Optimising cement packaging

Improving efficiency, sustainability and worker safety is paramount for cement producers. To identify the packaging solution with the greatest impact on these aspects, CEPI Eurokraft commissioned a comparative laboratory study that evaluated paper cement sacks and woven polypropylene (WPP) alternatives in terms of filling speed, product loss, dust emissions and carbon footprint. Across all key metrics, paper sacks were found to deliver superior performance.

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In the cement industry, packaging is often considered a mere commodity, with decisions primarily driven by cost and logistical factors. However, the choice of packaging can significantly influence key performance indicators such as filling speed, product loss and environmental footprint. Recognising this, CEPI Eurokraft commissioned a comprehensive laboratory study to compare the technical performance of paper cement sacks and WPP sacks. For all test set-ups, 50kg flush-cut valve paper sacks and WPP sacks were used. The paper sack consisted of two unperforated, high-porosity paper plies, while the WPP sack used a polypropylene layer with lamination and perforations for air release. (For full sack specifications, see Table 1.)

Paper sacks show a superior performance compared with WPP sacks

Optimising filling speed

Higher filling speed in cement production means better output, fewer bottlenecks and lower packaging costs. To assess the performance differences, CEPI Eurokraft conducted a laboratory test. A Haver & Boecker single-spout impeller packer was used to fill Portland cement from Heidelberg Materials (density 1400kg/m^3, Blaine value 4132cm^2/g).

Paper sacks fill 21% faster

On average, the paper sacks took 9.6s to fill up with 50.4kg of cement and the WPP sacks took 12.2s to fill up with 50.2kg of cement. This represents a 21 per cent speed advantage for the paper sacks. The difference is largely due to the natural porosity of paper. Highly porous paper sacks allow the air to escape rapidly during filling without having to use the complex or costly air extraction systems required for WPP sacks. With paper sacks, the machinery is therefore easier and quicker to set up and maintain, reducing downtime and costs. For cement producers aiming to boost throughput and efficiency on the packing line, paper sacks represent a cost-efficient solution.

Table 1: sack specifications

Specification	Paper sack	WPP sack
Material	Two plies of high-porous paper: inner ply 80gsm brown outer ply 90gsm white	63gsm PP 22gsm PP lamination
Air escape system	Unperforated	Perforated
Type	Flush cut valve sack	Flush cut valve sack
Length x width (mm)	630x500	630x500
Top/bottom width (mm)	110	110
Volume (l)	35.8	35.8
Air flow test (Mega Gurley) at 50mBar (Nm^3/h)	125	90

Minimising product loss

Building upon the efficiency advantages, the study also examined product loss during handling and transportation, which not only leads to material waste but also increases costs and environmental impact. To quantify the losses, CEPI Eurokraft conducted a second laboratory study. First, the study investigated cement losses during filling. After each filling, the wasted cement particles were collected on a sheet

Table 2: cement losses during filling		
Sample	**Cement loss paper sack (g)**	**Cement loss WPP sack (g)**
1	0.12	0.91
2	0.02	1.01
3	0.24	0.95
4	0.07	1.01
5	0.75	0.85
Mean value	**0.24**	**0.95**

Table 2: cement losses during handling in supply chain		
Sample	**Cement loss paper sack (g)**	**Cement loss WPP sack (g)**
1	1.00	9.00
2	3.00	8.00
3	0.00	8.00
4	4.00	11.00
5	3.00	7.00
Mean value	**2.20**	**8.60**

"Reducing cement losses is not only essential for productivity, equipment longevity and plant cleanliness, it is critical for workers' health as cement contains hazardous minerals such as chromium and silica."

and weighed. Second, typical supply chain handling and transport were simulated by subjecting both sack types to five consecutive drops from a height of 90cm.

WPP sacks cause four times higher cement loss

During the filling phase, paper sacks lost an average of 0.24g of cement per unit, whereas WPP lost approximately 0.95g – nearly four times as much. In drop tests the disparity was similar: paper sacks lost around 2.2g, while WPP sacks lost about 8.6g. This indicates significantly higher product loss with WPP sacks. The leakage in WPP sacks occurred across their entire surface, leading to contamination along the supply chain. Such product loss also contributes to increased machine maintenance, longer downtimes for cleaning, and greater health and safety risks for workers and the environment.

From laboratory to industry scale

When scaled to a production volume of 1Mta of cement, these losses become substantial: 44t of cement are lost using paper sacks versus 172t using WPP sacks. Therefore, switching to paper sacks could prevent the loss of approximately 128t of cement/1Mt produced, translating into a reduction of around 104t of fossil-based CO_2 emissions. This shift is particularly important given the energy-intensive nature of cement production as it would improve both economic efficiency and environmental impact.

Reducing dust emissions

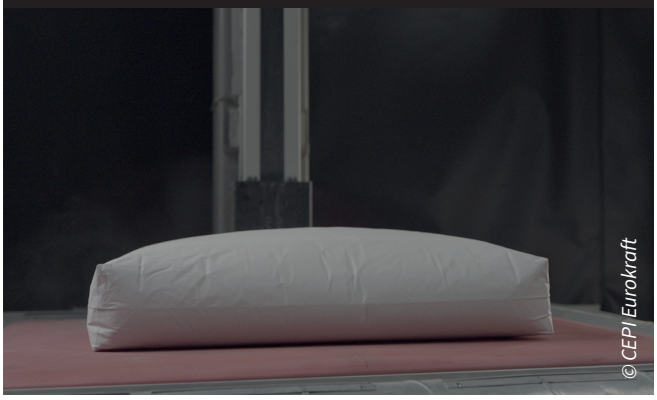
Reducing cement losses is not only essential for productivity, equipment longevity and plant cleanliness, it is critical for workers' health as cement contains hazardous minerals such as chromium and silica. To assess the role of sack types in dust development, CEPI Eurokraft commissioned another laboratory test comparing dust emissions during the filling of 50kg cement in the two packaging types. The study was carried out under the oversight of the Austrian Dust and Silicosis Control Centre (Österreichische Staubbekämpfungsstelle – ÖSBS). It measured particulate matter (PM) emissions, focusing on PM10 and PM2.5 particles. PM10 particles can irritate the skin, eyes, nose and throat, affecting both the skin and the upper respiratory tract. PM2.5 particles can penetrate deep into the lungs and trigger coughing, asthma and lung inflammation. Studies have found increased depression, anxiety and higher stress levels in people who are exposed heavily to cement dust. The test procedure included a direct measurement with an aerosol spectrometer, and a sampling process with gravimetric analysis in the ÖSBS accredited laboratory.

Two to three times less dust from paper sacks

The analysis shows that when compared with paper sacks, WPP sacks generate significantly more dust: three times more PM10 and twice as much PM2.5. The WPP sacks tested exhibited higher internal pressure during filling, which caused excessive cement leakage through the perforations and all over the sack surface. In contrast, the natural porosity of paper sacks retains the fine cement particles

Paper sacks can be filled faster than WPP sacks thanks to their high porosity, which was measured using an indication of air flow analysed with the Mega Gurley test

Paper sacks show only little product loss during filling and handling



WPP sacks lose four times more cement during filling and handling than paper sacks

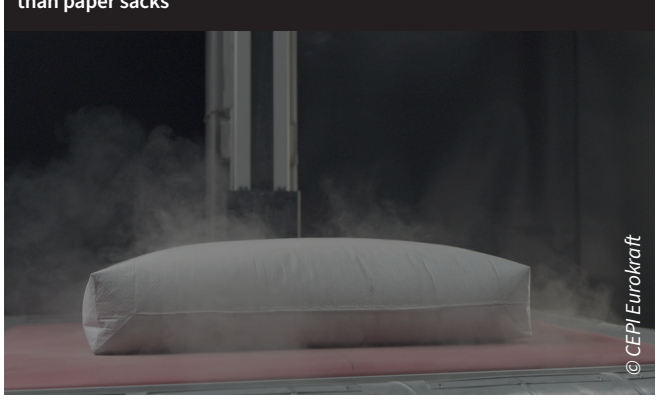
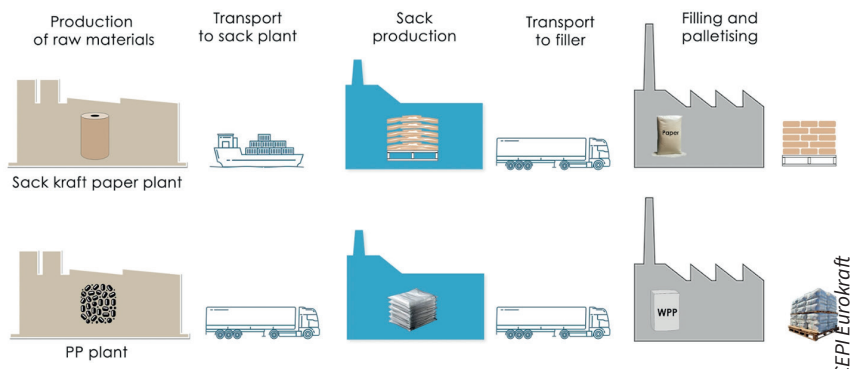


Figure 1: cradle-to-filler-out-gate approach: the study measured emissions from raw material extraction to the point when sacks are filled and ready for dispatch



inside the sack while enabling air to escape fast through the body of the sack. Reducing dust emissions improves workplace safety and reduces the need for frequent equipment maintenance and cleaning, resulting in cost savings and enhanced operational efficiency.

Comparative carbon footprint analysis of cement sacks

Besides the CO_2 emissions that can be attributed to cement losses, CEPI Eurokraft commissioned a comprehensive study conducted by the Research Institutes of Sweden (RISE) to assess the environmental performance of paper sacks versus WPP sacks. The study employed a cradle-to-filler-out-gate approach which examines the entire process: from producing all raw materials, transporting them to the sack plant, converting them into sacks and delivering the sacks to fillers, to filling them with cement and palletising the filled sacks for further distribution (see Figure 1). The study focussed on the fossil-based global warming potential (GWP) of both packaging types, adhering to ISO 14040/14044 standards. It analysed the

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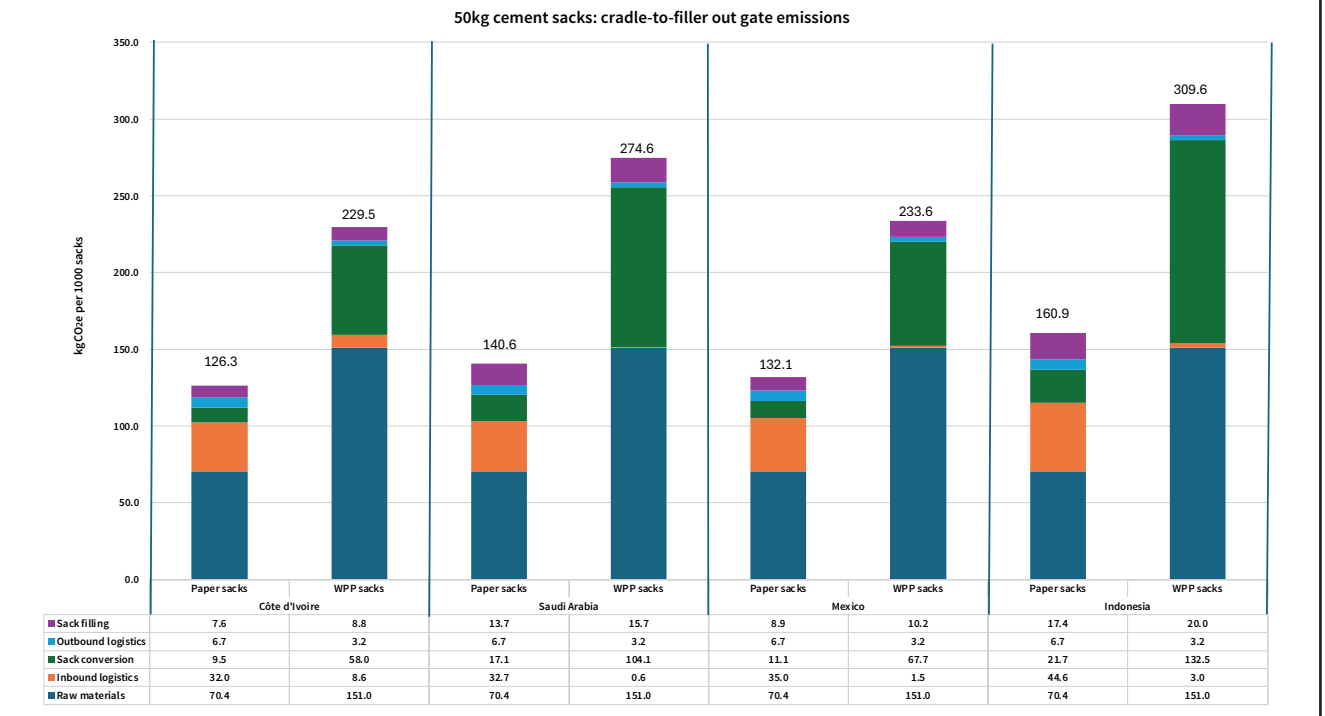
The natural porosity of paper sacks, retains the fine cement particles inside the sack while the air can escape during filling

WPP sacks caused 2-3 times higher dust development compared to paper sacks

Figure 2: cradle-to-filler out gate emissions for paper sacks and WPP sacks



	Côte d'Ivoire		Saudi Arabia		Mexico		Indonesia	
	Paper sacks	WPP sacks	Paper sacks	WPP sacks	Paper sacks	WPP sacks	Paper sacks	WPP sacks
Sack filling	7.6	8.8	13.7	15.7	8.9	10.2	17.4	20.0
Outbound logistics	6.7	3.2	6.7	3.2	6.7	3.2	6.7	3.2
Sack conversion	9.5	58.0	17.1	104.1	11.1	67.7	21.7	132.5
Inbound logistics	32.0	8.6	32.7	0.6	35.0	1.5	44.6	3.0
Raw materials	70.4	151.0	70.4	151.0	70.4	151.0	70.4	151.0

Source: CEPI Eurokraft

"Even though sack kraft paper is produced in Europe and transported to all four target markets for conversion, paper sacks retain a lower environmental footprint. The analysis shows that, across all studied markets, paper sacks generate approximately half the GWP of WPP sacks."

life cycle of cement sacks in four countries, each representing a specific market: Côte d'Ivoire (Africa), Saudi Arabia (Middle East), Mexico (Central America), and Indonesia (southeast Asia). These countries were selected to reflect diverse regional conditions and supply chain dynamics.

Two times higher CO_2 emissions from WPP sacks

Even though sack kraft paper is produced in Europe and transported to all four target markets for conversion, paper sacks retain a lower environmental footprint. The analysis shows that, across all studied markets, paper sacks generate approximately half the GWP of WPP sacks (see Figure 2). The lower overall carbon footprint offsets the higher transport-related emissions associated with the greater weight and longer supply chain of paper sacks. When including the average cement loss during filling and handling, the environmental gap between paper sacks and WPP sacks increases even further. Per 1000 units, emissions increase by 2.0kg CO_2e for paper sacks versus 7.7kg CO_2e for WPP sacks.

Overall environmental advantages of paper sacks

Two main factors account for the environmental advantage of paper sacks over WPP alternatives. Firstly, paper sacks are produced from renewable raw materials sourced from sustainably managed forests, whereas WPP sacks are made from fossil-based polypropylene. Secondly, the production of paper sacks is less energy-intensive, and a significant proportion of the energy used comes from renewable sources.

These aspects contribute to a lower carbon footprint throughout the overall packaging lifecycle. In addition to regulatory compliance, reducing fossil-based emissions can lower operating costs, improve resource efficiency and contribute positively to the corporate reputation – factors that are increasingly relevant in an energy-intensive industry such as cement production.

"Packaging decisions affect not only operational efficiency but also product preservation, workplace safety and environmental performance."

Packaging choice as a driver of performance and sustainability

The CEPI Eurokraft study highlights the strategic role of packaging in cement operations. Packaging decisions affect not only operational efficiency but also product preservation, workplace safety and environmental performance. In all key performance areas evaluated – including filling speed, product loss, dust emissions and carbon footprint – paper sacks consistently outperformed WPP alternatives. These findings underline the potential of paper sacks to contribute to both economic and environmental optimisation in an increasingly efficiency-driven and sustainability focussed cement industry. ■