ā’spḥālt n., & v.t. 1. n. Substance made by adding sand, gravel, etc. to bitumen and used for paving roads etc.; hence āspḥā’ltic a.

2. v.t. surface (road etc.) with asphalt. [ME; ult. f. LL asphalton, -um, f. Gk asphalton, of foreign orig.]
Asphalt Basics

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1. Introduction

Asphalt is a mixture of graded aggregates and bitumen binder. The actual composition varies according to the proposed use and is based on a combination of laboratory and field tests.

The requirements for an aerodrome mix are quite different to those of a school playground — the asphalt surfacing of an expressway is subjected to different stresses than the surface of a carpark. Similarly, the properties and mix proportions for an asphalt base course mix are different to those of an asphalt surface course mix.

The purpose of these notes is to:
(a) introduce some of the terms used to describe asphalt mixes and pavements,
(b) outline the use of asphalt in various layers of a pavement,
(c) discuss the types of asphalt pavement mixes available,
(d) outline the important properties of asphalt mixes,
(e) discuss the selection of mix type and size for various pavement uses,
(f) give a brief description of the equipment and processes involved.
2. Terminology

The terms "hotmix", "asphaltic concrete", "bituminous concrete", "bituminous premix", etc., are often used more or less loosely to describe mixtures of graded mineral aggregates and bitumen binder. The reason for the first name is obvious. The term concrete generally means a "mass formed of solid particles" and just as portland cement concrete is made of graded aggregate with a portland cement binder, so the term "asphaltic concrete" is similar in nature, but with bitumen as the binder or cementing agent. The American term "asphalt" is synonymous with our term "bitumen" and hence the term "asphaltic concrete".

2.1 ASPHALT MIX TERMS

The following brief description should serve to define the current usage of terms in Australia:

(a) ASPHALT — a general term covering all combinations of mineral aggregates and bitumen (or tar) binder which are produced by a manufacturing process. This definition includes all the materials listed below.

(b) ASPHALTIC CONCRETE — a mixture of dense graded aggregates (with or without added mineral filler) and bitumen which is produced at a temperature of about 150°C and is laid and compacted hot to produce a dense smooth surface. It is used for road and aerodrome pavements and similar applications and is by far the most common asphalt mix produced in Australia. The maximum aggregate size for mixes ranges from about 5 mm to 40 mm.

(c) BITUMINOUS CONCRETE — similar to asphaltic concrete. Asphaltic concrete is the preferred term in N.S.W. while bituminous concrete is the term used in Victoria and Queensland.

(d) TAR CONCRETE — similar to asphaltic concrete but using tar instead of bitumen as the binder.

(e) HOTMIX — a mixture of dense graded aggregates and bitumen which is produced at about 150°C and is laid and compacted while hot. Hotmix usually has a little less bitumen and mineral filler and consequently slightly higher air voids than asphaltic concrete. It is used for road pavements and is particularly suited for base courses and thick applications. Due to the lower filler content, hotmix is more workable than asphaltic concrete, and fine graded mixes can produce smooth even textured surfaces particularly where hand placing methods are required.

(f) OPEN GRADED MIX — Open graded mix is made from graded aggregates and bitumen but with less fine aggregate than dense graded mix. This type of mix presents an open textured appearance and is used for high porosity surface courses to prevent hydroplaning or to provide drainage under an impermeable asphalt layer.

(g) COLDMIX/PREMIX — Coldmix is made from semi-dense graded aggregates with a total binder content similar to hotmix. It is normally produced at about 100°C using bitumen fluxed with approximately 20% of flux oil to produce mixes which are workable at ambient temperatures. (Coldmix is used mainly for patching, temporary patching of road openings and service trenches etc., and is often available in 40 kg packs as well as in bulk.) It may keep in stockpiles for several months and when applied in thin layers the flux oil evaporates and the mix hardens. It can also be produced using a slow breaking bitumen emulsion as the binder.

(h) RETARDED ASPHALT — a mixture of dense graded aggregates, bitumen and a retarding agent and is produced at about 150°C. The mix is designed to remain workable for one to two days after it has been produced, depending on weather and storage conditions. It is used for patching.

(i) SHEET ASPHALT — hotmix asphalt with a maximum particle size of about 3 mm or less. It can be used for footpaths and other areas where a very fine grained surface is required.

(j) DEEP STRENGTH ASPHALT PAVEMENT — a pavement in which the base and wearing courses are constructed of asphalt mixes. It is similar to full depth asphalt except that a layer of granular material is placed on the subgrade first.

(k) FULL DEPTH ASPHALT PAVEMENT — a pavement in which asphalt mixtures are used for all courses above the subgrade or improved subgrade.

(l) DEEP LIFT ASPHALT — the process of placing asphalt base at compacted thicknesses of 75 mm or more.

(m) RECYCLED ASPHALT — an asphalt mixture made from asphalt reclaimed from an existing pavement (by profiling etc.) and new aggregate and bitumen and in some cases a bitumen softening agent. The recycled mix is usually produced hot through a modified asphalt plant but some mixes can be prepared cold.

(n) PAVEMENT PROFILING — is the process of restoring a pavement surface to its original, or better than original, grade and shape by removing bumps, ruts and other surface imperfections prior to overlaying.
2.2 ASPHALT PAVEMENT TERMS

The most common uses of asphalt mixes are:

(a) in a **FLEXIBLE PAVEMENT**, which is any form of road construction which is not completely rigid, i.e. any type other than cement concrete.

(b) as a **SURFACE COURSE** on new construction to provide a smooth riding surface, to resist traffic forces, to waterproof and protect the pavement and subgrade and, where required, to provide a skid resistant surface.

In some cases, the surface course comprises two layers — a **WEARING COURSE** which directly supports the traffic and a lower layer called **INTERMEDIATE COURSE**.

(c) as a **BASE COURSE** where the asphalt is used as a structural layer in either:

(i) a **DEEP STRENGTH ASPHALT PAVEMENT** where the pavement consists of a thick layer of asphalt (greater than about 75 mm) on a granular or treated granular base.

(ii) a **FULL DEPTH ASPHALT PAVEMENT** where the full depth of the pavement above the subgrade is constructed using asphalt.

(d) as a **LEVELLING COURSE** — to correct irregularities in the surface of an existing sealed pavement prior to resurfacing.

(e) as **RESHEETING** — to recondition the surface of a pavement by the addition of a new wearing course.

(f) as an **OVERLAY** to strengthen an existing pavement or improve profile.

---

**PAVEMENT COURSES.**

- **Asphalt Surface**
- **Granular Base**
- **Subgrade**

**CONVENTIONAL**

- **Asphalt Surface**
- **Asphalt Base**
- **Granular Sub-Base**
- **Subgrade**

**DEEP STRENGTH**

- **Asphalt Surface**
- **Asphalt Base**
- **Subgrade**

**FULL DEPTH**

**DEEP STRENGTH AND FULL DEPTH ASPHALT PAVEMENT.**

- **Overlay or Resheet**
- **Levelling Course**
- **Existing Uneven Pavement**

**LEVELLING COURSE, RESHEET, OVERLAY.**
3. Characteristics of Flexible Pavements

Some of the principal characteristics of modern flexible pavements are:

(a) **VERSATILITY** — the versatility of asphalt pavement construction can meet the needs and conditions of most areas.

(b) **CONSTRUCTION** — asphalt pavements are economical and quickly constructed. The method of construction in layers enables work to proceed at a number of points and can proceed progressively along the project as required. (As soon as construction is completed it can be opened to traffic. This is particularly important when resurfacing or when carrying out reconstruction work on busy sites.)

(c) **STAGE CONSTRUCTION** — asphalt pavements can be strengthened in depth and widened as the need arises.

(d) **MAINTENANCE** — asphalt pavements are easy and economical to maintain. Their life can be easily, quickly and economically extended by adding a new wearing course when required. Where it is not desirable to raise the level of the finished surface, the existing wearing course can be removed by profiling prior to the new surface being placed.

(e) **SERVICES** — asphalt pavements can be trenched and patched easily when utility lines under or across the pavements need repair.

(f) **FLEXIBILITY** — the normal slight movement under traffic on a flexible road is a feature which prevents any harshness in the riding quality of the road. Also, there is sufficient flexibility in the construction to accommodate any minor settlement.

(g) **RIDING QUALITY** — asphalt paving is smooth and continuous. In addition to being a uniform material without joints, the surfacing on asphalt pavements can be laid to a high degree of accuracy.

(h) **VISIBILITY** — there is greater visibility of lines and other traffic markings on asphalt pavements.

(i) **SKID RESISTANCE** — asphalt has good skid resistance properties and if required special mixes can be designed to meet special circumstances.
Mixes used in Australia are generally limited to those made from mixtures of well-graded aggregates (from sources such as crushed stone, river gravel or crystalline slag), sand, suitable filler (when required), and a road grade bitumen (or sometimes tar). In addition to the various definitions given in Section 2, there are other factors which determine the type of mix and its description.

4.1 MIX TYPES

The type of mix is generally referred to by the nominal maximum size of aggregate used, the gradation of the aggregate, and the position in the pavement at which the mix is placed. Thus a typical mix might be termed a 20 mm nominal size dense graded base course and is usually abbreviated to AC 20 or 20 BC base.

(a) NOMINAL MAXIMUM AGGREGATE SIZE.

In a well graded mix the nominal maximum size is generally taken as the sieve size through which 85% to 100% of the total aggregate will pass. Thus on a grading in which 90% of the aggregate passes a 10 mm sieve the mix would be termed a 10 mm nominal mix.

(b) GRADING

Mixes are termed “COARSE” or “FINE” depending upon the amount of stone (the percentage of aggregate larger than a 2.36 mm sieve size) in the mix. The terms coarse and fine mixes are also used to describe the texture of the compacted mat they produce. A coarse grading will produce a "bony" or coarse textured surface, while a fine grading will produce a sandy or relatively smooth textured surface.

(c) COMPACTED DENSITY

The compacted density of an asphalt mix is largely dependent upon the grading of the aggregates adopted for the mix and the corresponding voids in the mineral aggregate. The shape of the grading curve for maximum density will vary depending on the aggregates used (i.e. their shape, surface texture, etc.) and can usually only be satisfactorily defined by laboratory tests.
4.2 ASPHALT MIX PROPERTIES

In considering types of mixes and their properties, it is important to realise that different mixes have different properties, and in selecting a particular mix for a particular application, the desired mix properties should be kept in mind. Most mix properties are based on measurements by standard tests which have been correlated with the performance of pavements. These mix properties do not directly measure the performance in a road.

(a) **STABILITY** is the resistance of the mix to deform under load. For mixes using good quality aggregates, (shape, soundness, surface texture, etc.,) the major influence on stability will be aggregate grading, air voids content and bitumen content. Mixes with small aggregate sizes (e.g. less than 7 mm) may have relatively low stability because of the absence of coarse aggregate and, as a result the mechanical interlock within the mix is drastically reduced. Thus fine mixes, particularly in their early life, may show some distress in situations where there are severe stresses such as sharply turning traffic, point loads or heavy braking.

(b) **DURABILITY** is the resistance to weathering (including ageing) and to abrasive action of traffic. The effect of weathering or ageing of bitumen is to reduce its tensile strength, which results in hardening of the mix and finally in cracking.

(c) **FLEXIBILITY** is the ability of the mix to conform to long term movements in the base or subgrade. Many pavements are constructed on fills resting on soft compressible subgrades and hence differential settlement of the pavement must be accommodated by the mix without cracking.

(d) **FATIGUE RESISTANCE** is the ability of the mix to resist this repetitive load cracking. Heavy duty pavements subjected to a large number of load repetitions may exhibit cracking resulting from elastic or resilient deformations. This cracking may be, in its initial stages, accompanied by little or no permanent deformation of the pavement.

(e) **SKID RESISTANCE** is the ability of surface course asphalt mixes to provide sufficient friction for vehicular traffic in a complete range of weather conditions. Skid resistance is influenced by the resistance to polishing of the coarse aggregate and the surface texture in the mix. In some cases open graded asphalt mixes are used to prevent hydroplaning by providing a horizontal drainage system beneath the tyre.

(f) **WORKABILITY** is the property of an asphalt mix which determines the ease with which the mix can be placed and compacted. It is important in achieving compaction and also in areas requiring hand placing.
5. Selection of Mix and Size

5.1 MIX TYPE

The definitions given in Sections 2.1 and 4.1 will generally allow the type of mix to be selected for a particular application.

5.2 MIX SIZE AND LAYER THICKNESS

Mix size is generally dictated by the thickness of the asphalt layer and, in the case of wearing course mixes, by the texture required (e.g. a 5 mm mix gives a finer surface finish than a 10 mm mix).

An asphalt layer should be of sufficient thickness to prevent the mix tearing during laying and to allow the aggregate particles to mechanically interlock. To achieve this, the layer thickness should not be less than one and one half times the maximum aggregate size at any point. This is not the average thickness but the thickness over isolated high spots. In practice a minimum thickness of 2 to 5 times the nominal size should be used (depending on the particular grade of mix).

Also, there is a maximum layer thickness which should be used for each type to avoid compaction difficulties and to achieve an even surface. The maximum layer thickness is generally in the order of 4 times the maximum aggregate size for most mixes, with perhaps 5 times for fine mixes such as 5 mm. However, the thickness is really only limited by the ability to compact the mix to a satisfactory surface level.

Tables 1 and 2 can be used as a guide to the selection of mix size for dense-graded mixes such as asphaltic concrete, hotmix and sheet asphalt.
MIX SIZE — PAVEMENT TYPES

<table>
<thead>
<tr>
<th>USE</th>
<th>TYPICAL MIX SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Course &amp; Wearing Courses</td>
<td>5 mm or 7 mm</td>
</tr>
<tr>
<td>Footpaths</td>
<td>5 mm or 7 mm</td>
</tr>
<tr>
<td>Playgrounds etc.</td>
<td>5 mm or 7 mm</td>
</tr>
<tr>
<td>Recreational Areas such as:—</td>
<td></td>
</tr>
<tr>
<td>Tennis Courts, Cycle Tracks</td>
<td></td>
</tr>
<tr>
<td>Car Racing Tracks</td>
<td></td>
</tr>
<tr>
<td>Residential Driveways</td>
<td>10 mm or 13 mm</td>
</tr>
<tr>
<td>Small Parking Areas</td>
<td>5 mm or 7 mm</td>
</tr>
<tr>
<td>Parking Areas</td>
<td>5 mm or 7 mm</td>
</tr>
<tr>
<td>Road Pavements</td>
<td>5 mm, 10 mm or 13 mm</td>
</tr>
<tr>
<td>Highway Pavements</td>
<td>10 mm or 13 mm</td>
</tr>
<tr>
<td>Truck Parking</td>
<td>20 mm</td>
</tr>
<tr>
<td>Fork Lift Trucks</td>
<td>20 mm</td>
</tr>
<tr>
<td>Intermediate Courses</td>
<td>10 mm, 13 mm or 20 mm</td>
</tr>
<tr>
<td>Levelling Courses</td>
<td>10 mm, 13 mm or 20 mm</td>
</tr>
<tr>
<td>Base Courses</td>
<td>20, 28 or 40 mm depending on layer thickness and availability. In general it is better to use the largest size practicable.</td>
</tr>
<tr>
<td>Open graded mix to prevent</td>
<td>10 mm, 14 mm or 20 mm</td>
</tr>
<tr>
<td>hydroplaning</td>
<td></td>
</tr>
<tr>
<td>Patching</td>
<td>10 mm (also 5 mm, 7 mm, 13 mm and 20 mm)</td>
</tr>
</tbody>
</table>

TABLE 1 — GUIDE TO SELECTION OF MIX SIZE FOR VARIOUS PAVEMENT COURSES.

NOTE: TABLE 1
Within the guidelines above, some care needs to be taken in mix selection. For instance, some 20 mm mixes are not suitable for surface course work and some 5 mm mixes do not give a suitable surface for, say, tennis courts.

There are many mixes designed for particular applications (such as special mixes for tennis courts and car racing tracks, oil resistant mixes, aerodrome runways, tank bases, hydraulic works etc.) and expert advice should be sought in those cases.

MIX SIZE — LAYER THICKNESS

<table>
<thead>
<tr>
<th></th>
<th>Compacted Thickness in One Course</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wearing Course</td>
</tr>
<tr>
<td>Less than 5 mm</td>
<td>15 mm</td>
</tr>
<tr>
<td>5 mm</td>
<td>20 – 25 mm</td>
</tr>
<tr>
<td>7 mm</td>
<td>20 – 30 mm</td>
</tr>
<tr>
<td>10 mm</td>
<td>25 – 40 mm</td>
</tr>
<tr>
<td>13 mm</td>
<td>25 – 40 mm</td>
</tr>
<tr>
<td>20 mm</td>
<td>50 mm</td>
</tr>
<tr>
<td>28 mm</td>
<td>—</td>
</tr>
<tr>
<td>40 mm</td>
<td>—</td>
</tr>
</tbody>
</table>

TABLE 2 — SELECTION OF MIX SIZE IN RELATION TO LAYER THICKNESS
6. Asphalt Manufacture & Paving

6.1 ASPHALT MANUFACTURE

Asphalt is produced by drying and heating aggregates and mixing them with a bitumen binder in carefully controlled proportions and within narrow temperature bands (in the range of 130°C to 160°C depending on mix type). Developments in asphalt plants have been towards larger and more efficient units and modern plants can be likened to factories with computer controlled processes.

(a) RAW MATERIALS

(i) Aggregates constitute from 90% to 96% of asphalt mixes and are classified as coarse aggregate, fine aggregate and filler depending upon size. Aggregates for asphalt are derived from the following sources:

- **Coarse aggregate** — generally crushed from igneous rock or limestone rock quarries or from river gravel deposits. Another source is crystallised slag.

- **Fine aggregate** — can be extracted from river or dune sand deposits, or from the screening process during the production of coarse aggregates.

- **Filler** — Asphalt mixes usually always contain a small percentage of material finer than a 75 mm sieve. Filler usually consists of flyash, rock dust, cement, hydrated lime, crushed limestone dust or baghouse fines.

(ii) The Binder provides the necessary tensile strength and flexural properties required during the service life of the pavement. The normal binder used in Australia is bitumen derived from the processing of crude oil. An alternative but not widely used binder is tar derived from coal or oil.

(b) MANUFACTURE

Asphalt can be produced in two types of plants:—

(i) **Batch Plants** — the aggregates are taken from storage in controlled amounts and passed through a rotary dryer where they are dried and heated. The aggregates then pass over a screening unit which separates them into different sized fractions and deposits them into bins for
hot storage. The aggregates, mineral filler and bitumen are then proportioned by weight on sets of scales on a batch basis and thoroughly mixed in a twin shaft pugmill. The mix is then discharged into either a hot surge or directly into trucks and transported to the paving site. Batch plants are designed around flexibility — they can be operated intermittently and can change from one mix to another quite readily.

(ii) **Continuous Plants** — these plants produce asphalt in a continuous process. One special type of continuous plant is the Drum Mixing Plant — these plants differ from batch plants in that the aggregates are proportioned by accurately calibrated feeders which feed the desired aggregate grading into the dryer/mixer drum and the hot bitumen is proportioned by a calibrated pump and delivered into the drum by a separate pipe. Thus the aggregates are dried, heated and mixed with the bitumen binder in the drum dryer in the one operation. The mixed material is transferred to a hot surge or storage bin for subsequent loading into trucks. The operation is a continuous one, as opposed to batch, and hence is more suited to the continuous production of one type of mix.

(c) **ASPHALT STORAGE**

**Surge or Storage Bins** — These systems consist of one or more bin/s for storing hot asphalt with a system (slat conveyor, skip hoist, conveyor belt) to carry the mix from the asphalt plant (either batch or drum) to the bin/s. The mix is then discharged directly from the bin/s into trucks. These systems are used to even out the production process and/or to store mix ready for use. “Surge” bins retain mix for short periods (up to a few hours) and are not heated and often not insulated. “Storage” bins retain mix for longer periods and are usually heated and insulated.

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**LAYOUT OF TYPICAL DRUM MIXING PLANT.**
6.2 ASPHALT PAVING

(a) Preparation of Surface —
Granular Base Courses should be compacted to the designed density, with a tight surface and to the design profile. Any soft spots or uneven base should be corrected. A prime coat of tar or cut-back bitumen may be required where the pavement presents a smooth surface (some bush gravels and river gravels) or the prime is required to contribute to waterproofing the base. With existing surfacing the pavement should be patched if necessary and the surface cleaned as required. Any cold mix patching should be left for sufficient time for the flux oil to evaporate prior to overlaying.

A Tack Coat is used on both new work and existing pavements to promote adhesion between the underlying layer and the asphalt surfacing. The surface should be free from excess water and of all loose and foreign materials prior to spraying the bitumen emulsion tack coat, which should “break” before placing the asphalt.

(b) Paving —
Asphalt is generally placed using an asphalt paving machine, which performs the functions of spreading, levelling and partly compacting the asphalt mix.

Modern asphalt pavers are sophisticated items of equipment and are capable of high outputs (in terms of width, depth and speed) as well as being suitable for small jobs.

These machines consist of a tractor unit to drive the machine and a screed unit to level and partially compact the asphalt mix. There is a receiving hopper at the front where the delivery truck tips its load of asphalt, and the mix is then fed through to the screed unit.

Asphalt can also be laid by hand raking. However, this is generally restricted to small jobs where a paving machine cannot be used.

(c) Compaction —
The asphalt is compacted by rollers closely following behind the paving machine. The various types of compaction equipment include steel-wheeled rollers, either static or vibratory (which impart a greater compactive effort), rubber tyred rollers or a combination.

(d) Method of Measurement —
Experience has proven that the most satisfactory and equitable basis for measurement is on quantity, in tonnes, rather than on area.
Asphalt is — and will continue to be — the predominant pavement surfacing material. It is a very important construction and maintenance material and hence it is essential that engineers are in a position to use the material in its best and most economical form.

To those specifying and using asphalt it is hoped that this booklet serves as a useful guide to the selection of asphalt mixes as well as providing a fundamental appreciation of the terminology and manufacturing and paving processes involved.

If further information or clarification is required please contact our Head Office (see back cover).
Acknowledgement

The Australian Asphalt Pavement Association gratefully acknowledges the assistance of Bitupave Limited (NSW), with whose kind permission much of the material in their publication 'Bitupave Basics' is reproduced in this booklet.
The Australian Asphalt Pavement Association was formed in July, 1969, as a non-profit organisation to promote the economic use of asphalt based on sound technical and commercial grounds.

Throughout its history, AAPA has maintained as its major objective, the dissemination of technical knowledge aimed at constant updating and improvement in asphalt technology.

AAPA Members include the asphalt manufacturing and paving contractors, material suppliers, plant and machinery manufacturers, and individuals interested in asphalt technology.

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