

Pavement Materials & Design

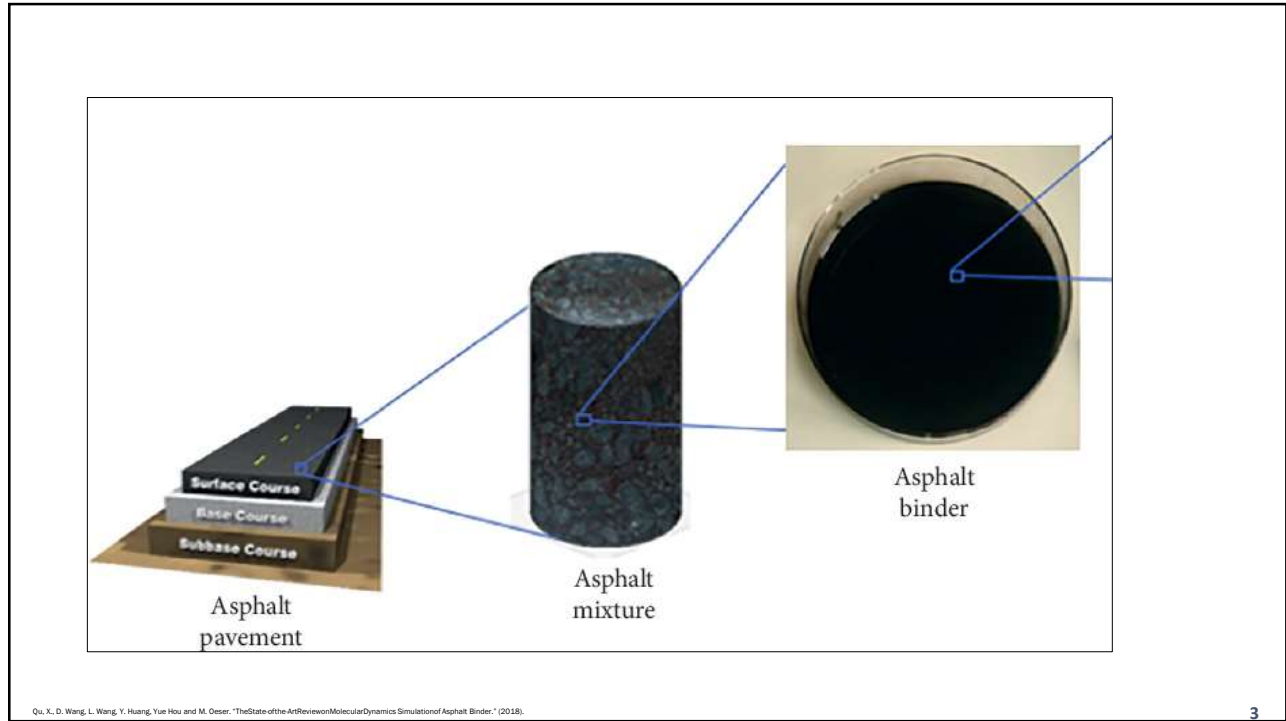
Exp_6_Aspphalt Mixture Production and
compaction

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Introduction

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<http://mix.j.paving.com/and/soil/see/5000000000.com.au/>

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What is Asphalt Mixture

- Asphalt mixture is combination of asphalt cement and aggregate that will give long-lasting performance as part of the pavement structure



Asphalt Cement/Binder

About 4% to 6% of total mix **by weight**
 About 10% to 14% of total mix **by volume**

Aggregates

About 94% - 96% of total mix **by weight**
 About 75%-85% of total mix **by volume**



(a)



(b)



(c)

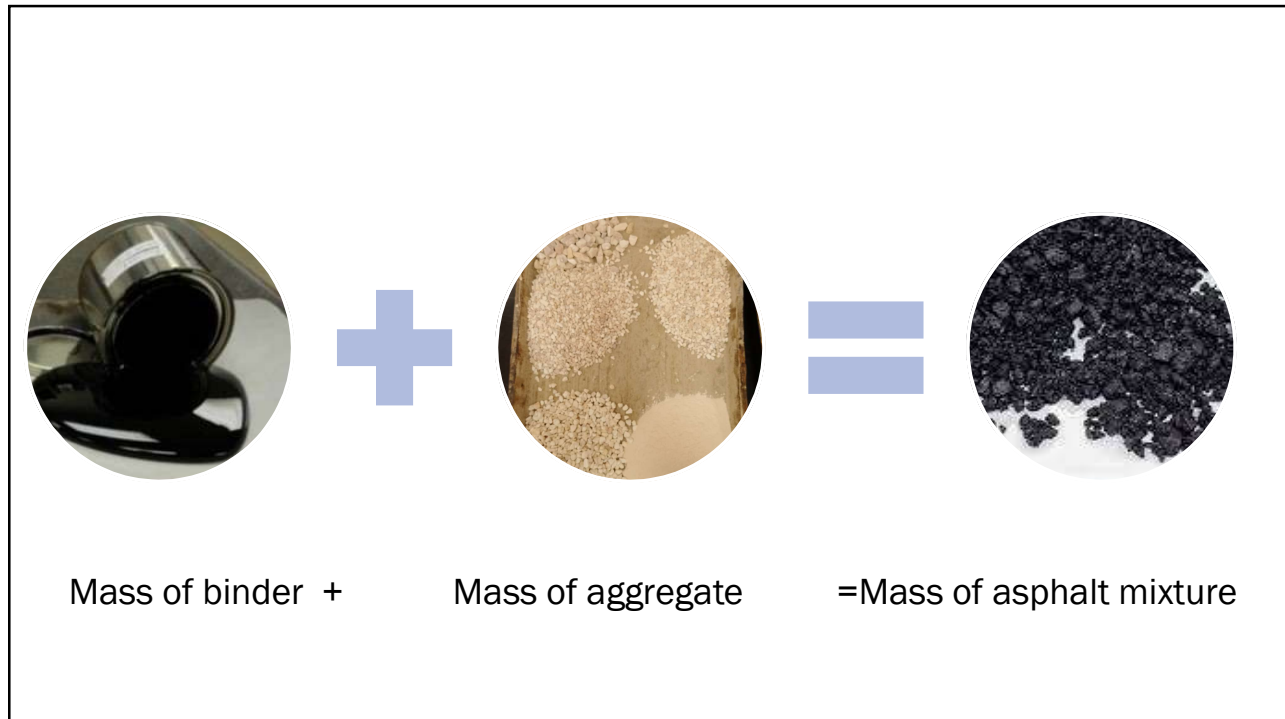


(d)

Image source: <https://www.floridadesignsolutions.org/learning-center/asphalt-101/>

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Mixture parameters

Percent Aggregate P_s

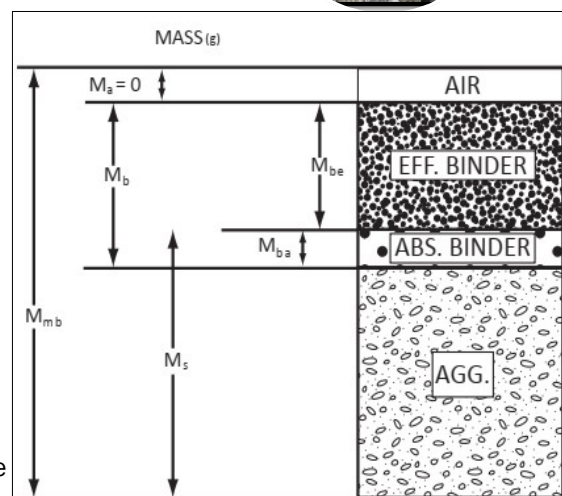
The total percentage of aggregate in the asphalt mixture

Expressed as

➤ *Percentage of the total mix mass*



Mass of binder + Mass of aggregate = Mass of asphalt mixture



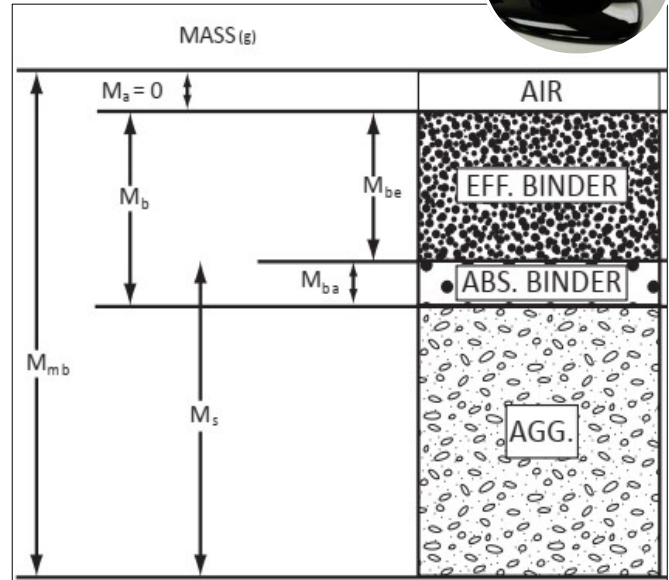
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Mixture volumetric parameters

Percent Binder P_b

- ❑ The total percentage of asphalt binder in the asphalt mixture
- ❑ Expressed as
 - Percentage of the total mix mass
 - Percentage of the aggregate mass
 - Note that
 $P_s + P_b = 100\%$

Mass of binder + Mass of aggregate = Mass of asphalt mixture



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HMA Mix Design

Objective of a mix design

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Objective of a mix design

- ❑ The **objective** of a mix design is to **determine the combination of asphalt cement and aggregate** that will give long-lasting performance as part of the pavement structure.
- ❑ **Mix design** involves **laboratory procedures** developed to **establish the necessary proportions** of materials for use in the asphalt mixture.
- ❑ These procedures include
 - *Determining an appropriate blend of aggregate sources to produce proper gradation of mineral aggregate*
 - *Selecting the type and amount of asphalt cement to be used as the binder for that gradation.*



[image source: <https://www.floridardesonus.org/learning-center/asphalt-101/> 12

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Asphalt Mixture *Production_Laboratory*

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Asphalt Mixture Production

Laboratory Mixing



Video source: <https://www.youtube.com/watch?v=BCctip8Rt2Q&t=174s>

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Asphalt Mixture

Production_Field

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Asphalt Mixture Production

HMA Manufacturing

- ❑ HMA is produced in a plant that proportions, blends, and heats aggregate and asphalt to produce an HMA that conforming to job mix formula (JMF) requirements.
- ❑ There are two basic types of HMA plants commonly in use today:
 - The batch plant
 - ❖ Produce HMA in individual batches
 - The drum plant
 - ❖ Produce HMA in a continuous operation
- ❑ The choice of a batch or drum mix plant depends upon
 - business factors such as purchase price, operating costs, production requirements and the need for flexibility in local markets; both can produce quality HMA.

Drum Plant



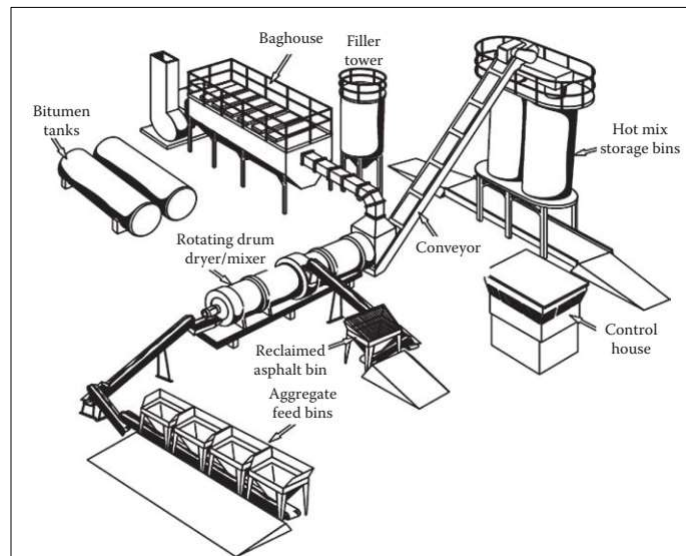
Covered Batch Plant



Asphalt Mixture Production

The drum plant

- ❑ generally, offer higher production rates than batch plants for comparable cost.
- ❑ Each type of plant can produce the same types of HMA and neither type of plant should impart any significant plant-specific HMA characteristics.



The drum plant

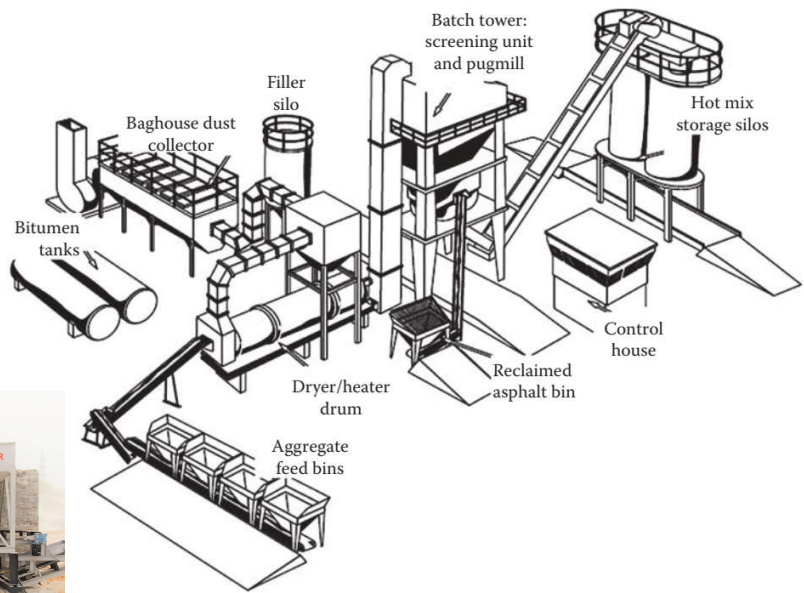
<https://www.youtube.com/watch?v=QUG7MzGpL4>

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HMA Manufacturing

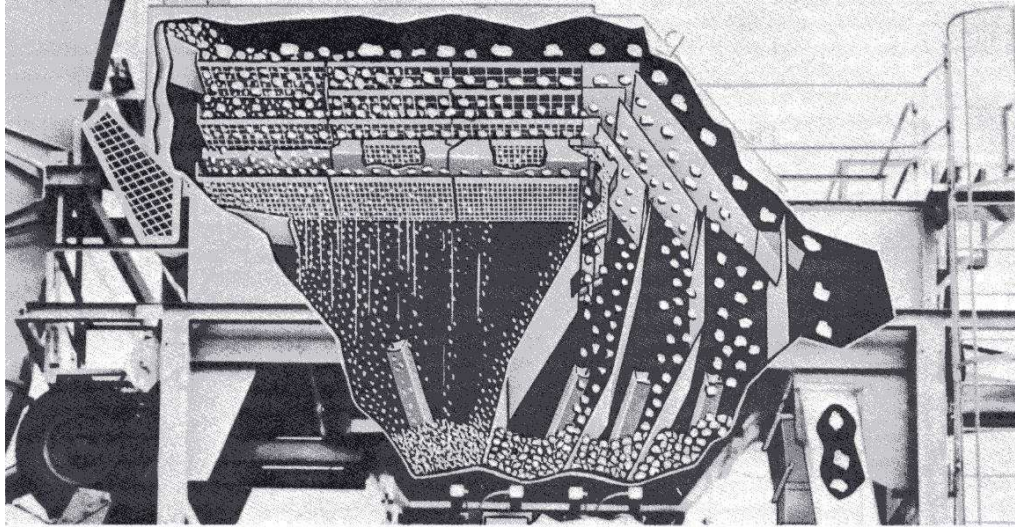
The batch plant



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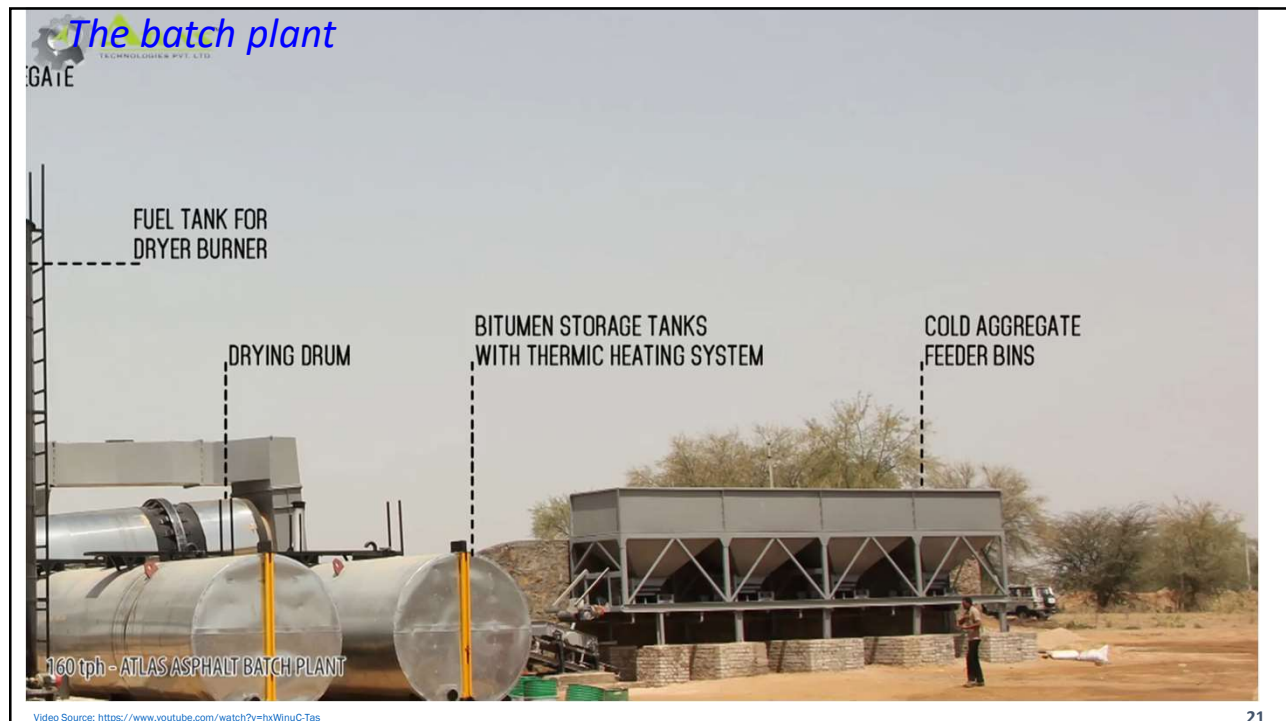
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HMA Manufacturing



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The batch plant

<http://www.youtube.com/watch?v=jCoVBtF8G8>

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Specifications for highway and bridge construction

استعمال الخلاطة الاسفلتية (Batch Plant) الأتوماتيكية وعدم استخدام
(Dryer Drum Mix. Plant) أو (Continous Plant) .

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Asphalt Mixture

Produced Loose Mixture

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Mixture phases

Loose Mixture



Field

A loose asphalt mixture typically refers to a mix of asphalt and aggregate materials that has not undergone the compaction process.



Laboratory

Image source: <http://asphaltmagazine.com/fix-your-mix/>

Image source: <https://www.floridastonestone.org/learning-center/asphalt-101/>

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Asphalt Mixture

Compaction_ Laboratory

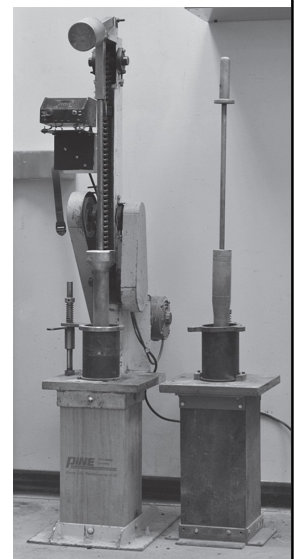
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Laboratory compaction

C-8: Compact the specimen at the *required Blow/side* according to Marshall specifications.

- ❑ The laboratory compaction effort is intended to replicate the ultimate or final compacted condition of the pavement after being exposed to several years of traffic loading.
- ❑ **Experience** has shown that pavements that maintain an air void level of around 4 percent provide the best long-term performance in the field.
- ❑ The Impact compaction is the method for volumetric mix design and quality control testing compaction used in Marshall



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Laboratory compaction

- ❑ Place a filter or nonabsorbent paper disk cut to size in the bottom of the mold.
- ❑ Place the entire batch in the mold with collar, and then spade the mixture vigorously with a heated spatula or trowel 15 times around the perimeter and 10 times over the interior. Smooth the surface to a slightly rounded shape.
- ❑ The **temperature of the mixture immediately prior to compaction** shall be within the limits of the compaction temperature established in paragraph otherwise, it shall be discarded. **In no case shall the mixture be reheated**



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Laboratory compaction



Video source: <https://www.youtube.com/watch?v=SujMH5RDFcQ>

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Laboratory compaction

- ❑ The number of blow/side is function with design traffic level

Marshall Method Criteria ¹	Light Traffic ³ Surface & Base		Medium Traffic ³ Surface & Base		Heavy Traffic ³ Surface & Base	
	Min	Max	Min	Max	Min	Max
Compaction, number of blows each end of specimen	35		50		75	

- Traffic classifications

- Light Traffic conditions resulting in a 20-year Design ESAL $< 10^4$
- Medium Traffic conditions resulting in a 20-year Design ESAL between 10^4 and 10^6
- Heavy Traffic conditions resulting in a 20-year Design ESAL $> 10^6$

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SGC



Wheel roller



Marshall

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Compacted Specimens



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Asphalt Mixture

Compaction_Field

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Asphalt Mixtures

Compaction

- ❑ The compaction of asphalt layers is possibly the most critical stage of asphalt works.
- ❑ It is needed to achieve proper and uniform compaction, which in turn ensures a better long-lasting performance.
- ❑ During compaction,
 - The coated aggregates are compressed, are re-oriented and take such positions that the distance between them becomes the smallest possible.
 - As a consequence, the air voids decrease, and the mixture density increases.
 - Because of aggregate re-orientation, the stability of the mix and the strength of the asphalt and of the pavement increase.
- ❑ The aim during compaction is to
 - achieve an optimum void content
 - and at the same time to ensure a smooth surface.

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Factors affecting compaction

Compaction equipment

- ❑ Effective compaction is related to the type of compaction equipment used.
- ❑ The desired compaction is achieved by applying a certain number of passes of the rollers over the asphalt layer, known as compaction effort
- ❑ The number of passes is always determined in situ and it depends on
 - The asphalt type, thickness of layer, weather conditions and type and weight of roller
- ❑ There are four types of rollers:
 - (a) static steel-wheel roller
 - (b) vibrating steel-wheel rollers
 - (c) pneumatic-tyre rollers
 - (d) combination rollers

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Factors affecting compaction

Compaction equipment



Three-wheel static roller



Double-drum vibrating roller



Pneumatic-tyre roller



Combination roller

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Factors affecting compaction

Compaction procedure

To achieve proper and effective compaction of asphalt layers, the following points are recommended:

- A. Rolling should start as quickly as possible after asphalt has been laid
 - B. Rolling consists of three consecutive phases:
 1. *The initial or breakdown rolling*
 - ❖ Most of the compaction is achieved during breakdown rolling
 2. *The intermediate rolling*
 - ❖ Increases the density of the mix further and minimizes all surface pores
 3. *The finish rolling*
 - ❖ During finish rolling, all roller traces and other surface deficiencies are removed
- Between the three phases, there should be no time delay.

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Specifications for highway and bridge construction

و- عملية الدحل :

يجب أن يتم الدحل كما هو موضح تالياً إلا إذا كانت هناك وسائل حديثة غير ذلك

وحسب موافقة المهندس :

١- يجب أن يتم الدحل الأولي (Breakdown Rolling) بحيث لا تكون درجة الحرارة أقل من ١٢٠ درجة مئوية بواسطة منطحة الحديد مع مراعاة أن تكون العجلات الجارة هي أول ما يدخل على الخلطة .



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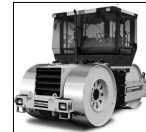
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Specifications for highway and bridge construction

٢- يتم الدحل بعد ذلك بمدحلة الكاوتشوك عندما تكون درجة الحرارة لا تقل عن ٩٠ درجة مئوية لمنع التصاق الاسفلت بالعجلات وبدونها يجب توقيف العمل مع مراعاة اضافة الماء على العجلات بشكل خفيف ولأول وجه دحل فقط, وعند الضرورة لضمان عدم انخفاض درجة الحرارة للخليط .

٣- يتم الدحل بعد ذلك (Finishing Rolling) مع ملاحظة أنه لا جدوى من الدحل إذا انخفضت درجة حرارة الخليط عن ٧٠ درجة مئوية وعليه يجب أن ينتهي الدحل النهائي قبل وصول حرارة الخليط الى هذه الدرجة .



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Specifications for highway and bridge construction

٩- سماكة الطبقة :
يتم فرش الخلطة بطبقة واحدة وسماكة لا تقل عن ٥ سم بعد الدحل (أو كما
هو موضح في المخططات) بالعرض المحدد لكل طريق على أن تشطف
الجوانب بميل (٢ أفقي : ١ شاقولي) .

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<https://www.youtube.com/watch?v=Qn0Bkgz88ok&t=196s>

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Asphalt Mixture

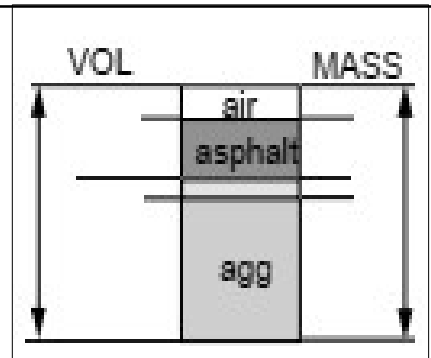
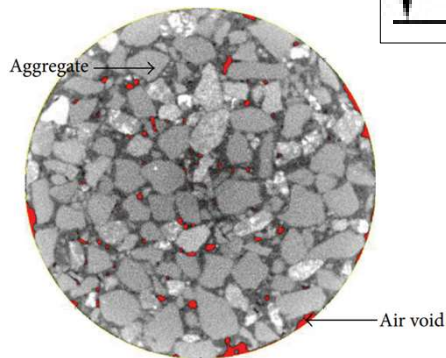
Compacted specimen

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Mixture phases

Compacted specimen



<https://downloads.hindawi.com/journals/nmmr/2014/507082.pdf>

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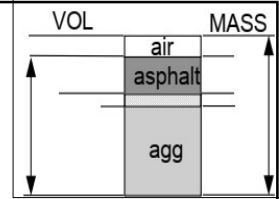
Mixture phases

Compacted Mixture



Field compacted

A compacted asphalt mixture typically refers to a mix of asphalt and aggregate materials that has undergone the compaction process.



Laboratory compacted



Loose Specimen



Compacted Specimen



Specimen types

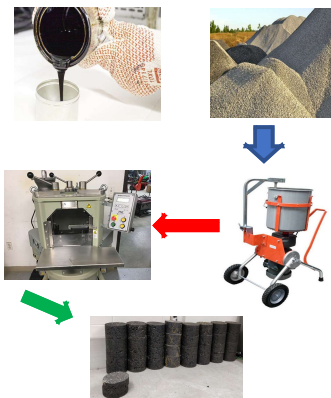
For asphalt mixtures design, production, and quality control

3. Terminology

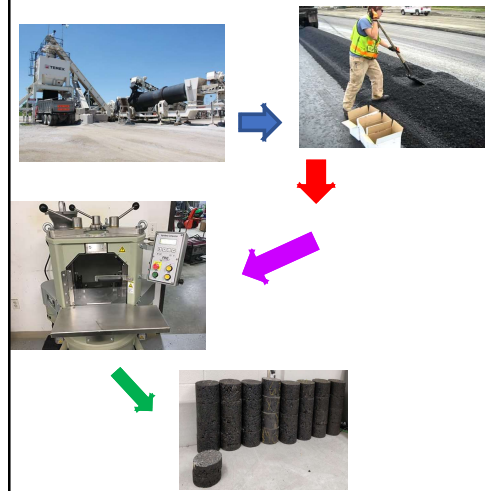
3.1 Definitions:

3.1.1 *lab mix lab compacted (LMLC) asphalt mixture, n*—asphalt mix samples that are prepared in the laboratory by weighing and blending each constituent then compacting the blended mixture using a laboratory compaction apparatus.

3.1.1.1 *Discussion*—LMLC typically occurs during the asphalt mixture design phase. Laboratory compaction devices such as the Superpave Gyrotory Compactor, Marshall Hammer, or other laboratory compaction devices may be used.



3.1.2 *plant mix laboratory compacted (PMLC) asphalt mixture, n*—asphalt mixture samples that are manufactured in a production plant, sampled prior to compaction, then immediately compacted using a laboratory compaction apparatus.



3.1.2.1 *Discussion*—PMLC specimens are often used for quality control testing. The asphalt mixture is not permitted to cool substantially and it may be necessary to place the mixture in a laboratory oven to equilibrate the mixture to the compaction temperature before molding. Laboratory compaction devices such as the Superpave Gyratory Compactor, Marshall Hammer, or other laboratory compaction devices may be used.



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3.1.3 *reheated plant mix lab compacted (RPMLC) asphalt mixture, n*—asphalt mixture samples that are manufactured in a production plant, sampled prior to compaction, allowed to cool to room temperature, then reheated in a laboratory oven and compacted using a laboratory compaction apparatus.

3.1.3.1 *Discussion*—RPMLC are often used for quality acceptance and verification testing. The reheating time should be as short as possible to obtain uniform temperature to avoid artificially aging the specimens. Asphalt mixture conditioning, reheat temperature, and reheat time should be defined in the applicable specification. Laboratory compaction devices such as the Superpave Gyratory Compactor, Marshall Hammer, or other laboratory compaction devices may be used.



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Field Cores



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Field Cores



https://www.youtube.com/watch?v=jqWalyzpxBs&ab_channel=%D8%AA%D8%B9%D9%84%D9%85%D9%87%D9%86%D8%AF%D8%B3%D8%A9%D8%A7%D9%84%D8%A8%D9%86%D8%A7%D8%A1

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Thickness measurement

Laboratory/ Filed specimen

Standard Test Method for Thickness or Height of Compacted Bituminous Paving Mixture Specimens¹

This standard is issued under the fixed designation D3549/D3549M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

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Thickness measurement

❑ Measuring Thickness

- Use a tape, ruler, or calipers to measure the thickness of a specimen with flat, horizontal layers.
- Take measurements **perpendicularly** between the top and bottom surfaces, focusing on any clear construction lines.
- Measure thickness at four points around the core's edge, or at the midpoint of each side for rectangular samples.
- Record the average of these four measurements as the specimen's thickness



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