

## **The Sustainable Way – Paving and Compaction Systems from Dynapac**

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The burning of fossil fuels has drastically increased the blanket of greenhouse gases around the earth. The resulting increase in global temperatures is significantly changing the complex web of systems that allow life to thrive on earth. According to forecasts by the Intergovernmental Panel on Climate Change (IPCC), the consequences could be frequently flooded coastlines, disruptions to food and water supplies, and the extinction of many species. These frightening scenarios force us to act *today* to contribute with sustainable solutions to reduce CO<sub>2</sub> emissions.

This paper deals with sustainable paving and compaction solutions from Dynapac. Furthermore, it also highlights the fact that revolutionary new technologies already exist but are not used on a large scale.

Dynapac supports the vision of the UN:

*“Sustainable development meets the needs of the present without compromising the ability of future generations to meet their own needs”*

For us, it is an absolute requirement that all new products and solutions contribute in a positive way to a more sustainable environment and a lasting, global infrastructure.

High quality products are the key for “sustainable productivity” creating a long-term value for all stakeholders.

Reducing environmental impact and at the same time increasing performance are not conflicting targets. By utilizing intelligent process control systems like the Compaction Analyzer for rollers, Safe Impact and Vario-Speed concepts for pavers, roads can be built with superior quality, high cost efficiency AND a low environmental impact.

The sustainable usage of Dynapac equipment is constantly improved and can be further optimized by using software platforms like CompBase, PaveComp and the Economic Efficiency Calculator calculating the economic benefits of our unique Compactasphalt<sup>®</sup> technology.

Additionally, the Atlas Copco group’s intention is to take environmental, ethical, economic and social responsibility. One example for social responsibility is the “Water for All” project. Water is essential for life, but billions of people suffer from limited access to this vital necessity. Water for All operates with the motto that clean drinking water is a human right and seeks to raise funds to support projects that provide clean drinking water for people in need. The organization was originally founded by Atlas Copco employees in Sweden in 1984. Today, there are local Water for All organizations in more than ten countries, all managed by Atlas Copco employees.

Water for All has helped to provide more than one million people with clean drinking water for life. This has been achieved with average monthly contributions of less than five euro per month per employee. The contributions are made on a voluntary basis and the Atlas Copco Group participates by matching employee donations. Water for All is run by Atlas Copco employees. It is the members who decide how to raise money and where to spend it. The money is used to dig or drill or protect natural springs in countries where clean drinking water is scarce. Simple techniques are preferred, most of all hand pumps. Water for All always cooperates with non-political aid organizations that run the projects and account for the money spent. Building water pumps close to villages contributes to a safer environment for women usually responsible for collecting water.

Water for All has successfully supported projects in countries like Peru, Kenya, Sudan, India, Afghanistan and China providing people with clean drinking water for life.

Dynapac is focussing heavily on sustainability throughout all the stages of the product lifecycle. Starting with the design and development process, aggressive targets are set for all new products to have reduced CO<sub>2</sub> emission levels, a higher share of recyclable components, environmentally friendly paint and so on. Also in the field of operator safety and ergonomics, we strive to constantly improve the operator platform and other working conditions for the operator. This, in turn, results in more efficient work flows and contributes to an overall improved quality in the end result.

The procurement of material is another area where sustainability is of key importance. In everything from choice of suppliers to choice of components and local sourcing, we work actively to minimize the environmental impact.

In the manufacturing of our products, we work with lean and sustainable processes and we train all employees yearly. In 2010, two days per production unit were entirely dedicated to information and training in this area. Not only the products, but also the processes must be designed in a way that consciously keeps environmental aspects and the minimization of waste in mind. Our distribution chain is constantly challenged and improved to keep transports, deliveries and packaging to a minimum when it comes to CO<sub>2</sub> emissions and waste. We train and consult our customers in order for them to utilize the equipment in the most productive and sustainable way. Approximately 90 % of the weight of each roller is recyclable.

Recycling and disposal is however an area where we are just at the beginning of our efforts. We see great potential for much more to be done and we are actively improving our processes and activities here. Also for the service & support of our products, we dedicate time to find solutions to keep emissions down and productivity high.

When we talk about innovation, we are always looking for new ways just as Henry Ford did in the beginning of the 20<sup>th</sup> century. His famous saying "*If I had asked people what they wanted, they would have said faster horses*" emphasizes the fact that sometimes we need to look at revolutionary new concepts and think "out of the box".

Dynapac's breakthrough innovation is the Compactasphalt® technology with the lowest carbon footprint taking in consideration the complete process chain.

Increasing wear, due mainly to the increase in heavy-goods vehicle traffic, has resulted in greater demands being placed on motorways and highways.

Every conventional paving method reaches its limits. Problems arise, especially in the extreme-temperatures of winter and summer. While low flexibility in winter leads to the formation of cracks, very low heat stability in summer causes the formation of ruts.

By using the innovative Compactasphalt paving method, the two upper asphalt layers are laid in one work process. Besides the fact that no bitumen emulsion is sprayed in between the two layers (as it is done in case of the conventional paving method, 0.3kg/m<sup>2</sup>), the superior interlocking between the courses increases the durability of the wearing course to the durability of the binder layer, in Germany up to 25 years. It means that no repaving is necessary once during the life cycle of the wearing course, compared with the conventional asphalt laying method, resulting in 0% CO<sub>2</sub> emission. As the wearing course has the highest bitumen content compared with subjacent layers, the halving of it also results in an additional bitumen saving of approx. 7 vol. %.

The benefit of the Compactasphalt construction method has operational and economic aspects. The operational benefit manifests itself in the effective use of personnel, technology and material. The economic efficiency is primarily related to the extension of the durability of traffic surfaces and therefore the clear reduction of the life cycle costs. [1]

Compactasphalt is also a faster paving method as the construction time is reduced by up to 50%. This allows roads to be opened to traffic sooner. Since 1988, more than 7 million square metres of roads have been built worldwide using Compactasphalt® and show no damages or deformities to date.

Laboratory and process engineering tests clearly show the main advantages of the Compactasphalt® construction method:

- Savings on material costs
- Significant extension of the time available for final compaction
- High final compaction degrees of 99% Marshall down to 0 °C ambient temperature
- Possibility to reduce the mix temperatures
- Better durability through the intensive interlocking of both layers
- Higher heat stability compared to conventional paving methods, as well as
- up to 50% less paving time [2]

This breakthrough performance not only creates savings in the governmental budget but it also reduces CO<sub>2</sub> emissions as no milling and repaving is necessary once during the life cycle of the road, compared with the conventional paving method. Economic benefit calculations based on real projects in Germany clearly emphasize this fact.

As an example, cost calculations in a project performed by the German contractor JOHANN BUNTE *Bauunternehmung GmbH & Co. KG* make the difference between the conventional and Compactasphalt paving clear. Based on the price difference between binder- and wearing course material (58,-€ / ton for binder and 88,-€ / ton for wearing course material), a total saving of 435,313 € was achieved.

	Area	Unit	Material type	Density to/m <sup>3</sup>	Thickness cm	Total material	Cost calculation €/to	Real costs €
						to		
BAB A 14	290.000	m <sup>2</sup>	Binder 0/22 S	2,33	8	54.079	58	3.136.594 €
								3.136.594 €
BAB A 14	290.000	m <sup>2</sup>	SMA 0/8 S	2,30	4	26.726	88 €	2.351.923 €
						<b>80.806</b>		2.351.923 €
BAB A 14	290.000	m <sup>2</sup>	tack coat				<b>0,15</b>	<b>43.500 €</b>
<b>Total material cost standard paving</b>								<b>5.532.017 €</b>
BAB A 14	290.000	m <sup>2</sup>	Binder 0/22 S	2,33	10	67.599	58 €	3.920.742 €
	290.000	m <sup>2</sup>	SMA 0/8 S	2,30	2	13.363	88 €	1.175.962 €
						<b>80.962</b>		5.096.704 €
BAB A 14	290.000	m <sup>2</sup>	NO TACK COAT					<b>0 €</b>
<b>Total material costs Compactasphalt</b>								<b>5.096.704 €</b>
<b>Material profit:</b>								<b>435.313 €</b>

**Figure 1 – Highway Project Calculation, A14 [3]**

Based on the fact that a Compactasphalt pavement does not require bitumen emulsion to be sprayed on the binder surface, in our example 290.000 m<sup>2</sup>, the company saved **43,500 €**, which is part of the total saving regarding material cost.

This calculation considers only material cost advantages. As a matter of fact, in case of Compactasphalt paving, contractors have also more positive economic effects:

- Up to 50% reduced paving time results in up to 50% less working hours for the crew to be paid by the contractor
- Reduced need for personnel: Only one paver crew is needed for two layers
- The final compaction of both layers is carried out in one work process.

Furthermore, we need to highlight that in case of a PPP project the company would have also saved the renewing of the wearing course once during its life-cycle. In Germany, for the renewing of the wearing course per square meter (including milling, repaving, material and personal costs) 11 € per square meter are calculated, i.e.:

$$290,000 \text{ m}^2 \times 11 \text{ €} = \mathbf{3,190,000 \text{ €}}$$

The savings arising from the high quality of the pavement are either on the local Government's side or it will be the benefit of the contractor when he will be the private operator of the road. (Public Private Partnership)

Besides economic considerations, the sustainability aspect here is obvious, resulting in the saving of costly natural resources:

- 50% less high quality aggregates were required (13 tons vs. 26 tons)
- 87 tons of bitumen emulsion is also saved as there is no need to spray bitumen emulsion between the asphalt courses (290,000 m<sup>2</sup> x 0.3kg)

The high quality of Compactasphalt results in significantly lower CO<sub>2</sub> emissions due to the increased durability of the wearing course compared with conventional pavements.

Furthermore, in case of an asphalt jobsite, a more holistic view is necessary to analyze CO<sub>2</sub> emissions throughout the process chain. As rolled asphalt is a three phase system consisting of aggregates, bitumen and air void content, we need to take in consideration the CO<sub>2</sub> emissions during

1. Mixed good production:
  - a) Oil production
  - b) Quarrying of aggregates
  - c) Breakers
  - d) Asphalt mixing plant
2. Machine usage: Milling & Repaving activities compromising
  - a) Planer(s),
  - b) Paver(s) and
  - c) Roller(s)
3. Repaving activities
  - a) Road closures result in traffic jams (higher CO<sub>2</sub> emissions by cars)
  - b) Channelization of traffic causes more damage to the traffic lane where the traffic is running. Additionally, standing traffic creates a high vertical load.

When we take in consideration that approximately 90-95% of the primary energy consumption as well as CO<sub>2</sub> emissions are generated during the mixing process in the asphalt mixing plant, laying quality becomes very important.

The remaining 5%-10% of CO<sub>2</sub> emissions are shared between transportation, paving and compaction.

According to AMMANN, 50kg CO<sub>2</sub> emission is discharged for producing 1 ton asphalt mix. This 50kg CO<sub>2</sub> emission is divided in "direct" and "indirect" CO<sub>2</sub> emissions. Indirect emissions are discharged during the production of bitumen, aggregates and electricity. Direct emissions arise from the asphalt plant when producing asphalt. [4]

In contrast, let us calculate the emissions of an hypothetical asphalt jobsite.

We assume one SD2500CS paver with a practical paving capacity of 350 tons per hour, four 8 tons rollers and 13 trucks circulating between the jobsite and asphalt mixing plant. We assume that we pave a 10 cm thick binder course with a total working width of 8 meters.

The paver is equipped with a 142 kW Cummins QSB6.7-C190 Tier 3 engine.

Machine type	Amount	350 tons, 8m, 10cm	Working hour	Diesel consumption / hour
	no.	Machine type	h	h/l
Paver	1	SD2500CS	1	26
Roller	4	8t Roller / Compaction	1	11
Trucks	13	Truck / Transport	1	25

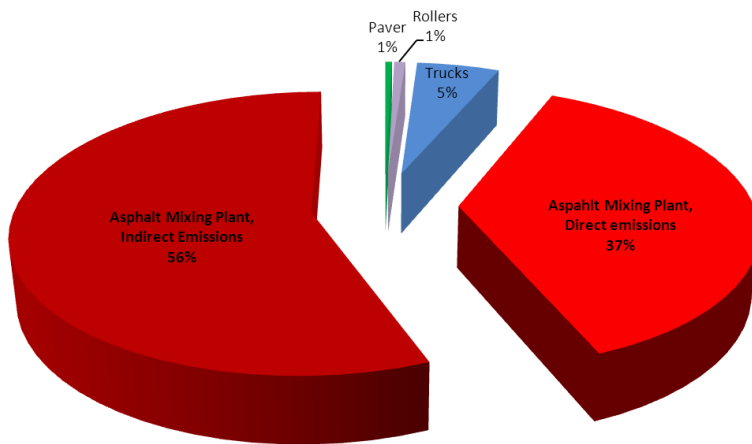
The diesel consumption for the paver is calculated with 26l per hour. We assume a 75% working condition without considering fuel saving equipments as *vario-speed* or *eco-mode*. The consumption of the roller is calculated with an average of 11 l per hour, the diesel consumption of the trucks with 25l / hour.

The CO<sub>2</sub> emission for burning one liter diesel causes 3.06 kg CO<sub>2</sub> emission, based on the figures from the German Federal Environmental Agency (Umweltbundesamt). [5]

Diesel consumption total	Diesel CO <sub>2</sub> emission	Total CO <sub>2</sub> emission
l	kg CO <sub>2</sub> / l	kg CO <sub>2</sub>
26	3,06	79,56
44	3,06	134,64
325	3,06	994,5

Paving capacity	CO <sub>2</sub> Emission
to / h	kg CO <sub>2</sub> / paved asphalt ton
350	0,227314286
	0,384685714
	2,841428571
<b>Total</b>	<b>3,45</b>

According to the calculation, the total CO<sub>2</sub> emission on our imaginary jobsite contributes only 7% to the total CO<sub>2</sub> emissions in comparison with the upstream process chain, e.g. direct and indirect CO<sub>2</sub> emissions caused during asphalt production. In case of different jobsites the CO<sub>2</sub> emissions will of course vary, it can be more or less as in our example but still: It will be only the smallest part in the process chain.



**Figure 2 – CO<sub>2</sub> emission analysis in the process chain**

Knowing this fact, the quality of the end-result (asphalt pavement) is of vital importance. Increasing quality means decreasing of CO<sub>2</sub> emissions!

With the Compactasphalt paving method, we are able to adapt the durability of the wearing course to the durability of the binder course. In Germany, it means a total durability of 25 years. The planned theoretical durability of the wearing course in Germany for a conventional asphalt pavement is 15 years.

This means that in case of a Compactasphalt pavement, the renewal of the top layer is not required after 15 years, compared with the life cycle of a conventional pavement.

This results in tremendous economic savings, as well as 0% CO<sub>2</sub> emissions caused by the process chain.

Compactasphalt is a revolutionary paving method with considerable potential of CO<sub>2</sub> emission savings world-wide. Road authorities and governments shall subsidize and encourage the use of innovative technologies having a great impact on the process chain (holistic view) instead of solely focusing on the CO<sub>2</sub> emissions of road building machinery.

Furthermore, the mixed good temperature can be lowered at 10-15° due to the enormous heat capacity of both layers. Lowering the mixed good temperature will also result in CO<sub>2</sub> savings in the asphalt mixing plant.

The superior quality of Compactasphalt® pavements has been documented by Universities and Road Authorities in Germany as well as in the USA by the NCAT test facility.

Dynapac got the opportunity to install twin layer OGFC in the summer of 2006 for testing purposes on the NCAT test facility in Auburn, Alabama.

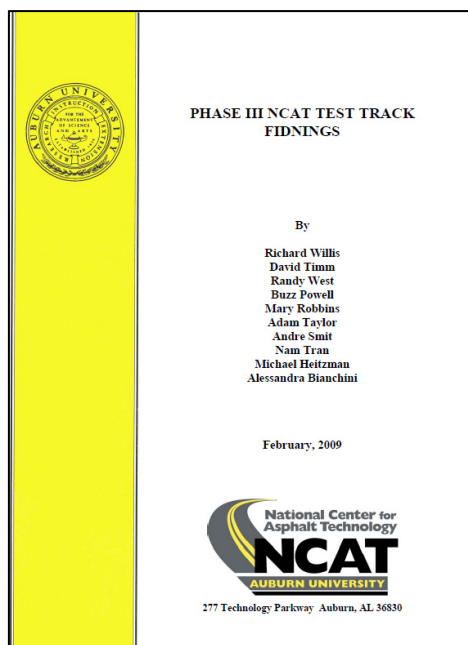
According to literature published by the National Center for Asphalt Technology (NCAT), the NCAT Pavement Test Track is a unique accelerated pavement-testing facility that unites real-world pavement construction with live heavy trafficking for rapid testing and analysis of asphalt pavements. It is funded and managed as a cooperative project among highway agencies and industry sponsors.

The track is a 1.7-mile oval with 46 different 200-ft test sections that are sponsored on three-year cycles. Each sponsor has specific research objectives for their section(s) and shared objectives for the track as a whole. Three cycles have been completed since the test track opened in 2000, and a fourth cycle will end in 2011. The planning process is currently underway for the fifth research cycle, which will be built in the spring and summer of 2012.

The track sections are exposed to a fleet of heavily loaded tractor-trailers that circle the track five days per week for 16 hours per day, applying 10 million equivalent single-axle loads (ESALs) to the pavements during each three-year research cycle. Pavement performance within each section is continuously monitored to evaluate rutting, fatigue cracking, roughness, texture, friction and noise. At the end of each cycle, test sections either remain in place for additional evaluation during the next cycle or are replaced, as determined by the section sponsor.

Test sections can be classified as either surface mix performance sections, which are built on a robust cross-section that limits distresses to the experimental surface layers, or as structural sections of different thicknesses that more closely resemble real-world pavements.

Structural pavement sections have embedded strain and pressure sensors to analyze pavement response to loads for validation of mechanistic-empirical pavement design procedures. All sections are also equipped with temperature sensors throughout the pavement depth. Construction materials are often long-hauled from other states as required by sponsors in order to build 200-ft test sections that are truly representative of sponsors' roadways.



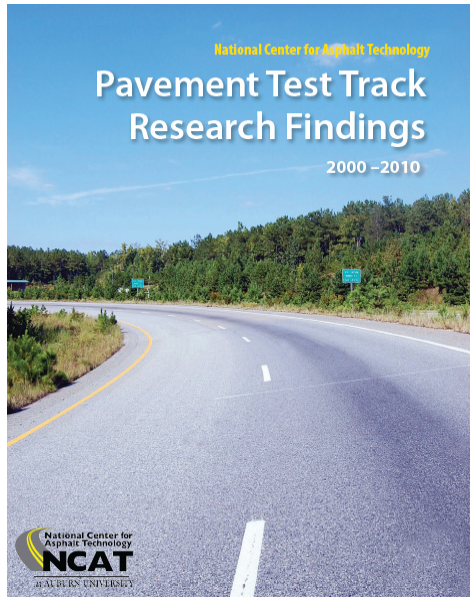
### Figure 3 – Phase III NCAT Test Track Findings

In February 2009, NCAT issued the “Phase III Test Track Findings”, officially attesting the superior quality of the test section N13, paved with Dynapac’s “twin-layer” Compactasphalt<sup>®</sup> paver.

At this point, the Phase III test sections had received 10 million ESALs (Equivalent Single Axle Load) of traffic.

*“The Georgia Department of Transportation (GDOT) funded construction and testing in sections N11, N12 and N13 to compare the construction and performance of permeable surface mixes containing two different aggregate sources that were placed with conventional and dual layer paving equipment. While all sections were constructed well, the section placed by the dual layer paver seemed to be the most effective in terms of drainage and noise reduction.” [6]*

Even more impressive is the actual state of the N13 section today, after 19 million ESALs.



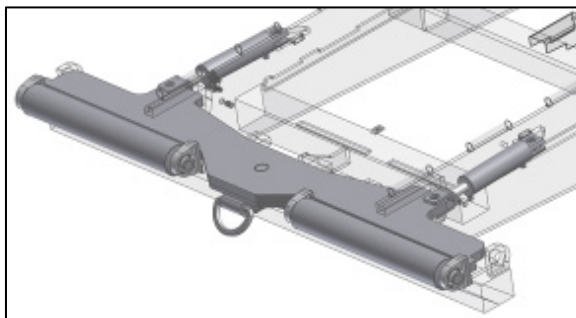
**Figure 4 – Pavement Test Track Research Findings 2000-2010, National Centre for Asphalt Technology [7]**

Dr. Buzz Powell, Assistant Director of NCAT, described the superior quality of the Compactasphalt section: *“One of the most interesting test sections on the track has been the twin-layer OGFC placed in 2006. This section has a 9.5 mm nominal maximum aggregate size (NMAS) OGFC surface layer on top of a 12.5 mm NMAS OGFC layer. Both OGFC layers were placed with a special paver built specifically to simultaneously place two HMA layers. “After five years (and 19 million ESALs) the twin-layer OGFC surface continues to be the quietest and most effective section at eliminating water spray on the track. “*

NCAT’s results regarding the N13 section are absolutely in-line with the latest official German research results. In December 2010, the Technical University of Darmstadt published a study on the very first Compactasphalt pavement with a modular paver in Germany on the A7 Highway between Kassel-Hattenbach. This very first 4.1 km long (25.000m<sup>2</sup>) Compactasphalt section was paved in 1998. After 13 years, it does not show significant deformities. Furthermore, no repair works were necessary although it was paved under unfavourable weather conditions (temperatures between -1°C and 5°C). The section is under heavy-load from day one, with 66,754 cars / day, with a heavy-traffic ratio of 21.1%. [8]

The innovative Compactasphalt technology offers an enormous potential for saving CO<sub>2</sub> emissions world-wide and shall be a standard solution in the future building our green highways.

Besides Compactasphalt, Dynapac is also focusing on CO<sub>2</sub> emission reductions on conventional pavers by using advanced and intelligent systems as the *Vario Speed* concept (improved eco-mode), load-sensing hydraulics as well as intelligent cooling systems. As a perfect interaction of all advanced systems in our pavers, a fuel saving up to 20% is achievable compared with predecessor models.

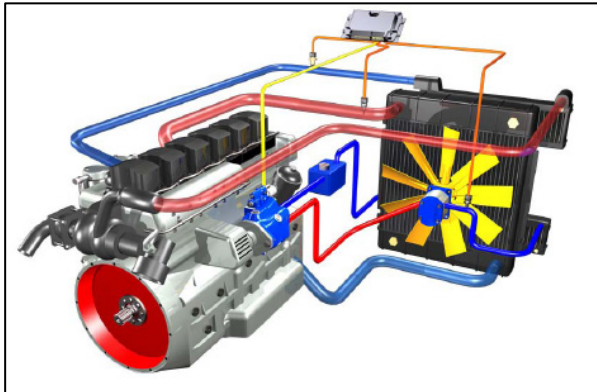


**Figure 5 – Hydraulic push rollers, the patented “Safe Impact System”**

Superior paving quality is also ensured - even in case lorries bump heavily in the paver – by using the patented Safe Impact Device, a hydraulically extendable push roller that actually acts as a shock absorber.

The new 2.55m tracked paver class is equipped with the Cummins 6.7 engine with improved fuel efficiency and cold-start performance. The pavers are designed in a way that they are fully prepared for the Tier 4 interim respectively Tier 4 final engines.

Besides the so called “Eco-mode” (reduction of the engine RPM to a preset value) Dynapac offers the optional *Vario Speed* concept. *Vario Speed* works in a way that concept sensors recognize the demand of power and a computer controls the engine speed infinitely, resulting in low fuel consumption and less noise.



**Figure 6 – Thermostatically controlled fan: Basic feature on all Dynapac SD pavers**

The fan is separated from the diesel engine, resulting in reduced fuel consumption, noise reduction (cold-start) and more rated output. The electronic motor management activates the fan only when required.

Often considered as “old-fashioned”, gas heated screeds for the paver also offer significant CO<sub>2</sub> emission savings.

Pavers are equipped with electric or gas-heated screeds. Our company deliberately leaves the choice of the heating system to the client, as preferences often play a key role in this decision. The majority of energy is used to heat up the screed before paving operation starts. Under normal operating conditions, it occasionally requires brief reheating depending on paving conditions.

Investigations of Utterodt reveal the fact that gas heated screeds show an approx. 65% reduction of CO<sub>2</sub> emissions compared with electrically heated screeds. [9]

When it comes to sustainable, innovative product development and ergonomics, compaction equipment from Dynapac is in the forefront. The company now presents the first completely battery driven roller of its type, the conceptual CC900E.

The new roller offers many benefits. In addition to being diesel fumes emission free, it is very quiet in operation and offers the same compaction performance as its diesel-driven counterpart, the CC900. Twin electric drive motors ensure comfortable, smooth travel and, together with electric vibration motors, generate high-quality compaction results.

For normal tasks, the CC900E electric roller will work for a full day on one charge and can be recharged simply overnight. Thanks to its very low noise level and exhaust-free drive this machine is also ideal for indoor tasks and work in noise-sensitive environments.

The Dynapac CC900E is very simple to maintain with just a few, easily accessible service points. Not yet in serial production, the Dynapac CC900E is being evaluated by customers in the field during spring 2011. Using the European average for CO<sub>2</sub> emissions per generated kWh the reduction is 65 % compared to a diesel powered CC 900. If you do the same calculation for electricity generated in Sweden the reduction is 97%.

We have also compared CC224HF/CC234HF with the predecessors CC222HF/CC232HF and found out that we managed to lower the fuel consumption with as much as 24%.

The CO<sub>2</sub> emissions go down with the same percentage. The comparison was done under the same circumstances and the same working cycle.

The diesel engine that we used in the CC222HF and CC232HF was always considered to be rather descent in terms of fuel consumption. Therefore, the low fuel consumption is not a result of changing from an old inefficient diesel engine to a new modern one.

We went away from a very energy consuming vibration valve for the vibration system and instead we used two vibration pumps, one for each drum, and just simple on/off valves on each pump to make it possible to choose front drum vibration, rear drum vibration or both drum vibration. We got rid of as many orifices as possible by using less angled adapters for the hydraulic hoses and we made the cooling fans hydraulically driven and the thermostat regulated to make sure that we do not spin the cooling fans more than necessary. Thereby we kept the energy consumption lower because a fan that is directly connected to the diesel engine will consume a lot of energy never mind if you need the cooling effect or not. At cooler temperatures this also made the hydraulic system and the diesel engine reach the correct working temperature faster and we also got less noise.

The CC722 is the largest Dynapac asphalt roller, offering great compaction performance. It is also the first Dynapac roller to have the Tier4i / Stage IIIB engine, using Cummins as the engine supplier. The CC722 is equipped with the Cummins QSB 6.7 engine with 164 kW/ 220 hp. For this power rating the Tier 4i/ stage IIIB was valid from 1st of January 2011 within EU and North-America. The Cummins engine in the CC722 uses the Diesel Particle Filter Technique (DPF) to get the Particulate Matter (PM) down from 0.2 to 0.025 g/kWh which is a substantial decrease in percent. The Tier 4i/ Stage IIIB will also have substantial lower values for nitrogen oxides and hydrocarbons.

Apart from improved machine technology, optional documentation systems on our rollers ensure a decrease in diesel consumption and at the same time significantly increase compaction quality.

The Dynapac Compaction Analyzer for Asphalt (DCA-A) gives support for the following:

- Register the number of passes (static / vibratory)
- Measure and register the surface temperature (calculate core temperature)
- Graphic display of the temperature and the number of passes (real time in the roller)
- Documentation of the compaction process
- Background material for the quality analysis
- Support for continuous improvements of the paving process, rolling patterns and overall compaction results

The roller operator will get answers for the following questions:

- Where have I been with my roller?
- How many passes did I make and were they static or vibrating passes?
- What was the temperature?

A similar DCA system is also available for soil (DCA-S) where the roller operator gets answers for the same questions but instead of measuring the temperature, we measure the compaction showing the Compaction Meter Value (CMV).

The new hand-held compaction control system, *CompLogger* is introduced by Dynapac as a soil compaction analyzer providing the customer with a real time image of compaction over the entire surface to be compacted. This easy to use gadget can be used for production planning and throughout compaction. Furthermore, the data can also be saved for future quality control and evaluation. Based on Dynapac's existing Compaction Meter and Compaction Analyzer, the new hand-held system is thought to be an industry 'first' and features a rugged PDA and wireless data transfer technology. The new hand-held facility is an easy to use, simplified version of the fully comprehensive Dynapac Compaction Analyzer System (DCA) which nevertheless allows the operator to continuously read a direct feedback of the compaction results: Enhancing the operator's efficiency and compaction performance. It is able to accommodate and evaluate a wide spectrum of parameters. These include rolling direction, rolling speed, vibration frequency and amplitude as well as the Compaction Meter Value (CMV) as measured by the roller.

The sustainable usage of Dynapac equipment is constantly improved and can be further optimized by using application software platforms like *CompBase* and *PaveComp*.

*PaveComp* is based on several practical tests with Dynapac rollers on a lot of different asphalt mixes. It contains enormous amounts of information regarding compaction performance. This information is used to optimize the rolling pattern and amplitude settings for maximum compaction performance. The software also provides accurate cooling time data as a base for the rolling pattern and machine requirements together with dimensional data for the job at hand.

The output from *PaveComp* includes the following information:

- Paving speed
- Screed settings
- Cooling time
- Number of rollers needed
- Number of passes
- Amplitude settings
- Number of laps

These application software platforms are available for all users of Dynapac equipment.

The target of drastically reduced CO<sub>2</sub> emissions in road building can only be achieved if all related industries are contributing with their state-of-the-art technologies. As a matter of fact, creating innovative solutions require costly research and development activities. New products and technologies are only sustainable from the point of view of a manufacturer if capital intensive innovations are used on a large scale.

In this respect governments and local road authorities play a key-role to remove barriers and encourage the usage of innovative technologies building our green future.

## Appendix:

- [1] Utterodt, R., Egervári, R.: *Effectiveness of the Compactasphalt® Technology*,  
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Roland Egervári, Sales Support Manager Compactasphalt®, Wardenburg  
Christina Bergquist, Environmental Manager, Karlskrona  
Lars Lundahl, Product Manager Roller, Karlskrona