APPLICATION COMPANION #6
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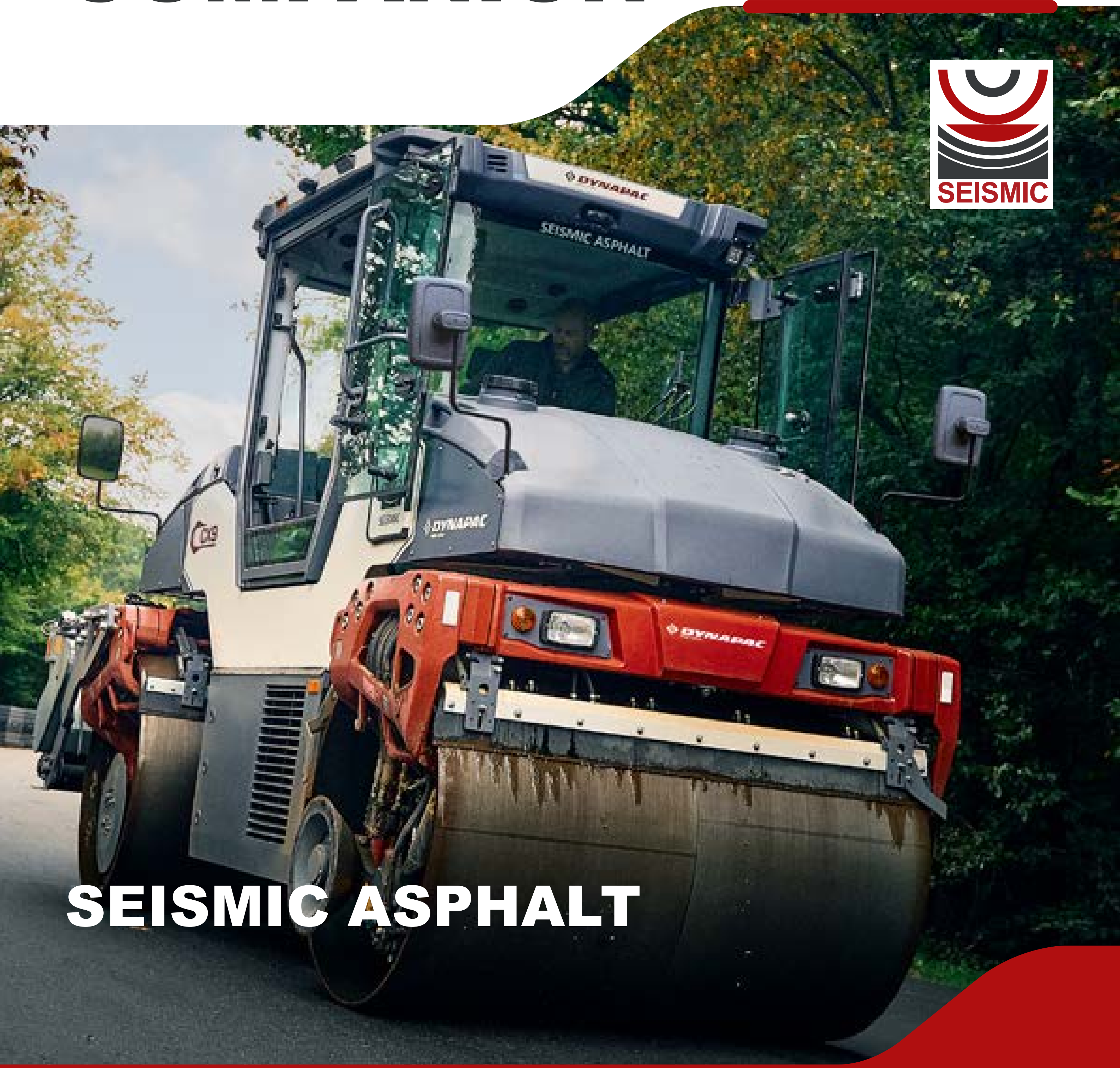
APPLICATION COMPANION



SEISMIC ASPHALT

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Dear Readers,

Welcome to our sixth “Application Companion” Bulletin. In this issue we cover Dynapac´s latest innovation within the area of asphalt compaction, namely the SEISMIC ASPHALT system. The system is based on SEISMIC for soil applications, but with a few additions and modifications to accommodate for the changing characteristics of an asphalt mix as a function of temperature. Let us have a look at how the system works and what benefits you can expect from SEISMIC ASPHALT!

INTRODUCTION TO SESIMIC ASPHALT

The SEISMIC system aimed for Dynapac's soil rollers has been around for a couple of years with a proven and well documented performance. Among the benefits from the SEISMIC system on soil (unbound materials), we have found:

- Reduced vibration power and energy consumption.
- Lifetime fuel consumption reduction.
- Elimination of bouncing (double jumping)
- Lower noise levels thanks to lower vibration frequency
- Reduced machine wear and tear

Since an asphalt mix consists of minerals to an extent of approx. 90-95 %, see figure 1, there is a good reason to believe that the benefits mentioned above might be possible to obtain also for asphalt. However, one must account for the fact that the characteristics (mainly viscosity) of the binder have a strong temperature dependency in an asphalt mix.

Figure 1. Constituents of a typical asphalt mix. The black part in the bottom represents the volume fraction of the binder.

Working principle of SEISMIC ASPHALT
When an asphalt mix is hot, it is rather easy to compact, but as the mix cools off (which can happen quite quickly if the weather is bad), the mix soon becomes very stiff and sticky, thus much more difficult to compact. From figure 2, one concludes that the compaction effort (amplitude) must be increased to be able to further increase the density as the mix temperature drops. An intelligent tandem roller should be able to account for this "stiffening phenomena" due to cooling of the mix to be effective even at lower temperatures.
From what has been outlined above, the problem with an adjustable drum amplitude can be solved via a complex, sensitive and expensive mechanism inside the drum. Some competitors have solved the need for amplitude change in this very cumbersome way. However, there is a smarter, more robust and more energy efficient way to do this. Taking the SEISMIC system for soil as a base, one can modify it slightly to fit the curve in figure 2 quite well without adding a lot of extra components inside the drum.

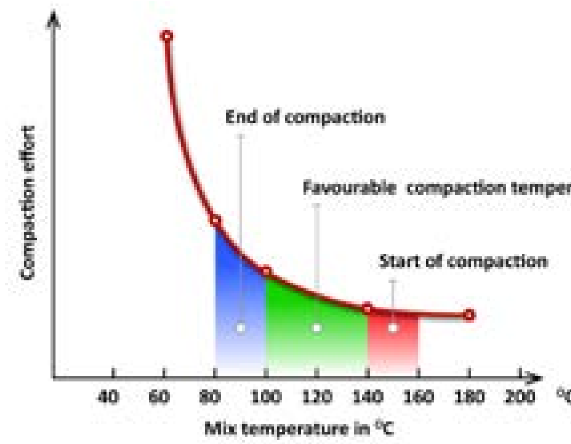

Figure 2. Compaction effort as a function of the mix temperature. To achieve the desired density, it is clear that a cooler mix requires a higher compaction effort (higher amplitude) compared to a warmer mix.

Hopefully by now, the reader is aware of the principle that SEISMIC is based upon. It is called the resonance phenomena, or natural frequency phenomena. Please refer to Application Bulletin no 3, for a detailed description of how SEISMIC for soil applications works. Based on that idea, and for every combination of a drum with a certain mass and a soil/asphalt with a certain stiffness, a resonance curve can be created, see figure 3.

Before we proceed, one should be aware of that the value of the drum amplitude specified in leaflets, technical data or similar, is the so called "nominal amplitude". This amplitude value is valid for a vibrating drum freely suspended in the air, i.e. without any contact with the ground. As soon as the drum is in contact with the ground, the nominal amplitude changes according to the dynamics in the drum-ground system. The amplitude is affected by the resonance phenomena, according to figure 3.

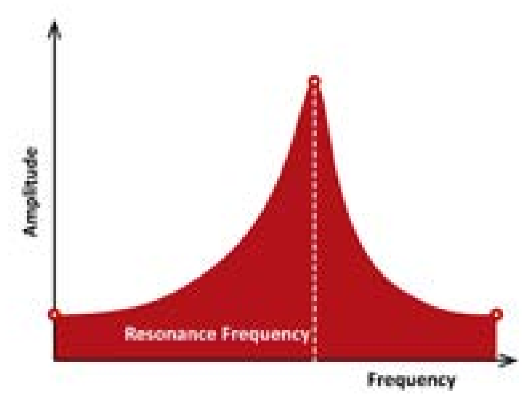

Figure 3. General resonance curve. The vibration amplitude is amplified when the compaction frequency correlates to the resonance frequency (natural frequency) of the drum-material system.


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From the curve in figure 3, it is clear that the amplitude shows its highest value when the frequency is close to the resonance (or natural) frequency. For a soil or asphalt application, the curve looks more like the one presented in figure 4. The amplitude peak is not as pronounced as in figure 3, but it is clearly visible. What is obvious from the curve though, is that operating the compaction tool at a vibration frequency lower than the resonance frequency, i.e. to the left of the peak, yields a drastic drop in amplitude and compaction performance. Operating at a frequency above the resonance frequency, yields a slightly decreased amplitude as frequency is increased, but not at all as drastic as below the resonance frequency.

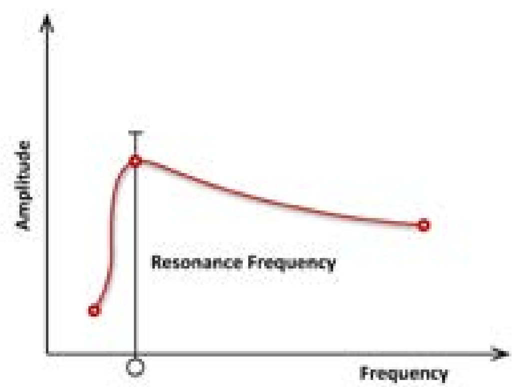

Figure 4. Resonance curve from an asphalt application.

We know from soil applications that the actual drum amplitude can be increased just by adjusting the vibration frequency to a value close to the resonance frequency, without any advanced mechanical systems in the drum. This is a great advantage compared to our competitors that adjust the amplitude via a complex mechanical system in the drum. By doing it in this ”cumbersome way” you introduce a lot of complexity, cost and sensitivity into your product and at the same time you lose the savings in power/energy/fuel consumption. This is the reason why Dynapac has chosen to work ”together with mother nature” with the simple, robust and energy efficient SEISMIC system.

With the combined knowledge of the need to increase the drum amplitude to be able to still achieve a satisfactory compaction as the mix cools off, and the fact that the drum amplitude can be increased in a ”natural way” by just adjusting the frequency to correlate with the resonance frequency of the drum-material system, we are now ready to understand the working principle of the SEISMIC ASPHALT system.

By combining the information in figures 3 and 4, we end up with a result according to figure 5. How can we interpret this? From what has previously been described, a hot mix is easily compacted, i.e. does not require any ”increased amplitude”. This means that by adjusting the vibration frequency to a value above the resonance frequency, there will be no ”extra amplitude boost” since the machine is not operating on the slope of the resonance curve. However, as the mix cools off, and thus requires a ”boost” in amplitude to be compacted in an effective way, this ”boost” can be easily obtained by just decreasing the vibration frequency to a value closer to the resonance frequency, see figure 5. The temperature of the mix (detected by the IR temperature sensors) decides how ”close” to the resonance peak the machine shall operate. This is to achieve exactly the right ”boost” in amplitude necessary to create an efficient compaction of the mix at hand. Compare this with how competitors have solved the problem. The SEISMIC system creates the necessary amplitude boost by benefitting from the resonance phenomena, whereas our competitors have chosen a much more complex, costly and sensitive way!

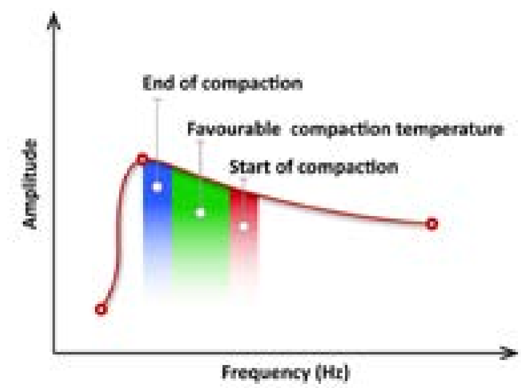

Figure 5. Combined temperature and stiffness/resonance curve for an asphalt application. How close the machine shall operate with respect to the resonance frequency is based on the mix temperature, giving exactly the right “amplitude boost” required to maintain an efficient compaction process even at lower mix temperatures.

From a machine perspective, the workflow is described in figure 6, see page 8. The IR temperature meter in the actual driving direction (forward or reverse) records the surface temperature of the asphalt mix. At the same time, the compaction meter registers and calculates the resonance frequency in the drum-asphalt system. By combining this information, a curve similar to what is shown in figure 5 can be established. Based on that curve, the logic unit decides the optimum vibration frequency to obtain the correct “amplitude boost” for the specific conditions at hand. The calculations and adjustments are performed five times per second, ensuring a process that quickly adapts to changing conditions (temperature, stiffness) of the asphalt mix.

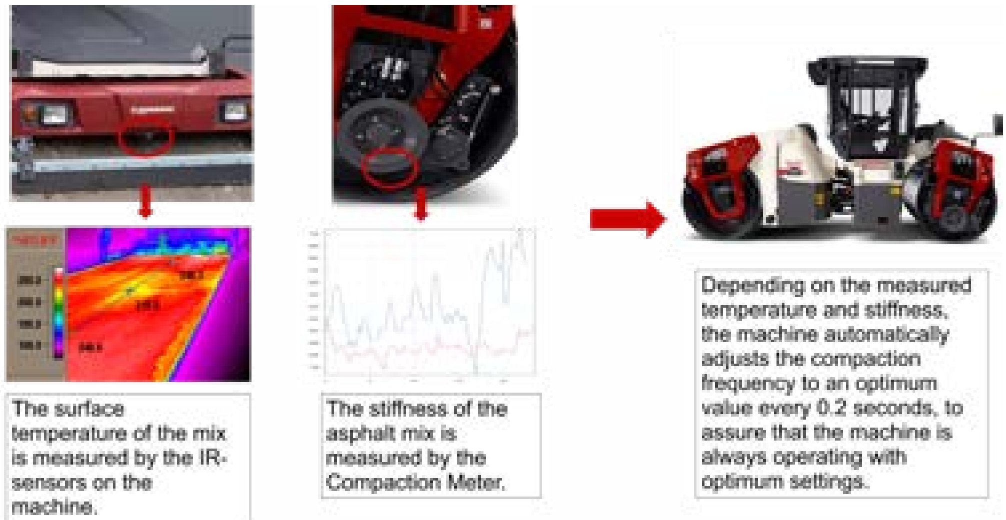

Figure 6. Working principle of the SEISMIC ASPHALT system.

Does it work in reality?

To make sure that the SEISMIC asphalt system performs as expected, a series of in-house trials and a lot of field trials have been performed.

The in-house trials were performed on various mix types, such as SMA and AC with various fractions and layer thicknesses. From the paved and compacted lanes, not less than 360 core samples were drilled and analyzed with respect to degree of compaction (air voids).

Figure 7. In-house compaction trials in progress at the Karlskrona site.

Figure 8. Coring in progress. 360 core samples were extracted during the in-house trials of the SEISMIC ASPHALT feature.

Some results from the tests are shown in figures 9. The figures show the degree of compaction in the asphalt mix as a function of the number of passes conducted. Each curve represents a different frequency setting, but the machine has been the same throughout all tests (a CC4000 VI). Note that even though the curves indicate very similar compaction performance, the mean frequency for SEISMIC has been considerably lower compared to the other fixed frequency settings. This means that despite the lower frequency, and thus much lower energy and fuel consumption, SEISMIC outputs the same compaction performance as a machine operated at a fixed higher frequency. This in turn indicates that a machine fitted with the SEISMIC system has a much higher efficiency compared to a similar machine with fixed vibration frequency. Thanks to the SEISMIC system using the resonance frequency as a tool to increase the vibration amplitude it thereby also increases the efficiency of the compaction process. Again, compared with our competitors, as they have chosen a much more complex way of amplitude adjustments, with advanced mechanics inside the drum, they can only afford to fit their machines with active amplitude adjustment on the front drum. This results in a machine that "limps" in a way, since the rear drum does not have any adjustment possibilities at all. A Dynapac SEISMIC machine can and does adjust both the rear and front drum simultaneously, giving an even more effective machine compared to our competitors!

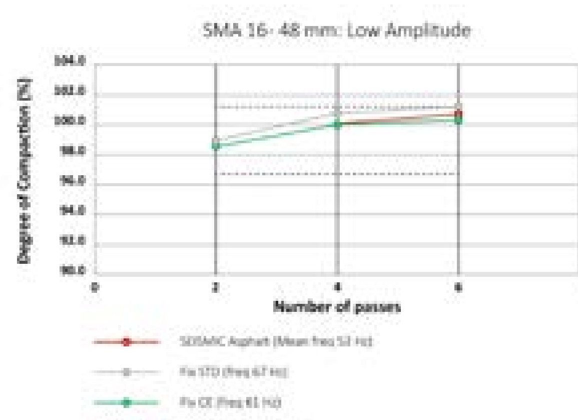

Figure 9. Degree of compaction as a function of the number of passes for a CC4000 VI with different frequency settings operated at High Amplitude (HA).


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BENEFITS WITH SEISMIC ASPHALT

Based on numerous trials and experience we can confidently claim the following benefits for a SEISMIC ASPHALT machine:

- The system is very user-friendly. You only need to select High or Low or amplitude, the machine handles the rest.
- Instead of using a complex mechanism, SEISMIC benefits from the resonance dynamics, yielding a less complex machine which requires less maintenance and with a reduced risk of costly breakdowns.
- Fuel consumption reduction around 10 % with SEISMIC active and 25 % in combination with ECO-mode.
- Significantly reduced noise levels and increased comfort.
- Reduced wear and thus increased lifetime on vibrating components.

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