

# Air Voids in Asphalt

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## INTRODUCTION

The intention of this Work Tip is to highlight the importance of proper compaction. Compaction techniques and other factors influencing compaction are referred to in other Work Tips.

The air voids within a compacted dense graded asphalt mix have a major influence on service properties. Insitu air voids are partly a function of design and manufacture but more particularly are an outcome of compaction achieved during placing. This Work Tip gives an indication of the change in service properties at varying levels of compaction and outlines the role of field measurement and mix design.

## INFLUENCE OF AIR VOIDS AND COMPACTION LEVEL ON ASPHALT PROPERTIES

The compacted density of a dense graded asphalt mix will affect the following:

- Rate of rutting
- Fatigue life (cracking)
- Structural strength (stiffness modulus)
- Permeability (entry of air and water)
- Ravelling.

### Rutting

At low air voids (less than about 2%) the binder almost totally fills the void space between the aggregate particles, so that the mix acts as a fluid and is less resistant to rutting when subjected to heavy traffic. Poorly compacted mixes also have less resistance to rutting due to a weaker structure and secondary consolidation under traffic.

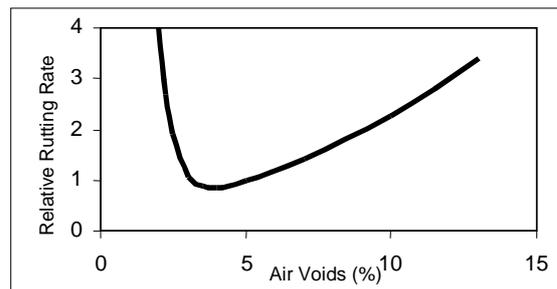


Figure 1: Relative Rutting Rate vs. Air Voids

Figure 1 gives an indication of relative rutting rate of a mix designed for 5% voids and compacted to different voids levels.

### Fatigue Life

Fatigue life, or resistance to cracking under repeated load, is directly proportional to the compaction level. Figure 2 shows results of fatigue testing of the same mix relative to compaction at 5% voids. In this case an increase of air voids from 5% to 8% has resulted in a 50% reduction in fatigue life.

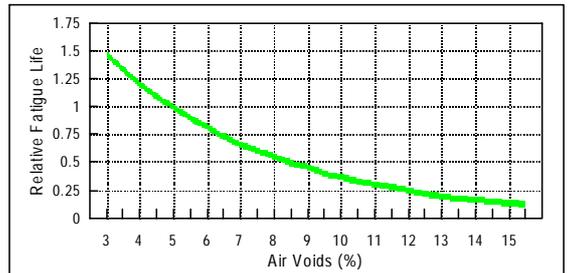


Figure 2: Relative Fatigue Life vs Air Voids

### Strength/Stiffness

The structural strength of an asphalt mix, as measured by its stiffness or modulus, is also related to compaction level. Figure 3 shows modulus relative to 5% air void content. In this case an increase in voids from 5% to 8% has resulted in a 20% reduction in stiffness or load carrying capacity.

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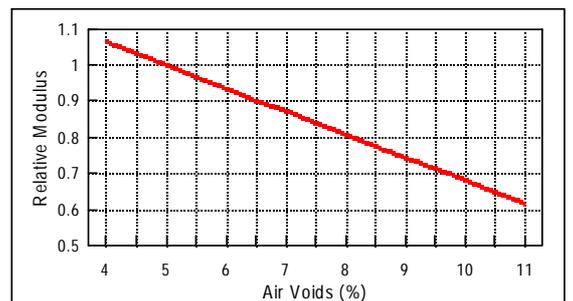


Figure 3: Relative Modulus vs. Air Voids

### Key Summary

*This issue of 'pavement work tips' outlines the influence of air voids on the performance of dense graded asphalt mixes, and emphasises the importance of compaction in achieving intended service properties*



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## Permeability

Permeability is the term given to the ability of air or water to enter and move through an asphalt mix.

Air ingress will cause gradual hardening of the asphalt binder leading, eventually, to raveling due to the binder having insufficient cohesion to hold the aggregate particles together. Figure 4 shows the result of a study by ARRB TR of binder hardness in 10 year old asphalt mixes. At 5% insitu air voids, binder viscosity is little changed from that expected in a newly placed mix (typically 3.7 Log Pa.s). Above 7%, the binder in all mixes has hardened to more than 5 Log Pa.s which is approaching the critical viscosity level (5.67 Log Pa.s) specified in testing bitumen for long term exposure to heat and air (durability test).

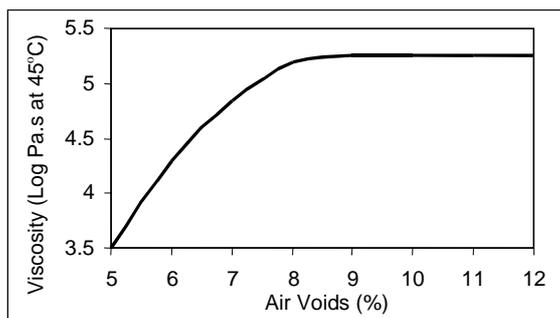


Figure 4: Binder Viscosity and Air Voids in 10 year old asphalt

Water permeating through an asphalt mix can cause damage to underlying layers as well as damage to the asphalt mix itself.

At around 6-7% air voids, the void spaces are largely unconnected and the rate of moisture entry is low and unlikely to cause harm. Above about 13% air voids the asphalt is free draining. Between 7 and 13% there is a risk that the asphalt mix can become saturated.

Heavy traffic, which causes pore pressure within the saturated mix, can then lead to separation or stripping of the binder from the aggregate surface.

## Ravelling

Ravelling is loss of aggregate from the surface of the mix. It can be partly due to ageing effects and partly due to poor aggregate interlock from poorly compacted materials.

In either case, high air voids and poor compaction will reduce the effective service life of the asphalt.

## ASSESSING FIELD DENSITY

Field density may be either expressed relative to the bulk density of a laboratory compacted mix or the maximum density (void-free density). In the first case, estimation of insitu air voids must make allowance for the air voids in the laboratory compacted mix. In the latter case, relative density is a direct measure of air voids as shown in Table 1.

Insitu Air Voids (%)	Density Ratio (Relative Compaction)	
	Relative to maximum density	Relative to laboratory density of 5% voids
4	96	101
5	95	100
6	94	99
10	90	95
14	86	91

Table 1: Insitu Air Voids and Density Ratio

## DESIGN AIR VOIDS

Design air voids are selected on the basis of the expected level of traffic and the risks associated with rutting and texture loss of wearing course mixes subjected to heavy traffic. Table 2 gives an outline of laboratory compaction levels and air voids for typical dense graded mixes.

Traffic Group	Mix Type	Laboratory Compaction Level (cycles)	Design Air Voids (%)
	Application		
Light	Wearing and base	50	4.0
Medium	Wearing and base	80	4.0
	High fatigue base	80	3.0
Heavy	Wearing and base	120	4.0
	High fatigue base	120	3.0
Very Heavy	Wearing and base	120	5.0

Table 2: Typical Design Air Voids

## CONCLUSION

Dense graded asphalt mixes are designed to achieve the lowest practicable air voids consistent with the risks of rutting and instability under heavy traffic. Service properties will, however, be seriously affected if mixes are not compacted close to the laboratory design level.

For more information on any of the construction practices discussed in "pavement work tips", please contact either your local AUSTROADS Pavement Reference Group representative or AAPA — tel (03) 9853 3595; fax (03) 9853 3484; e-mail: info@aapa.asn.au  
A complete list of "pavement work tips" issues is available on AAPA's web site: www.aapa.asn.au

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