Asphalt Compaction
Comparison of different compaction methods, circular vibration – directed vibration - oscillation

Abstract
On the market in Europe are four different compaction systems on asphalt available. Static compaction, represented by several manufacturers, traditional circular vibration, also represented by several manufacturers, directed vibrations together with automatic setting of to angle of the direction, represented by Bomags Asphalt Manager and finally oscillation, represented by Hamm.
All these systems have been tested except static compaction by several institutes/contractors. All of the tests have reached the same result. On thin layers all three systems are equal, they all need the same number of passes to reach required density. However, on thick layers traditional circular vibration has reach a much better result, with a 30-100% higher capacity than Asphalt Manager and oscillation.
Traditional circular vibration is the most versatile compaction system, suitable on both thin layers, <50mm, and thick layers, >50mm. The important issue is to have an amplitude that suit thin or even super thin layers, around 0,2-0,3mm, to avoid or reduce the risk of crushing the aggregate.

Contents

Objectives

The objectives of this investigation is to find if there are any differences between respective systems, circular vibration – represented by Dynapac, directed vibration – represented by Bomag and oscillation – represented by Hamm.

Dynapac has during recent years developed a circular vibration system with a low amplitude and high frequency. The amplitude is reduced compared to "older" rollers down to 0,2-0,3mm instead of around 0,4mm and the frequency is increased up to the range 60-70Hz. The reason for reducing the amplitude was to reduce the risk of crushing the aggregate, especially on stone mastic asphalt. A way to maintain or increase the compaction efficiency was the increase of the frequency.

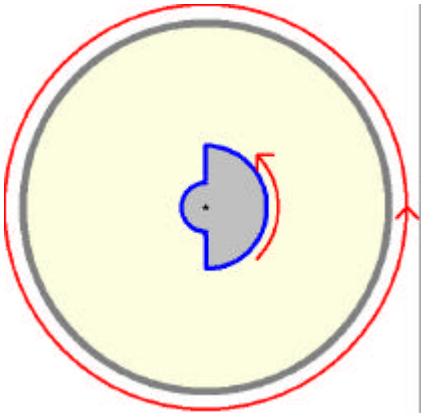
Bomag has during the last couple of years developed a directed vibration system, which they call Variomatic. Together with Variomatic 2 they have developed a system, which they call Asphalt Manager. The direction of the vibration can be changed simultaneously. They measure what they call E_{VIB}, a system measuring the stiffness of the ground. We are not investigating the adequacy of E_{VIB}.

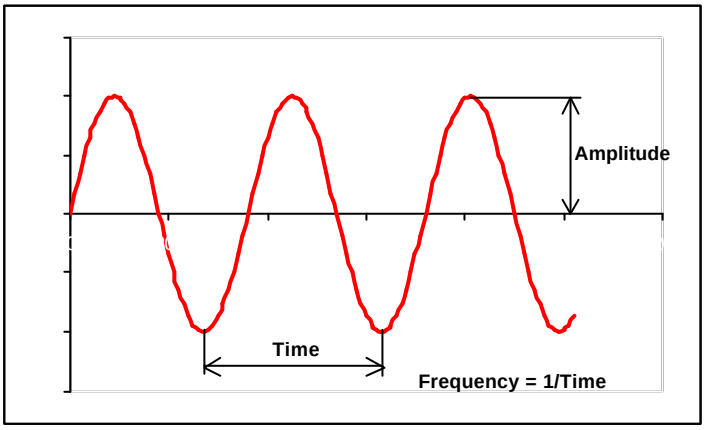
Hamm has used the oscillation system for many years, which was developed by Geodynamik. Oscillation is a system where the drum are turning forward and backward around its centre. One of the main problems with oscillation has been the wear of the drum shell.

Principles

Circular vibration

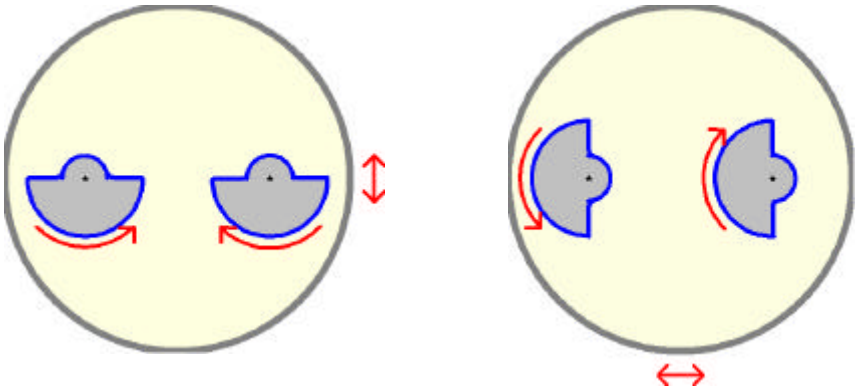
Circular vibration is a very simple method to create vibration. A weight, attached eccentric to a shaft is rotating. To keep balance the drum starts vibrating.





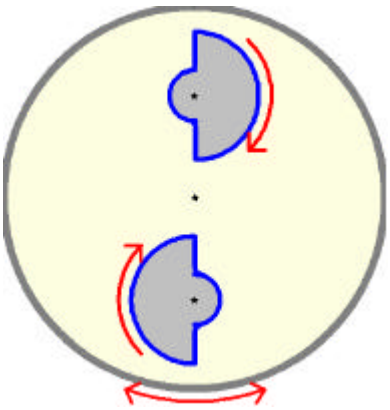
Directed vibration

Directed vibration is created by the same principle as circular, but two eccentric weights are used connected to each other by a gear. The eccentric weights are rotating in different directions to create directed vibration. The direction of the vibration can be changed by rotating one of the eccentric weight, rotate position between the weights.



Oscillation

Oscillation is created by the same principle as circular vibration, but two eccentric weights are used connected to each other by a belt. The eccentric weights are rotating in same direction to create oscillation, turnings around the centre of the drum.



Rollers

Comparison tests have been performed with the following rollers:
Circular vibration – Dynapac CC 422HF
Directed vibration – Bomag BW 174AD Asphalt Manager
Oscillation – Hamm DVO 8 and HDO 90
It is important to select rollers, which are equal as possible. The above rollers have about the same weight, drum width and drum diameter.

Roller	Dynapac CC 422HF	Bomag BW 174AD Asphalt Manager	Hamm DVO 8	Hamm HDO 90
Operating weight (kg)	10.400	9.560	9.340	9.700
Static linear load (kg/cm), front	30,7	30,2	28,7	29,8
Static linear load (kg/cm), rear	31,2	26,7	26,9	28
Amplitude, high/low (mm), front	0,7/0,3	0,84	0,61/0,4	0,61/0,4
Amplitude, high/low (mm), rear	0,7/0,3	0,23	1,3/1,3	1,3/1,3
Frequency, high/low (Hz), front	50/62	46	42/50	42/50
Frequency, high/low (Hz), rear	50/62	46	33/39	33/39
Drum diameter (mm)	1300	1220	1200	1200
Drum width (mm)	1680	1680	1680	1680

Data from leaflets.

The rollers are all about the same size exactly the same drum width and nearly equal weight. CC 422HF is slightly heavier, which is an advantage.
BW 174AD Asphalt Manager has directed vibration on the front drum and circular on the rear one. This roller was tested in the automatic mode, the most suitable direction would be decided by the roller itself.
DVO 8 and HDO 90 have oscillation on the rear drum and circular vibration on the front one.

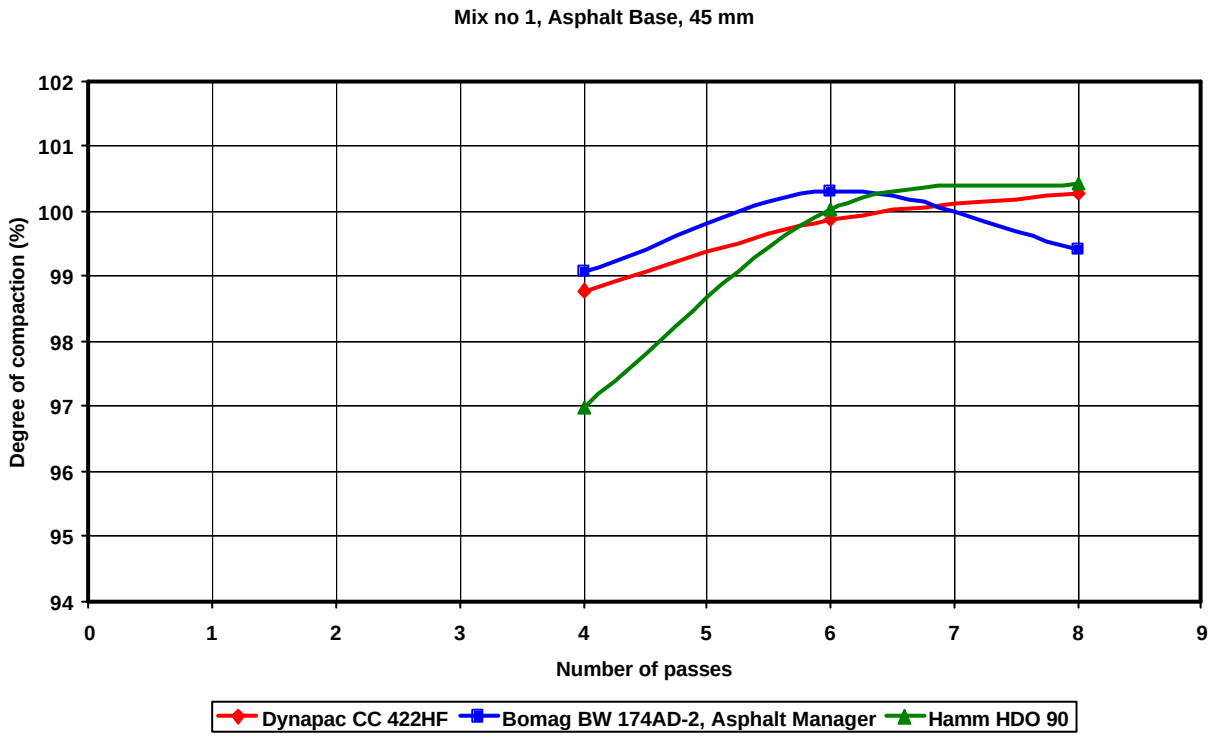
Asphalt mixes

Five different asphalt mixes have been tested. Two of the tests are performed by ourselves, two of the others by a contractor (no 1) and the last one by a second contractor (no 2).

Mix no	1	2	3	4	5
Type of mix	Asphalt base	Stone mastic	Asphalt base	Dense asphalt concrete	Asphalt concrete, 40% recycled material
Nominal max particle size (mm)	22	16	22	11	10
Penetration (mm*10)	180/220	70/100	70/100	50/70	
Layer thickness (mm)	45/70	40	70	35	50-60
Test performer	Dynapac	Dynapac	Contractor no 1	Contractor no 1	Contractor no 2

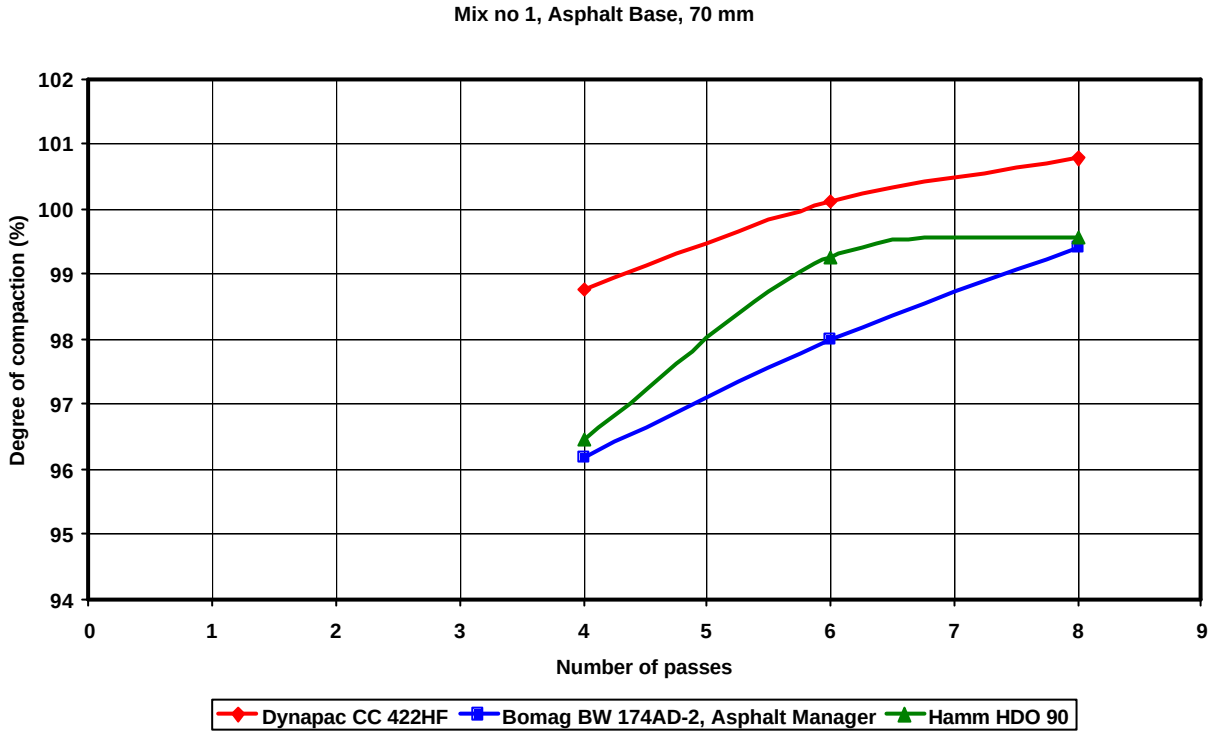
Test result
Weather condition was equal for all rollers for each test. The test result is presented with bars showing 80% probability, means that the probability is 80% that the average result of the test is within the bars. If the bars are overlapping the result are considered equal.

Asphalt Base, mix no 1
Mix no 1 was tested in two layer thicknesses, 45 and 70mm.



Asphalt base, max particle size 22mm, penetration 160/220, layer thickness 45mm, number of passes performed are 4, 6 and 8.

The test was performed with low amplitude selection when it's applicable. For thin asphalt base all three methods would be considered equal.
Minimum requirement is in the range 99-100%. To reach the requirement all three rollers need about 6 passes. Even though the amplitude for both Bomag and Hamm rollers are considerable higher the compaction are equal.

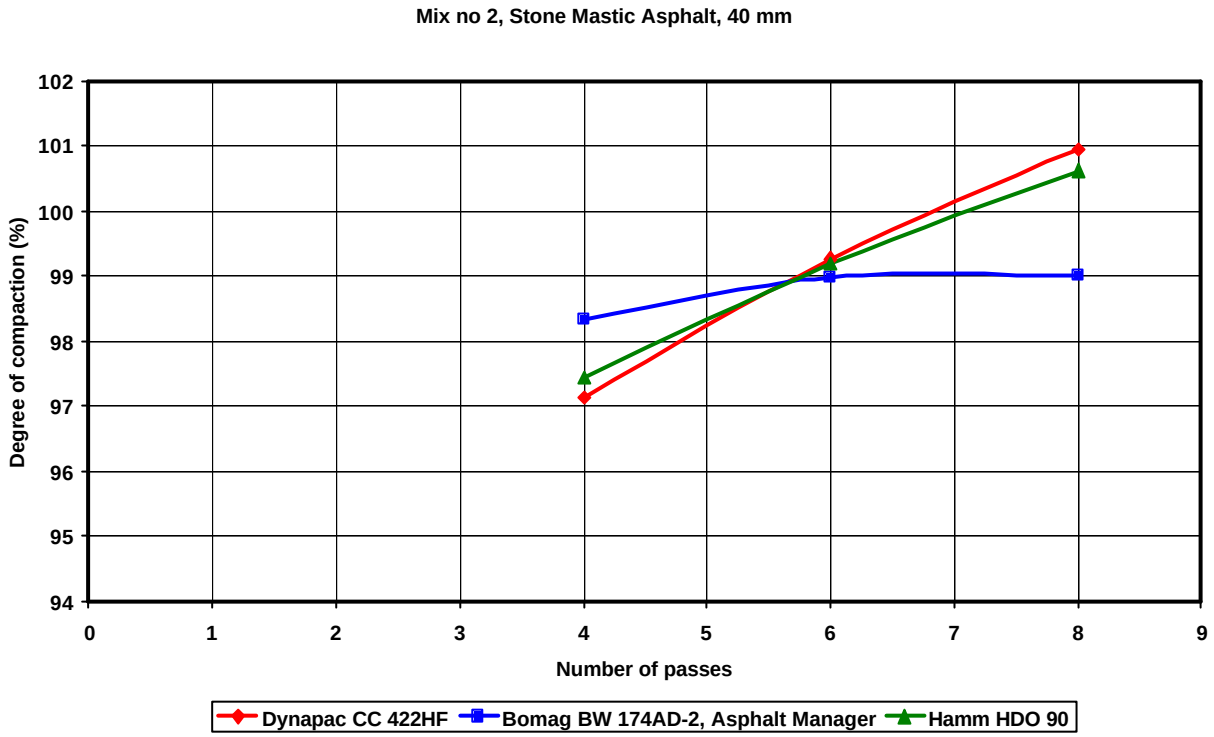


Asphalt base, max particle size 22mm, penetration 160/220, layer thickness 70mm, number of passes performed are 4, 6 and 8.

The test was performed with high amplitude selection when it's applicable. For thick asphalt base layer the traditional method, circular vibration, is the most efficient one. Minimum requirement is in the range 99-100%. To reach the requirement CC 422HF need 6 passes and the two other rollers need at least 8 passes. CC 422HF is at least 30-50% more efficient. If the requirement is in the upper limit of the range the Asphalt Manager and oscillation do not reach the required density.

Stone Mastic Asphalt, mix no 2

Mix no 2 was tested in one layer thickness, 40mm.



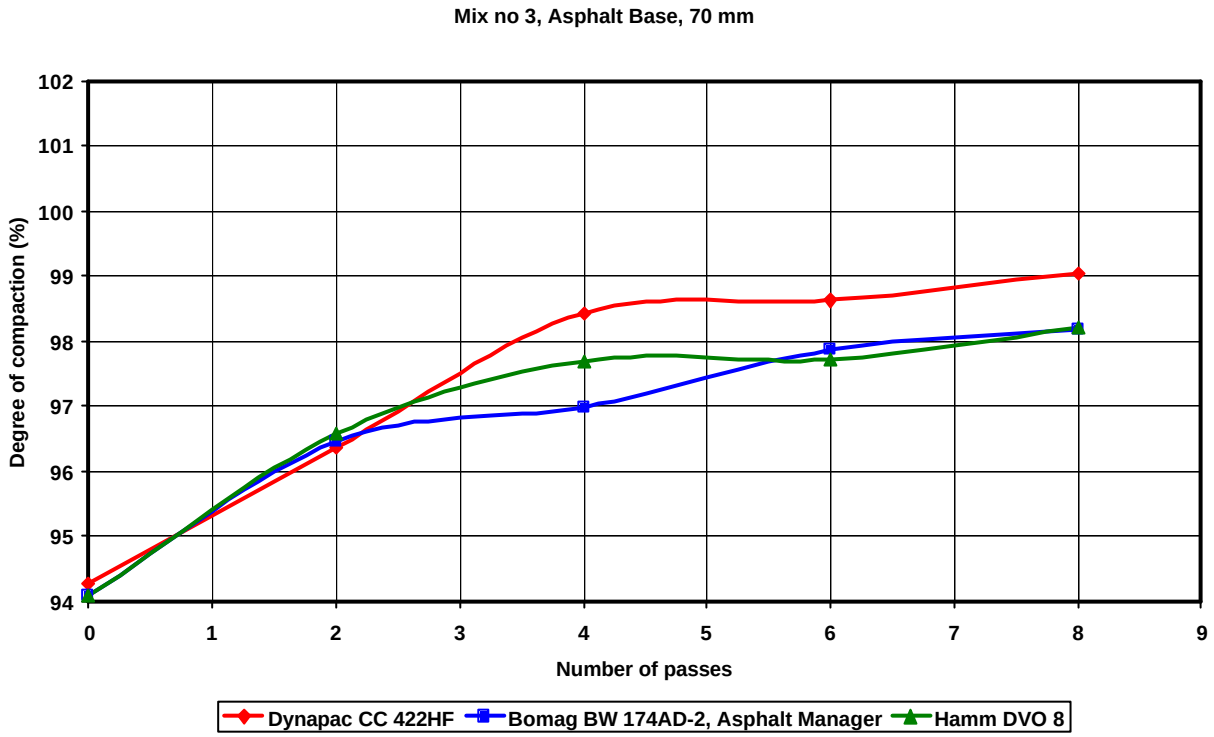
Stone mastic asphalt, max particle size 16mm, penetration 70/100, layer thickness 40mm, number of passes performed are 4, 6 and 8.

The test was performed with low amplitude selection when it's applicable. For thin stone mastic asphalt all three methods would be considered equal.

Minimum requirement is in the range 99-100%. To reach the requirement all three rollers need about 6 passes. If the requirement is in the upper limit of the range the Asphalt Manager does not reach the required density.

Asphalt Base, mix no 3

Mix no 3 was tested in one layer thickness, 70mm.

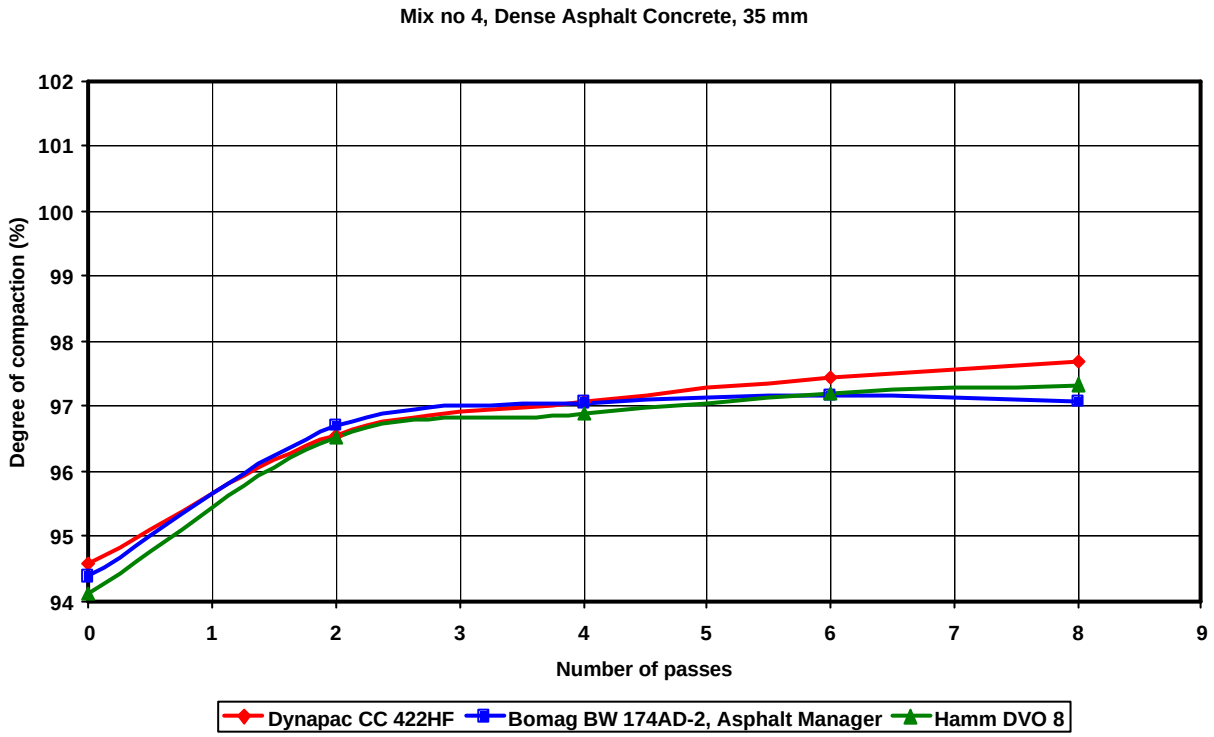


Asphalt base, max particle size 22mm, penetration 70/100, layer thickness 70mm, number of passes performed are 2, 4, 6 and 8.

Each manufacturer made the amplitude setting by them selves. CC 422HF used high amplitude. For a thick asphalt base layer the traditional method, circular vibration, proved to be the most efficient one. Minimum requirement is in the range 99-100%. To reach the requirement CC 422HF need 4 passes and the two other rollers need at least 8 passes. CC 422HF is at least about 100% more efficient.

Dense Asphalt Concrete, mix no 4

Mix no 4 was tested in one layer thickness, 35mm.

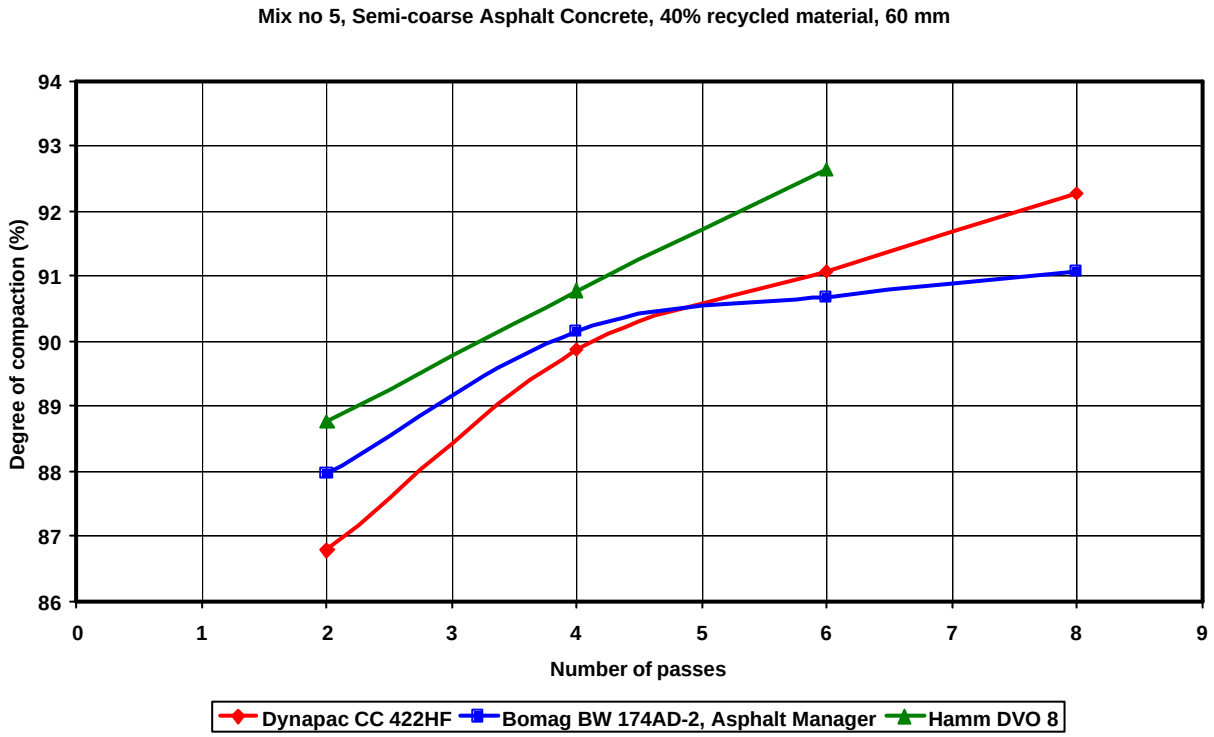


Dense asphalt concrete, max particle size 11mm, penetration 50/70, layer thickness 35mm, number of passes performed are 2, 4, 6 and 8.

Each manufacturer made the amplitude setting by them selves. CC 422HF used low amplitude.
For thin dense asphalt concrete all three methods would be considered equal.
Minimum requirement is in the range 97-98%. To reach the requirement all three rollers need about 6 passes.

Semi-coarse asphalt concrete, 40% recycled material, mix no 5

Mix no 5 was tested in one layer thickness, 50-60mm.



Semi-coarse asphalt concrete, 40% recycled material, max particle size 10mm, layer thickness 50-60mm, number of passes performed are 2, 4, 6 and 8. ***Note****, the asphalt temperature was 10 °C less with CC 422HF.*

The test was performed with low amplitude selection when it's applicable. For thick asphalt concrete layer the traditional method the low amplitude is less suitable. Note, the asphalt temperature was 10 °C less with CC 422HF, which have some negative influence on the result. The low amplitude of DVO 8 is higher compared to CC 422HF, ~35% higher, which also have an influence on the result.

Minimum requirement is 92%. To reach the requirement CC 422HF need 8 passes, DVO need 6 passes and BW 174AD did not reach the required density.

Conclusion

Traditional circular vibration is the most versatile compaction system compared to directed vibration (asphalt manager system) and oscillation.

For thin layers, less than ~50mm, irrespective of asphalt mix all three system are equal. We also recommend using low amplitude setting to avoid or reduce risk of crushing the aggregate.

For thick layers, more than ~50mm, irrespective of asphalt mix traditional circular vibration has an advantage compared to the two other systems. The capacity is about 30-100% higher. Sometimes the Asphalt Manager system does not reach the required density.

We can also see that if the selection of amplitude is not the most suitable one, we do not have the advantage any longer.

A points system is used to evaluate the performance of the rollers on each asphalt mix, where the gets 3 points, second place 2 points, etc. Equal result means the points are shared between the rollers. The results can be seen below.

	CC 422HF	BW 174AD	DVO 8/HDO 90
1. Asphalt base / 45mm	2	2	2
2. Stone mastic / 40mm	2	2	2
4. Dense asphalt / 35mm	3	1,5	1,5
Sum, thin layers	***7***	***5,5***	***5,5***
1. Asphalt base / 70mm	3	1	2
3. Asphalt base / 70mm	3	1,5	1,5
Sum, thick layers	***6***	***2,5***	***3,5***
Sum, all layers	**13**	**8**	**9**