Importance of Compaction

Traffic causing debonding of particles at or near a surface is a result of poor compaction. If there is insufficient voids and intimate particle contact have been achieved with a particle mix.

What Affects Compaction?

The ease of compaction is affected by both the materials used and construction practices.

Aggregates—Aggregates influence compaction through both shape and surface texture. Angular particles are more difficult to compact than rounded ones. Particles with harsh surface texture are more difficult to compact than those that are plate-shaped. However, those particles having shapes or textures that cause difficulty in compaction are the same ones that give high stability. For example, aggregate consisting of marbles would provide a mix that would be easy to compact but would have low stability.

In addition to particle shape and texture, gradation also influences ease of compaction. Mixes with high proportions of coarse particles are difficult to compact. With other factors being equal, a mix that is graded uniformly from large through small size aggregate will be easiest to compact. Don’t be fooled by the easy workability of a finely graded or oversanded mix. Although easily worked, they will tend to show under a roller and will be difficult to compact. Such mixes are said to be ‘tender.’ Mixes with excessive material near the size of the No. 30 sieve are often tender.

Particle strength and absorbency also affect compaction. Weak particles will crush under rolling creating uncemented faces that decrease the tensile strength of the mat and provide open surfaces for water penetration. Absorbent aggregates can increase particle-to-particle friction by soaking up hot asphalt cement that otherwise would act as a lubricant during compaction.

Asphalt Cement—The grade (based on penetration or viscosity) of asphalt cement influences the viscosity of the hot binder in a mat. Binder is a mixture of asphalt cement and dust (aggregate particles passing the No. 200 sieve). Mixes with low viscosity binders will compact easier of course. If compacted while hot enough, however, any grade of asphalt used by MDOT should have a viscosity low enough to act as a lubricant. High asphalt film thicknesses make compaction easier. However, as discussed above, excessive asphalt will fill all the voids and begin forcing particles apart, creating an easily worked but unstable mix.

Construction Practices—The hot asphalt binder provides a lubricant for compacting the aggregates. When the binder cools below about 185°F, however, it prevents the particles from being pulled apart—a desirable characteristic for the finished roadway—but also prevents particle movement and thus stops further compaction. Further rolling, instead of compacting, tends to fracture aggregate causing more problems. Thus, although rolling should begin at a much higher temperature, it is essential that compaction of a conventional asphalt mix be completed while its temperature is above 185°F. Asphalt mixes incorporating certain additives such as latex must be compacted at higher temperatures, depending upon the type and quantity of the additive. A steel wheeled roller should not even be allowed to try to compact a mat whose temperature is below 175°F. Temperature of the mix during compaction is a function of: 1) how...
hot the material comes out of the plant, 2) how much cooling
takes place during transportation, 3) layer or lift thickness
(thicker lifts hold heat longer), 4) weather conditions (air
temperature and wind), 5) temperature of the surface on
which the mix is being placed.

Figure 1 shows the relationship between mat thickness,
base and air temperature, and time before the material
cools to 185 F, when further compaction cannot be accom-
plished. Mix temperature is that measured behind the paver

![Figure 1](image)

**MAT THICKNESS, INCHES**

Figure 1. Time for mat to cool to 185 F. (Wind
velocity 12 mph, ambient temp. same as base).

at a depth of 1/4 to 1/2 in. below the surface. Notice how
rapidly the material cools as mat thickness decreases. For
example, at 60 F base and air temperature, a mat 3 in. thick
will cool to 185 F in about 30 minutes. A mat 1-1/2 in.
will cool in only about 10 minutes. This illustrates
the importance of early rolling of thin lifts; MDOT often
uses lifts less than 1-1/2 in

Rolling - The three types of self-propelled rollers cur-
cently used are: 1) steel wheeled static, 2) steel wheeled
vibratory, and 3) pneumatic rubber tired. These types will
be discussed in detail in a later article, together with rolling
patterns. For now, it will only be said that each type does
its job by applying pressure over a contact area. As the
material is forced into a smaller volume and mix tempera-
ture drops, the resistance to further movement increases
preventing the roller from penetrating into the mat. Figure
2 shows how this occurrence reduces the roller-to-mat contact
area thereby increasing unit contact pressure. Usually,
as shown in Figure 3, the largest amount of compaction
takes place during the first pass and then rapidly diminishes
with subsequent passes. Figure 3 shows a typical compaction
curve for conventional rollers. Vibratory rollers should
compact much more rapidly.

Overcompaction

Although overcompaction is a common worry, it is sel-
dom a real problem. Overcompaction occurs when a mix
is reduced in volume to a point where air void content is
lower than the design value. MDOT designs for about 3
percent air voids on interstate highways and usually the
best compaction efforts during construction can reduce
the mix to about 5 percent air voids. Traffic, over a period

![Figure 2](image)

![Figure 3](image)

Crushing of aggregate, perceived by some to be over-
compaction, is really caused by poor practices. Aggregate
crushing can be caused by: 1) using aggregate that is too
large with respect to lift thickness, 2) using aggregate with
low strength, 3) improper use of a vibratory roller, and 4)
using a steel wheeled roller on a mat that is too cold to
be compacted. When mat temperature falls below 175 F,
steel wheel rolling for compaction should cease. In general,
overcompaction should be of very little concern, while poor
compaction is of major concern. Adequate attention to
this single detail can add several years to the service lives
of many pavements.

-Fred Copple