 (dry sieve). When asphalt content is determined by the nuclear method, aggregate gradation shall be determined from hot bin samples on batch plants, or from the cold feed on drum mix or continuous mix plants, and tested in accordance with ASTM C 136 (dry sieve) using actual batch weights to determine the combined aggregate gradation of the mixture.

c. Moisture Content of Aggregate. The moisture content of aggregate used for production shall be determined a minimum of once per lot in accordance with ASTM C 566.

d. Moisture Content of Mixture. The moisture content of the mixture shall be determined once per lot in accordance with ASTM D 1461 [or AASHTO T 110].

ASTM D 1461 may be replaced with AASHTO T 110 moisture content testing procedure using a conventional oven or microwave.

e. Temperatures. Temperatures shall be checked, at least four times per lot, at necessary locations to determine the temperatures of the dryer, the bitumen in the storage tank, the mixture at the plant, and the mixture at the job site.

f. In-Place Density Monitoring. The Contractor shall conduct any necessary testing to ensure that the specified density is being achieved. A nuclear gauge may be used to monitor the pavement density in accordance with ASTM D 2950.

g. Additional Testing. Any additional testing that the Contractor deems necessary to control the process may be performed at the Contractor's option.

h. Monitoring. The Engineer reserves the right to monitor any or all of the above testing.

401-6.4 SAMPLING. When directed by the Engineer, the Contractor shall sample and test any material that appears inconsistent with similar material being sampled, unless such material is voluntarily removed and replaced or deficiencies corrected by the Contractor. All sampling shall be in accordance with standard procedures specified.

401-6.5 CONTROL CHARTS. The Contractor shall maintain linear control charts both for individual measurements and range (that is, difference between highest and lowest measurements) for aggregate gradation and asphalt content.

Control charts shall be posted in a location satisfactory to the Engineer and shall be kept current. As a minimum, the control charts shall identify the project number, the contract item number, the test number, each test parameter, the Action and Suspension Limits applicable to each test parameter, and the Contractor's test results. The Contractor shall use the control charts as part of a process control system for identifying potential problems and assignable causes before they occur. If the Contractor's projected data during production indicates a problem and the Contractor is not taking satisfactory corrective action, the Engineer may suspend production or acceptance of the material.

a. Individual Measurements. Control charts for individual measurements shall be established to maintain process control within tolerance for aggregate gradation and asphalt content. The control charts shall use the job mix formula target values as indicators of central tendency for the following test parameters with associated Action and Suspension Limits:

Control Chart Limits For Individual Measurements		
Sieve	Action Limit	Suspension Limit
¾ in (19.0 mm)	0%	0%
½ in (12.5 mm)	+/-6%	+/-9%
¾ in (9.5 mm)	+/-6%	+/-9%
No. 4 (4.75 mm)	+/-6%	+/-9%
No. 16 (1.18 mm)	+/-5%	+/-7.5%
No. 50 (0.30 mm)	+/-3%	+/-4.5%
No. 200 (0.075 mm)	+/-2%	+/-3%
Asphalt Content	+/-0.45%	+/-0.70%

b. Range. Control charts for range shall be established to control process variability for the test parameters and Suspension Limits listed below. The range shall be computed for each lot as the difference between the two test results for each control parameter. The Suspension Limits specified below are based on a sample size of n = 2. Should the Contractor elect to perform more than two tests per lot, the Suspension Limits shall be adjusted by multiplying the Suspension Limit by 1.18 for n = 3 and by 1.27 for n = 4.

Control Chart Limits Based On Range (Based On n = 2)	
Sieve	Suspension Limit
½ in (12.5 mm)	11 percent
¾ in (9.5 mm)	11 percent
No. 4 (4.75 mm)	11 percent
No. 16 (1.18 mm)	9 percent
No. 50 (0.30 mm)	6 percent
No. 200 (0.075 mm)	3.5 percent
Asphalt Content	0.8 percent

c. Corrective Action. The Contractor Quality Control Program shall indicate that appropriate action shall be taken when the process is believed to be out of tolerance. The Plan shall contain sets of rules to gauge when a process is out of control and detail what action will be taken to bring the process into control. As a minimum, a process shall be deemed out of control and production stopped and corrective action taken, if:

- (1) One point falls outside the Suspension Limit line for individual measurements or range; or
- (2) Two points in a row fall outside the Action Limit line for individual measurements.

The aggregate control chart parameters and Suspension and Action Limits contained in the above paragraphs are based on ¾ in (19.0 mm) maximum size aggregate gradation. When 1 in (25.0 mm) or 1 ½ in (37.5 mm) maximum size aggregate is specified, the Individual Measurements Chart requirements should be amended as follows:

Sieve	Action Limit	Suspension Limit
1 in or 1-½ in	0%	0%
¾ in	6%	11%

When ½ in (12.5 mm) maximum size aggregate is specified, the ¾ in (19.0 mm) and 1 in (25.0 mm) sieves should be deleted from the Individual Measurements Chart and the ½ in (12.5 mm) sieve Action and Suspension Limits should be changed to 0%. For the ½ in (12.5 mm) gradation, the ½ in sieve should be deleted from the Range Chart.

401-6.6 QUALITY CONTROL REPORTS. The Contractor shall maintain records and shall submit reports of quality control activities daily, in accordance with the Contractor Quality Control Program described in General Provisions, Section 100.

METHOD OF MEASUREMENT

401-7.1 MEASUREMENT. Plant mix bituminous concrete pavement shall be measured by the number of tons (kg) of bituminous mixture used in the accepted work. Recorded batch weights or truck scale weights will be used to determine the basis for the tonnage.

BASIS OF PAYMENT

401-8.1 PAYMENT. Payment for a lot of bituminous concrete pavement meeting all acceptance criteria as specified in Paragraph 401-5.2 shall be made based on results of tests for [smoothness,] mat density and

air voids. Payment for acceptable lots shall be adjusted according to paragraph 401-8.1a for mat density and air voids and 401-8.1c for smoothness, subject to the limitation that:

The total project payment for plant mix bituminous concrete pavement shall not exceed [] percent of the product of the contract unit price and the total number of tons (kg) of bituminous mixture used in the accepted work (See Note 1 under Table 6).

The price shall be compensation for furnishing all materials, for all preparation, mixing, and placing of these materials, and for all labor, equipment, tools, and incidentals necessary to complete the item.

The Engineer shall specify a value ranging from 100 to the maximum lot pay factor amount. (106 percent for single-sided density or 103 percent when double-sided density is specified.) When the total project payment for Item P-401 pavement exceeds the contract unit price, any AIP or PFC funds used to pay the excess may require an amendment to the AIP grant or PFC application for the project.

a. Basis of Adjusted Payment. The pay factor for each individual lot shall be calculated in accordance with Table 6. A pay factor shall be calculated for both mat density and air voids. The lot pay factor shall be the higher of the two values when calculations for both mat density and air voids are 100 percent or higher. The lot pay factor shall be the product of the two values when only one of the calculations for either mat density or air voids is 100 percent or higher. The lot pay factor shall be the lower of the two values when calculations for both mat density and air voids are less than 100 percent.

Table 6. Price Adjustment Schedule¹

Percentage of Material Within Specification Limits (PWL)	Lot Pay Factor (Percent of Contract Unit Price)
96 – 100	106
90 – 95	PWL + 10
75 – 89	0.5 PWL + 55
55 – 74	1.4 PWL – 12
Below 55	Reject ²
¹ Although it is theoretically possible to achieve a pay factor of 106 percent for each lot, actual payment above 100 percent shall be subject to the total project payment limitation specified in paragraph 401-8.1. ² The lot shall be removed and replaced. However, the Engineer may decide to allow the rejected lot to remain. In that case, if the Engineer and Contractor agree in writing that the lot shall not be removed, it shall be paid for at 50 percent of the contract unit price and the total project payment shall be reduced by the amount withheld for the rejected lot.	

For each lot accepted, the adjusted contract unit price shall be the product of the lot pay factor for the lot and the contract unit price. Payment shall be subject to the total project payment limitation specified in paragraph 401-8.1. Payment in excess of 100 percent for accepted lots of bituminous concrete pavement shall be used to offset payment for accepted lots of bituminous concrete pavement that achieve a lot pay factor less than 100 percent.

NOTE TO ENGINEER. The Engineer may specify both upper and lower PWL acceptance criteria (two-sided) for density. Use the following pay adjustment schedule when two-sided acceptance criteria for density is specified edit Table 5 to include the Upper tolerance limits and edit paragraph 401-8.1.

TABLE 6. Price Adjustment Schedule¹

Percentage of Material Within Specification Limits (PWL)	Lot Pay Factor (Percent of Contract Unit Price)
93 – 100	103
90 – 93	PWL + 10
70 – 89	0.125 PWL + 88.75
40 – 69	0.75 PWL + 45
Below 40	Reject ²
¹ Although it is theoretically possible to achieve a pay factor of 103 percent for each lot, actual payment above 100 percent shall be subject to the total project payment limitation specified in paragraph 401-8.1. ² The lot shall be removed and replaced. However, the Engineer may decide to allow the rejected lot to remain. In that case, if the Engineer and Contractor agree in writing that the lot shall not be removed, it shall be paid for at 50 percent of the contract unit price and the total project payment shall be reduced by the amount withheld for the rejected lot.	

If a profilograph is used, add the following paragraphs and change existing paragraph 401-8.1b to 401-8.1d (The pay adjustment in Table 7 is optional to the Owner and Engineer when using the profilograph):

b. Profilograph Smoothness. When the final average profile index (subsequent to any required corrective action) does not exceed 7 in per mile, payment will be made for that section at the contract unit price for the completed pavement. If the final average profile index (subsequent to any required corrective action) exceeds 7 in per mile, but does not exceed 15 in per mile, the Contractor may elect to accept a contract unit price adjustment in lieu of reducing the profile index.

c. Basis of Adjusted Payment for Smoothness. Price adjustment for pavement smoothness will be made in accordance with Table 7. The adjustment will apply to the total tonnage of asphalt concrete within a lot of pavement and shall be applied with the following equation:

(Tons of asphalt concrete in lot) x (lot pay factor) x (unit price per ton) x (smoothness pay factor) = payment for lot

Table 7. Average Profile Index Smoothness Pay Factor

(Inches per mile per 1/10 mile)	Short Sections	Pay Factor
00.0 - 7	00.0 - 15.0	100%
7.1 - 9	15.1 - 16	98%
9.1 - 11	16.1 - 17	96%
11.1 - 13	17.1 - 18	94%
13.1 - 14	18.1 - 20	92%
14.1 - 15	20.1 - 22	90%
15.1 & up	22.1 & up	Corrective work required ¹
¹ The Contractor shall correct pavement areas not meeting these tolerances by removing and replacing the defective work. If the Contractor elects to construct an overlay to correct deficiencies, the minimum thickness of the overlay shall not be less than twice the size of the maximum size aggregate. The corrective overlay shall not violate grade		

(Inches per mile per 1/10 mile)	Short Sections	Pay Factor
Criteria and butt joints shall be constructed by sawing and removing the original pavement in compliance with the thickness/maximum aggregate size ratio. Skin patching shall not be permitted.		

Unit bid price adjustment will apply to total bituminous mixture and asphalt cement quantities within the 1/10 mile segment of pavement. Deductions will be applied to recorded project quantities. Any pavement section less than 1/10 mile will be accepted on a pro-rated basis.

Material used in building the pavement above the specified grade shall not be included in the quantities for payment.

b. Payment. Payment will be made under:

Item P-401-8.1a Bituminous [Surface] [Base] [Binder] [Leveling] Course-per ton (kg)

TESTING REQUIREMENTS

ASTM C 29	Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C 88	Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C 117	Materials Finer than 75 µm (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C 127	Specific Gravity and Absorption of Coarse Aggregate
ASTM C 131	Resistance to Degradation of Small Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 136	Sieve Analysis of Fine and Coarse Aggregates
ASTM C 183	Sampling and the Amount of Testing of Hydraulic Cement
ASTM C 566	Total Evaporable Moisture Content of Aggregate by Drying
ASTM D 75	Sampling Aggregates
ASTM D 979	Sampling Bituminous Paving Mixtures
ASTM D 995	Mixing Plants for Hot-Mixed Hot-Laid Bituminous Paving Mixtures
ASTM D 1073	Fine Aggregate for Bituminous Paving Mixtures
ASTM D 1188	Bulk Specific Gravity and Density of Compacted Bituminous Mixtures Using Paraffin-Coated Specimens
ASTM D 1461	Moisture or Volatile Distillates in Bituminous Paving Mixtures
ASTM D 2041	Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
ASTM D 2172	Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
ASTM D 2419	Sand Equivalent Value of Soils and Fine Aggregate
ASTM D 2489	Estimating Degree of Particle Coating of Bituminous-Aggregate Mixtures
ASTM D 2726	Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures
ASTM D 2950	Density of Bituminous Concrete in Place by Nuclear Methods
ASTM D 3203	Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures
ASTM D 3665	Random Sampling of Construction Materials
ASTM D 3666	Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials
ASTM D 4125	Asphalt Content of Bituminous Mixtures by the Nuclear Method
ASTM D 4318	Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D 4791	Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D 4867	Effect of Moisture on Asphalt Concrete Paving Mixtures
ASTM D 5444	Mechanical Size Analysis of Extracted Aggregate
ASTM D 6926	Preparation of Bituminous Specimens Using MARSHALL Apparatus
ASTM D 6927	MARSHALL Stability and Flow of Bituminous Mixtures
ASTM E 11	Wire-Cloth Sieves for Testing Purposes

ASTM E 178 Dealing with Outlying Observations
 ASTM E 1274 Measuring Pavement Roughness Using a Profilograph
 AASHTO T 30 Mechanical Analysis of Extracted Aggregate
 AASHTO T 110 Moisture or Volatile Distillates in Bituminous Paving Mixtures
 The Asphalt Institute's Mix Design Methods for Asphalt Concrete
 Manual No. 2
 (MS-2)

END OF ITEM P-609

3.4 - Regas betuminosas de impregnação, colagem ou cura

Emulsões betuminosas clássicas

Para regas de colagem;

Para regas de impregnação

Quadro 1 – Requisitos/Propriedades das emulsões betuminosas clássicas

Requisitos /Propried.	Ref. normativa	Un.	Regas de colagem e cura de sub-bases e bases tratadas com ligantes	Regas de impregnação	
			C60B3 (C60B4/ECR-1)	C50BF4 (C50BF5/ECI)	C60BF4 (C60BF5/ECL-1)
Índice de rotura	EN13075-1	-	Classe 3 70-155	Classe 4 110-195	Classe 4 110-195
Teor em ligante	EN1428 ou	% massa	Classe 6 58 - 62	Classe 4 48 – 52	Classe 6 58 - 62
	EN1431	% massa	Classe 6 ≥ 58	Classe 3 ≥ 48	Classe 6 ≥ 58
Teor em óleo destilado	EN1431	% massa	Classe 3 ≤ 3,0	Classe 7 5 – 15	Classe 5 ≤ 8,0
Tempo de escoamento, 2 mm a 40 °C	EN12846-1	s	Classe 3 15 - 70	Classe 3 15 - 70	Classe 3 15 - 70
Tempo de escoamento, 4 mm a 40 °C	EN12846	s	-	-	-
Resíduo de peneiração - peneiro de 0,5 mm	EN 1429	% massa	Classe 2 ≤ 0,1	Classe 2 ≤ 0,1	Classe 2 ≤ 0,1
Tendência à sedimentação (7 dias de armazenagem)	EN12847	% massa	Classe 3 ≤ 10	Classe 3 ≤ 10	Classe 3 ≤ 10
Ligante recuperado (EN13074-1)	Penet. a 25 °C	EN1426	0,1 mm	Classe 7 ≤ 330	Classe 7 ≤ 330
	Temp.de amolec.	EN1427	°C	Classe 8 ≥ 35	Classe 8 ≥ 35
Ligante estabilizado (EN13074-1 e 2)	Penet. a 25 °C	EN1426	0,1 mm	Classe 5 ≤ 220	Classe 5 ≤ 220
	Temp.de amolec.	EN1427	°C	Classe 8 ≥ 35	Classe 8 ≥ 35

(a) A reciclagem semi-temperada corresponde à anteriormente designada reciclagem semi-quente.

3.4.1 Rega de impregnação betuminosa

Entende-se por rega de impregnação a aplicação de uma emulsão betuminosa sobre uma base granular de granulometria extensa sobre a qual será executada uma camada de mistura betuminosa. Será dispensada a sua aplicação caso o projeto explicitamente a dispense.

O equipamento a utilizar no espalhamento deve cumprir os requisitos legais para o transporte destes produtos e os requisitos de segurança e saúde necessários. Deve estar munido de um dispositivo de rega automático ou semi-automático que garanta uma distribuição uniforme do ligante à temperatura especificada. Nos casos de difícil acesso ou em situações muito específicas poder-se-á recorrer à distribuição do ligante com equipamento manual.

Preparação da camada para posterior impregnação/limpeza

Após a aprovação do trecho e previamente à aplicação da rega de impregnação, dever-se-á iniciar o processo de limpeza da camada granular. A superfície a impregnar deve apresentar-se livre de material solto, sujidades, detritos e poeiras que devem ser retirados do pavimento. A limpeza será basicamente efetuada por ação de escovas mecânicas e/ou jato de ar comprimido que deverá deixar a descoberto as partículas com maiores dimensões, sem no entanto provocar a desagregação da camada. Deve obter-se o aspeto de um mosaico formado pelo topo das britas e gravilhas, devidamente travadas pelos materiais mais finos. Nos locais de difícil acesso a estes equipamentos a limpeza da camada deve ser feita com vassouras manuais.

Após concluída a limpeza, ficará interdito o tráfego de obra sobre a zona tratada até que seja executada a rega de impregnação.

Caso se verifique tendência para desagregação superficial, seja por limpeza excessiva, por distorção granulométrica ou segregação, ou ainda em virtude do tráfego de obra, a Fiscalização deverá determinar a escarificação da camada e o seu posterior tratamento em conformidade com os requisitos acima apresentados.

Execução da rega de impregnação

Na execução da rega de impregnação betuminosa deve ser observado o seguinte:

- Previamente à aplicação do aglutinante a superfície deve ser humidificada de modo a facilitar a penetração do aglutinante na camada;
- O aglutinante e a taxa de aplicação a utilizar deverão ser os indicados no projeto e em conformidade com as especificações do Quadro 7. O valor da taxa de espalhamento deverá

ser ajustado experimentalmente sendo normalmente o correspondente ao que a camada pode absorver ao fim de 24 horas mas nunca inferior a 1,0 kg/m² de betume residual;

- No momento de aplicação do aglutinante, a temperatura ambiente e do pavimento devem ser superiores a 5 °C;
- Não deve ser iniciado o processo de espalhamento se houver probabilidade de ocorrência de chuva;
- A aplicação da emulsão deverá ser feita por um camião cisterna com barra distribuidora semi-automática ou automática;
- A distribuição do aglutinante não pode variar na largura efetiva, mais do que 15%;
- Quando o aglutinante não for completamente absorvido pela base no período de 24 horas, deve espalhar-se um agregado fino que permita fixar todo o aglutinante em excesso;
- O tempo que decorrerá entre a impregnação e a aplicação da camada betuminosa seguinte será fixado pela Fiscalização, em face das condições climatéricas.

CrITÉRIOS de aceitação

A tolerância da taxa de aplicação da emulsão betuminosa para impregnação será de 15% em relação ao valor especificado, sendo esta verificada em relação à média de num conjunto de cinco ensaios (tabuleiro metálico ou folha de papel), apenas um ensaio poderá ultrapassar essa tolerância. Esta verificação será efetuada por lotes e sempre que a Fiscalização assim o entenda

3.4.2 Regas de colagem

Entende-se por rega de colagem a aplicação de uma emulsão betuminosa sobre: camadas tratadas com ligantes betuminosos, camadas em misturas betuminosas ou camadas/superfícies de betão sobre a qual será aplicada uma mistura betuminosa. Estas regas poderão ser realizadas com emulsões ou emulsões modificadas, devendo cumprir os requisitos especificados no Quadro 11. Quando no fabrico da camada sobrejacente for utilizado um betume modificado, a rega de colagem deve com emulsão modificada.

Preparação da camada

O adjudicatário só poderá dar início aos trabalhos de limpeza da camada sobre a qual será aplicada a rega de colagem, quando esta tiver sido aprovada pela Fiscalização tendo em conta os critérios de aceitação especificados neste Caderno de Encargos para os diferentes tipos de camada. Deve ser dada particular atenção à limpeza dos topos das juntas de trabalho. Para a remoção dos detritos,

material solto e sujidade da camada deverão ser utilizados os meios mais adequados tendo em conta o estado de limpeza da mesma, nomeadamente jato de água, vassoura mecânica ou jato de ar. Nas situações de difícil acesso aos referidos equipamentos deverá recorrer-se a vassouras manuais. O jato de ar será, contudo, sempre considerado como processo de acabamento da limpeza da camada para a remoção dos materiais mais finos e pó. Os materiais resultantes do processo de limpeza deverão ser removidos do local de forma a não constituírem nova ameaça de contaminação.

Execução da rega de colagem

Na execução da rega de colagem deve ser observado o seguinte:

- A superfície deve estar seca para que o processo de cura seja mais rápido;
- O aglutinante e a taxa de aplicação a utilizar deverão ser os indicados no projeto e cumprir os requisitos especificados no Quadro 11. O valor da taxa de espalhamento de betume residual deverá ser de 0,5 kg/m²;
- No momento de aplicação do aglutinante, as temperaturas ambiente e do pavimento devem ser superiores a 5 °C;
- Não deve ser iniciado o processo de espalhamento se houver probabilidade de ocorrência de chuva;
- A aplicação da emulsão deverá ser feita por um camião cisterna com barra distribuidora semi-automática ou automática, no caso dos topos das juntas de trabalho ou outras superfícies verticais que ficarão em contacto com a mistura betuminosa, a aplicação poderá ser manual com recurso a cana;
- Quando tenha decorrido muito tempo ou tenha chovido após a aplicação, a fiscalização poderá exigir a execução de uma nova rega;
- A distribuição do aglutinante não pode variar na largura efetiva, mais do que 15%;
- Será interdita a circulação dos veículos sobre a rega, podendo a mesma ser excecionalmente autorizada pela fiscalização, desde que seja devidamente fundamentada e tomadas as devidas precauções para que a rega não seja contaminada.

Critérios de aceitação

A tolerância na taxa de emulsão betuminosa para colagem será de 15% em relação ao valor especificado, sendo esta verificada em relação à média de num conjunto de cinco ensaios (tabuleiro

metálico ou folha de papel), apenas um ensaio poderá ultrapassar essa tolerância. Esta verificação será efetuada por lotes e sempre que a Fiscalização assim o entenda.

3.5 - Trabalhos específicos dos pavimentos rígidos:

3.5.1 Separação entre a laje e a base granular:

3.5.1.1 Com folha de polietileno:

Antes da aplicação do betão deverá proceder-se à aplicação, em toda a área a intervencionar, de manga plástica de polietileno com 250 g/m² com as juntas sobrepostas em, pelo menos, 0.40 m.

3.6 - Trabalhos especiais de pavimentação

3.6.1 Saneamentos em pavimentos existentes, conforme definido em projeto, incluindo corte das camadas betuminosas, escavação em terreno de qualquer natureza, remoção e transporte a vazadouro dos produtos escavados, eventual indemnização por depósito

Este artigo refere-se ao saneamento dos pavimentos betuminosos existentes na zona em que ocorreu o assentamento localizado (abatimento), incluindo toda a estrutura de pavimento existente, bem como o solo de fundação, até à profundidade necessária à execução da camada de leito de pavimento e camadas estruturais de pavimento preconizadas em projeto.

Todos os materiais removidos deverão ser carregados, transportados e colocados em depósito provisório, para posterior reutilização, e/ou em vazadouro, incluindo, neste caso, eventual indemnização por depósito. Todos estes trabalhos complementares estão igualmente incluídos neste artigo.

Os meios a utilizar na remoção dos pavimentos deverão ser adequados à zona de intervenção.

Refere-se assim ao corte das camadas betuminosas ao longo do perímetro da área a intervencionar, seguida de remoção das camadas ligadas de pavimento existentes (a executar de acordo com o definido nas peças escritas e desenhadas do projeto de execução) e escavação da camada de base (e sub-base) granular e solo de fundação, na espessura mínima necessária à execução das novas estruturas de pavimento preconizadas em projeto, incluindo camada de leito de pavimento.

Trata-se de escavação de materiais na linha, que apenas exigem meios mecânicos de desmonte. Para este efeito, entende-se como desmonte por meios mecânicos, o que é possível efetuar com os equipamentos de lâmina, balde ou ripper.

4 - Equipamentos de sinalização e segurança

Trata-se de todas as marcas feitas no pavimento à custa de pintura, que constituem a designada sinalização horizontal, que é formada pelo conjunto das marcas longitudinais e transversais.

Este trabalho inclui o fornecimento dos materiais, e a utilização dos equipamentos necessários, bem como todas as operações preparatórias indispensáveis para a execução das marcas no pavimento, designadamente, a pré-marcação com o respetivo apoio topográfico, a limpeza prévia do pavimento e a preparação de moldes especiais para a execução de inscrições.

Relativamente às características dos materiais a utilizar refira-se o seguinte:

TINTAS PARA PRÉ-MARCAÇÃO

As tintas a utilizar na pré-marcação devem ser, de preferência, na cor branca (cor da marca), de secagem rápida, de resistência ao desgaste compatível com o tempo de duração exigido pela data prevista para a marcação, tendo em consideração o volume de tráfego em presença.

MATERIAL TERMOPLÁSTICO

AGREGADO E CARGAS

O agregado será constituído por areia siliciosa, calcite, quartzo ou outros produtos similares.

As cargas serão pós finos, que dão corpo ao material termoplástico, podendo utilizar-se, por exemplo, cré (carbonato de cálcio) ou litopone.

As granulometrias dos agregados e das cargas deverão ser escolhidas de modo a permitir uma boa compacidade do material termoplástico.

PIGMENTO PARA TERMOPLÁSTICO BRANCO

O pigmento a utilizar será dióxido de titânio (TiO_2).

LIGANTE

O ligante deverá ser constituído por um material resinoso termoplástico natural ou sintético, plastificado com óleo mineral.

PÉROLAS REFLECTORAS

a) Características básicas

As pérolas deverão ser de vidro transparente ou de material equivalente que permita, por adição, tornar o material termoplástico refletor.

As pérolas deverão ser suficientemente incolores para não comunicar às marcas rodoviárias, sob a luz do dia, nenhuma modificação apreciável da cor. Consideram-se como defeituosas as pérolas não esféricas, opacas, opalescentes e que contenham bolhas de gaz, de dimensão superior a 25% da sua área projetada e graus de materiais estranhos.

A percentagem de pérolas não esféricas, determinada segundo a especificação ASTM 1155-53, deve ser inferior a 30%.

b) Índice de refração

As microesferas de vidro não devem apresentar um índice de refração menor que 1,5.

c) Resistência à água

Após 60 minutos de tratamento por refluxo com água destilada, as pérolas não devem apresentar alteração superficial apreciável, e o volume máximo admissível de solução de ácido clorídrico 0,01 N, para neutralizar a água após a realização do ensaio, será de 9 cm³.

d) Resistência aos ácidos

Após 90 horas de imersão numa solução diluída de ácido à temperatura de 23 ± 2 °C, estabilizada a um PH entre 5,0 e 5,3, as pérolas não devem apresentar senão uma ligeira perda de brilho em comparação com uma amostra não sujeita ao ensaio.

e) Resistência ao cloreto de cálcio em solução

Após 3 horas de imersão numa solução aquosa de cloreto de cálcio a 5,5%, à temperatura de 23 ± 2 °C, as pérolas não deverão apresentar nenhuma alteração superficial em comparação com uma amostra não sujeita ao ensaio.

f) Granulometria

A granulometria das pérolas introduzidas no material termoplástico deve estar de acordo com os valores a seguir especificados:

Peneiro ASTM	Percentagem acumulada do material que passa
1,700 mm	100
0,425 mm	0 – 10

A granulometria das pérolas de vidro, projetadas no momento da aplicação deve estar de acordo com os valores seguintes:

Peneiro ASTM	Percentagem acumulada do material que passa
1,700 mm	100
0,600 mm	80 – 100
0,425 mm	45 – 100
0,300 mm	10 – 45
0,212 mm	0 – 25
0,075 mm	0 – 5

MATERIAL TERMOPLÁSTICO BRANCO

- a) O material deverá ser constituído por agregado, pigmento, cargas, ligados por um ligante plastificado com óleo mineral e pérolas de vidro com uma granulometria apropriada para se obter o efeito refletor desejado.
- b) A composição do material deve atender às seguintes proporções em massa:

Agregado, incluindo as pérolas	60 ± 2%;
Pigmento e cargas	20 ± 2%;
Pigmento	6% mínimo;
Ligante	20 ± 2%;
Pérolas de vidro.....	20% mínimo;
Peso específico	compreendido entre 1,96 e 2,04 g/cm ³ ;
Ponto de amolecimento (anel e bola)	superior a 80 °C.

Resistência ao abatimento – a percentagem de diminuição da altura de um cone feito com o material, sujeito a 23 ± 2 °C, não deve ser superior a 10%;

Repassamento – o material termoplástico, aplicado sobre base de argamassa betuminosa, não deve apresentar, por repassamento, uma variação de cor inferior ao grau 8 da escala fotográfica da especificação ASTM D 868-48.

Resistência ao envelhecimento acelerado – o material termoplástico aplicado com a espessura seca de 1,5 mm sobre argamassa betuminosa, quando sujeito a envelhecimento acelerado durante 168 h numa máquina "Weather- Ometer" de arco voltaico, com o seguinte ciclo diário:

..... 17 h de luz e calor (55 °C, c/ molhagem intermitente de 18 em 18 min.)

..... 2 h de chuva forte

..... 5 h de repouso

não deverá apresentar qualquer defeito assinalável à observação visual.

Resistência à imersão em água - o material termoplástico, com a espessura seca de 1,5 mm, aplicado sobre fibrocimento, seco durante 72 h ao ar e imerso em água à temperatura de 20 a 30 °C durante 24 horas e observado 2 horas mais tarde, não deverá apresentar empolamento, fissuração, nem destacamento em relação à base.

Resistência à alteração da cor - o material termoplástico, submetido à ação da luz solar artificial durante 100 horas, não deve apresentar alteração de cor.

Fator de luminância – o facto de luminância do material termoplástico branco, determinado numa direção normal à superfície com iluminação a 45 °, por uma fonte CIE do tipo C, deve ser não inferior a 0,70 segundo a NP-522-1966.

Resistência à derrapagem – o material termoplástico, com a espessura seca de 1,5 mm, deverá apresentar uma resistência ao atrito não inferior a 45 BPN, medida com o "pêndulo britânico"; em zonas pontualmente perigosas, aquele valor deverá ser superior a 50 BPN.

Relativamente aos métodos construtivos refira-se o seguinte:

MATERIAL TERMOPLÁSTICO DE APLICAÇÃO A QUENTE

PRÉ-MARCAÇÃO

A pré-marcação é obrigatória, não sendo permitido o início da marcação sem que aquela tenha sido revista e aprovada pela Fiscalização.

Sempre que seja possível apoiar mecanicamente a marcação de uma linha na pré-marcação de outra que lhe seja paralela, a pré-marcação da primeira pode ser dispensada (caso da marcação de guias apoiadas na pré-marcação do eixo).

A pré-marcação pode ser executada pelos processos:

a) Manual

Por meio de um cordel suficientemente esticado e ajustado ao desenvolvimento das respetivas marcas, ao longo do qual, por intermédio de um pincel ou outro meio auxiliar apropriado, se executa a piquetagem por pontos, por pequenos traços ou por linha contínua fina, ou recorrendo a pintura de referência ou contornos (quando há lugar à utilização de moldes).

b) Mecânica

Não dispensando a pré-marcação manual, sobre a qual ele se apoia, o processo mecânico é utilizado a partir da máquina de marcação, mediante utilização de um braço com ponteiro de pintura que, à direita e à esquerda, executa a piquetagem.

A pré-marcação deve prever, no pavimento a marcar, a definição de:

a) Nas linhas longitudinais:

Piquetagem;

Indicação dos limites das zonas com diferentes relações traço/espço;

Indicação dos limites das zonas de linhas contínuas.

b) Nas marcas diversas:

Pintura de referência, para implantação dos moldes de execução.

PREPARAÇÃO DA SUPERFÍCIE

A superfície que vai ser marcada deve apresentar-se seca e livre de sujidades, detritos e poeiras.

O Empreiteiro será responsável pelo insucesso das pinturas causado por deficiente preparação da superfície.

Se se tratar de um pavimento velho e polido, deverá ser utilizado um aparelho com características adesivas adequadas ao caso em presença, a fim de se garantir uma aderência conveniente das marcas.

MARCAÇÃO EXPERIMENTAL

Para verificação da uniformidade da marcação das linhas longitudinais, quanto a dimensão, largura, homogeneidade de aplicação do produto e das pérolas de vidro e ainda para se regular o equipamento de aplicação (velocidade de avanço, pressão de ar nos bicos e no compressor, temperatura) deverá ser feita uma marcação experimental, fora da zona da obra e em local a definir pela Fiscalização, tanto quanto possível, com características semelhantes de superfície. A passagem à marcação definitiva dependerá do parecer da Fiscalização em face dos resultados obtidos, quer em observação diurna, quer noturna (retro reflexão).

MARCAÇÃO

Aprovação da pré-marcação

A marcação não poderá ser iniciada sem que a Fiscalização tenha aprovado a pré-marcação, como já foi referido.

Processo de marcação

Para execução das marcas rodoviárias (marcação) devem ser utilizados, para aplicação de material termoplástico, os seguintes processos:

a) Manual (por moldagem)

A utilizar na execução de:

Marcas transversais e barras em zonas mortas;

Setas (de seleção, de desvio e outras);

Símbolos (sinais e outros);

Inscrições (números e letras).

As marcas rodoviárias serão executadas em sobre espessura por colagem gravítica e espalhamento manual com emprego de moldes. A espessura seca do material aplicado deve apresentar um valor entre 2,5 e 3,0 mm.

A temperatura de aplicação deve situar-se entre 165 °C e 190 °C e o tempo de secagem (ausência de pegajosidade resistente à passagem de veículos) não deve ultrapassar 2 a 3 minutos.

As caldeiras de aquecimento devem estar munidas de dispositivos de agitação mecânica, para se evitar a segregação dos diversos constituintes.

A utilização de sistemas de pré-aquecimento da superfície a marcar não é permitida, por princípio, a menos que a Fiscalização o reconheça como indispensável.

b) Mecânica (spray)

utilizar na execução de:

Marcas longitudinais.

Deve ser concretizado com o emprego de máquinas móveis com dispositivos manuais e automáticos de aplicação do material termoplástico pulverizado (spray) e de projeção simultânea, sobre a superfície do material, de esferas de vidro.

A espessura seca do material aplicado deve apresentar um valor uniforme não inferior a 1,5 mm.

A temperatura de aplicação deve situar-se entre 200°C e 220°C e o tempo de secagem não deve ultrapassar os 40 segundos, para as espessuras previstas.

A taxa de projeção de esferas de vidro deve estar compreendida entre 400 e 500 g/m².

APROVAÇÃO DAS MARCAS

As marcas que não se apresentem nas condições exigidas (geométricas, de constituição ou de eficácia), serão rejeitadas e como tal removidas, podendo, contudo, ser repetida a execução, se houver da parte do Empreiteiro a garantia de uma retificação conveniente e suscetível de ser aceite pela Fiscalização.

A remoção deve ser efetuada no prazo de 3 dias a contar da data de notificação da rejeição, pelo que o Empreiteiro, se o não fizer nesse prazo, ficará sujeito aos encargos resultantes da remoção que a Fiscalização mande executar por terceiros.

ELIMINAÇÃO DE MARCAS

Na eventualidade de se ter que apagar marcas rodoviárias pré-existents com o fim de se executar uma nova marcação, o processo de eliminação a utilizar deverá ser escolhido de entre os seguintes:

- a) Decapagem por projeção de um abrasivo sob pressão, não podendo aquele abrasivo ser areia, exceto quando a decapagem seja feita em presença da água;
- b) Decapagem mecânica, utilizando decapadores mecânicos ou máquinas de percussão próprias.

No caso de as marcas a eliminar serem de material termoplástico, obtêm-se melhores resultados com tempo frio, para ambos os processos indicados.

Quando aplicado qualquer dos processos descritos, devem ser tomadas as seguintes precauções:

- a) Quando a circulação se mantém, deverá a zona restrita dos trabalhos ser convenientemente isolada a fim de que a segurança da circulação de peões e veículos não seja afetada pelos materiais ou agentes envolvidos na obra;

- b) Após a decapagem, deverá ter-se o cuidado de remover, quer os detritos do material termoplástico, quer os abrasivos utilizados.

Não será permitida, em caso algum, a utilização de processos de recobrimento como método de eliminação de marcas.

LOTES, AMOSTRAS E ENSAIOS

- a) Durante a execução dos trabalhos, e sempre que o entender, a Fiscalização reserva-se o direito de tomar amostras e mandar proceder às análises e ensaios que julgar convenientes para verificação das características dos materiais utilizados. As amostras serão, em geral, tomadas em triplicado, e levarão as indicações necessárias à sua identificação.
- b) As análises e ensaios necessários poderão vir a ser executados pelas entidades que o dono da obra entender adequadas, por conta do Adjudicatário.

5 - Considerações finais

Em tudo o que o presente Caderno de Encargos for omissos aplicar-se-á:

- A *Advisory Circular n.º 150/5370-10F – “Standards for Specifying Construction of Airports”*, da FAA (*Federal Aviation Administration – U.S. Department of Transportation*);
- Caderno de Encargos Tipo Obra das Infraestruturas de Portugal, S.A.
- Elementos constituintes do projeto de execução – peças escritas e peças desenhadas.

AERÓDROMO MUNICIPAL DE SEIA

Estudo de pavimentação e drenagem da pista principal

Projeto de Execução

IV – Mapa de Medições Detalhadas

AERÓDROMO MUNICIPAL DE SEIA

Estudo de pavimentação e drenagem da pista principal

Projeto de Execução

V – Mapa de Quantidades