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European Producers of Sack Kraft Paper and Kraft Paper

PROJECT REPORT

Comparative analysis of the technical properties and performances of paper sacks vs. woven polypropylene sacks

A lab study with 50 kg cement paper sacks and woven polypropylene (WPP) sacks intended for markets in Africa, Middle East, Southeast Asia, Mexico and Central America.

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Content

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Overview

This project compared the technical performances of pasted block-bottom valve sacks made from high-porosity paper and from laminated woven polypropylene (WPP), intended for the cement industry in the following regions/countries: Africa, Middle East, Southeast Asia, Mexico, and Central America.

The workgroup identified numerous aspects where the two packaging solutions differ from each other, and a lab study confirmed these differences.

To have robust and trustworthy results for the environmental comparison, CEPI Eurokraft commissioned RISE (Research Institute of Sweden) to conduct a comparative carbon footprint study, which was then third-party reviewed.

This project report details the identified differences between paper sacks and WPP sacks.

Summary

The report highlights the numerous advantages of using paper sacks over woven polypropylene (WPP) sacks for packaging cement, focusing on cost, efficiency, environmental impact, and health and safety aspects.

- A lab test demonstrated that the tested paper sacks are filled 21% faster with cement than the tested WPP sacks. This makes paper sacks a highly cost-effective solution for cement brand owners. Additional advantages with paper sacks are no need of extra complex and costly air extraction systems to keep the high filling speed. To add to that, machine set-up and maintenance for paper sack filling machines are quicker, resulting in further lower operational costs.

- In addition, a lab study verified that cement losses from filling and handling afterwards (simulated by five drop tests from 90 cm height) were four times higher for WPP sacks than paper sacks. According to the study, 44 tons of cement per million tons produced are lost when using paper sacks, while 172 tons are lost with WPP sacks. By switching to paper sacks, this would result in a saving of 128 tons of cement per million tons produced. Since cement production is a greenhouse gas (GHG) emission-intensive industry, this reduction would also translate into a saving of 104 tons of CO2e per million tonnes of cement produced.

- Dust in the form of PM10 and PM2.5, was measured during a filling lab study. The emitted dust from WPP sacks were 2-3 times higher compared to the dust emitted from the paper sacks. Cement dust often contains various types of chemicals and minerals in addition to lime and silica, such as calcium, aluminum, chromium and iron, and such chemicals/minerals cause different health complications and pathogenesis in addition to respiratory disorders including asthma, airway inflammation and lung infections.

- The surface friction of WPP and paper sacks appeared to be similar according to the conducted lab test. Surface friction is important due to loading security (sacks laying more stable when they are palletized and transported) as well as the handling of single sacks in the value chain.

- A comparative Carbon Footprint study demonstrates the total fossil-based global warming potential for WPP sacks is approximately twice as high as for paper sacks when packaging 50 kg of cement.

Conclusion

Paper sacks offer significant advantages over WPP sacks, including higher productivity, reduced environmental impact, faster filling times, and enhanced health and safety conditions. Their sustainability credentials and efficiency make them a superior packaging solution for cement.

Filling speed lab study

CEPI Eurokraft organized a lab test to compare the speed of filling cement into a paper sack and a WPP sack. A Haver & Boecker single spout impeller packer at the Billerud Packaging Development Center in Karlsborg, Sweden, was used.

Persons present at Billerud lab tests

Robert Zakrisson, Technical Service Manager Sack, MF and FibreForm, Business Area Paper - Billerud
Mattias Wintervidd, Laboratory technician PDC - Billerud
Elin Gordon, Secretary General - CEPI Eurokraft
Erik Wernerlich - Fotograf Wernerlich AB

Specifications

The Portland cement, from Heidelberg Materials in Slite, Sweden, had a density of 1,4 kg/l and Blaine value of 4 132 cm^2/g.
Note: Paper is suited also for higher cement Blaine values.

The packaging types and their specifications, see table 1.

Table 1. *Packaging types and specifications.*

Specification	Paper sack	WPP sack
Material:	2 plies high-porous paper: inner ply 80 gsm brown, outer ply 90 gsm white	63 gsm PP 22 gsm PP lamination
Air escaping system:	Unperforated	Perforated
Type:	Flush cut valve sack	Flush cut valve sack
Length x Width (mm):	630 x 500	630x500
Top/Bottom width (mm):	110	110
Volume (l):	35,8	35,8
Air flow test (Mega Gurley) at 50 mBar (Nm3/h):	125	90

Test methodology

A total of five samples per packaging type were tested. The first two samples for each packaging were not taken into consideration, as was the recommendation from machine supplier (the equipment is not ramped up correctly and the figures do not reflect reality). For the three remaining samples, an average value was calculated.

Result

The result shows that the tested paper sacks are filled 21% faster than the tested WPP sacks with this machine setup.

On average, the paper sacks took 9,6 seconds to fill up with 50,4 kg cement, and the WPP sacks took 12,2 seconds to fill up with 50,2 kg cement. See details in table 2.

Table 2. *Filling time.*

Filling time (seconds)		
Sample	Paper sack	WPP sack
3	9,55	12,02
4	9,74	11,37
5	9,62	13,23
Mean value	9,6	12,2

Conclusion

The tested paper sacks are filled 21% faster with cement than the tested WPP sacks. This makes paper sacks a highly cost-effective solution.

Additional advantages with paper sacks are no need of extra complex and costly air extraction systems to keep the high filling speed. To add to that, machine set-up and maintenance for paper sack filling machines are quicker, resulting in further lower operational costs.

Lab study on cement losses

An investigation on product leakages during the filling operation and the handling afterwards took place at the same occasion as the above filling speed study.

Test methodology

A large, blank white paper sheet was laid down below the filling equipment. Five sacks per packaging type were filled up with cement. After each filling procedure, the cement particles on the paper sheet were collected and weighed.

The supply chain handling after filling was simulated by five drop tests from 90 cm height. In order to collect cement losses from this test, the sacks were weighed before drop tests and after all five drop tests. The weight difference is the cement loss value from the handling procedure.

Cement losses from filling operation

Cement leakage from filling in a paper sack was on average 0,24 g and from filling in a WPP sack on average 0,95 g. See details in table 3.
This result corresponds to four times more cement losses with WPP sacks in the filling operation compared with paper sacks.

Table 3. *Cement losses during filling.*

Cement losses during filling (g)		
Sample	Paper sack	WPP sack
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

- Cement losses generated at the filling site increases the maintenance cost of filling equipment, the downtime for cleaning and shortens the lifetime of machinery.
- Health & safety issues for the employees.
- Product losses create lower efficiency at the production site, even though this is normally taken back to production.

Cement losses from supply chain handling

Cement losses in the handling afterwards show that 2,20 g cement leaked from a paper sack during the five drop tests, while 8,60 g cement losses were observed from a WPP sack after the five drop tests. See details in table 4.
This corresponds to four times more cement losses in the handling of filled WPP sacks compared to handling of filled paper sacks.

Table 4. *Cement losses during handling.*

Cement losses supply chain (g)		
Sample	Paper sack	WPP sack
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

- The WPP sack created cement losses all over the sack, not only in the perforations but also from the woven surface.
- Product losses create lower efficiency at the production site.
- Health & safety issues increase for the employees, and all others in the value chain that handle the sacks.

Conclusion

At a cement plant, 44 tonnes of cement per million tonnes produced is lost via paper sacks, and 172 tonnes via WPP sacks. Switching to paper sacks saves 128 tonnes of cement and saves 104 tonnes of CO_2e per million tonnes produced, benefiting both efficiency and environmental emissions.

The lab study demonstrates that paper sacks have lower cement losses compared to WPP sacks, resulting in cleaner operations, lower maintenance costs, and improved efficiency throughout the distribution supply chain.

Health and safety for employees at filling sites

- Cement dust typically contains various types of chemicals and minerals in addition to lime and silica, such as calcium, aluminum, chromium and iron, and such chemicals/minerals cause different health complications and pathogenesis in addition to respiratory disorders including asthma, airway inflammation and lung infections.

- The two classes of PM (Particulate Matter) of most relevance to the cement industry are PM2.5 (diameter below 2.5µm) and PM10 (diameter below 10µm)[1], where PM10 causes irritation of skin,

[1] Magazine Global Cement, 21 February 2014: Global cement emissions standards

eyes, nose and throat, while PM2.5 particles enter the deeper respiratory system, causes cought, asthma and lung inflammation.

- If contact with the skin, a risk of developing skin problems, ranging from mild and brief to severe and chronic, can arise.

Lab study on dust generated from filling operation

A lab test measuring dust during filling operation took place at the Mondi Frantschach Bag Application Center in Austria, on July 17, 2024, comparing the two types of sacks: high porous paper sacks and woven polypropylene (WPP) sacks. Here, the Natro Tech - Air Packing Machine was used to fill up the sacks with cement.

Persons present at Mondi lab test

Christian Ressler, Consultant - ÖSBS
Alexander Fink, Application Engineer - Mondi Uncoated Fine and Kraft Paper GmbH
Christian Münzer - Mondi Industrial Bags GmbH

Test methodology

The dust measurements were taken by the Austrian Dust (silicosis) Control Centre (ÖSBS) consultant in two different test procedures: one direct measurement with an aerosol spectrometer, and one sampling process with gravimetrically analyzing afterwards in the ÖSBS accredited laboratory.

The sampling places were located to the left of the filling machine, to the right of the filling machine and 2 m before/in front of the filling machine.

10 measurements at each sampling place were taken per packaging type (10 paper sacks and 10 WPP sacks) and a mean value per sampling place was calculated. Finally, a mean value for the three sampling places was calculated and compared.

Result

Dust, with particle sizes smaller than 10 µm (PM10), generated from filling operation is 3 times higher when filling into the WPP sacks compared to filling into the paper sacks.
Dust, with particle sizes smaller than 2.5 µm (PM2.5), generated from filling operation is 2 times higher when filling into the WPP sacks compared to filling into the paper sacks.

Table 5. *PM10 and PM2.5 measurements.*

PM10 / inhalable				PM2.5 / respirable		
Sample location (mg/m3)	Paper sacks	WPP sacks		Sample location (mg/m3)	Paper sacks	WPP sacks
Left side	9,7	18,5		Left side	1,5	2,8
Right side	5,1	25,9		Right side	1,9	7,5
Front	3	5,1		Front	2,3	2,8
Mean	5,9	16,5		Mean	1,9	4,4

- The natural porosity of paper sacks enables the air to escape but not cement particles.
- The WPP sacks tested had higher internal pressure during filling, while at the same time leakages all over the sacks, not only in the perforations.

Conclusion

Dust in the form of PM10 and PM2.5 generated from filling operation, is 3 times resp 2 times higher for the tested WPP sacks compared to the tested paper sacks. Cement dust typically contains various

types of chemicals and minerals in addition to lime and silica, such as calcium, aluminum, chromium and iron, and such chemicals/minerals cause different health complications.

Surface friction test of filled paper sacks and WPP sacks

In order to evaluate how dust on the sacks can affect stabilization when palletizing them, a surface friction test took place. This test measures the resisting force that arises when a surface of one material tends to slide or slides over another surface of the same, or some other material.

Test methodology

The surface friction test is based on the standard Tappi 815, and the test was conducted at the Billerud Packaging Development Center in Karlsborg, Sweden.

The tested sacks were filled with cement in the filling station, and then dropped from 90 cm height five times before the friction test took place.

Two sacks were placed on the friction table and then two other sacks on top of them. The elevator increased the angle with a constant speed until one of the sacks moved. The test was done three times with the same sacks, and for all three tests the static friction coefficient was calculated.

Result

The test shows similar results for paper sacks and WPP sacks, where the static friction coefficient is 0,60 respective 0,59 on average for each type.

Table 6. *Surface friction result.*

Friction test filled sack		
coefficient (µs)	Paper sacks	WPP sacks
Test 1	0,58	0,62
Test 2	0,61	0,57
Test 3	0,60	0,57
Mean value	0,60	0,59

- The result indicates that even when the WPP sacks are having more dust on their surfaces, the friction is still on a good level. This is due to: either the woven material have loosen up after the drop tests which could make the surface more rough, or the woven material was coated to improve the friction properties.
- It is important to have as clean sacks as possible due to load security, as well as employees and customers don't have to handle dusty and slippery sacks.

Conclusion

The lab test result indicated similar values for paper sacks and WPP sacks. This property is important due to loading security (sacks laying more stable when they are palletized and transported) as well as the handling of single sacks in the distribution value chain.

Sustainability

Raw material

WPP sacks are made from fossil-based raw materials, which are limited resources that contribute to greenhouse gas (GHG) emissions and accelerate climate change. In contrast, paper sacks are produced from renewable resources sourced through sustainable forest management practices. This approach not only ensures a continuous supply of raw materials but also benefits in reducing environmental impact, making paper sacks a sustainable choice.

Recyclability

The European sack kraft paper and paper sack industry commissioned independent research in the recyclability of paper sacks. The study concludes that not only are used and unused cement paper sacks perfectly recyclable. They also offer product and process benefits when incorporated into the recovered fibre furnish.[2]

Carbon footprint

Study overview

CEPI Eurokraft contracted RISE (Research Institutes of Sweden) to calculate the potential cradle-to-gate contribution of global warming of paper sacks (manufactured from virgin sack kraft paper) and woven polypropylene (WPP) sacks (manufactured from virgin polypropylene) for packaging 50 kg of cement in markets outside of Europe. The results are then applied to compare the two solutions in each market, with a view to understanding the differences in the carbon footprint of paper sacks and WPP sacks for cement and identifying the factors that have the most influence over relative standing of the two solutions. Sensitivity and uncertainty analysis shows that the results achieved, and conclusions drawn are robust, and the study has been peer reviewed by the Sustainability in Metrics (SIM) team at SimaPro UK.

Methodology

This life cycle study focuses on the fossil global warming potential for the studied systems and follows the requirements of ISO14040/14044.

The study investigates paper sacks and WPP sacks for cement in four specific markets:

- Africa – represented by a case study considering Ivory Coast
- Middle East - represented by a case study considering Saudi Arabia
- South/Central America – represented by a case study considering Mexico
- South East Asia – represented by a case study considering Indonesia.

[2] Kay M, Sturges M and Langley R (2023) Investigating the papermaking potential from recycling kraft paper sacks within standard high-volume paper mills. In Paper Technology International (PITA), Vol. 64, No. 3, Autumn 2023, PP. 10-15. https://www.pita.org.uk/ The 6-page article is also available here: Technical article: Recycling kraft paper sacks

Key results

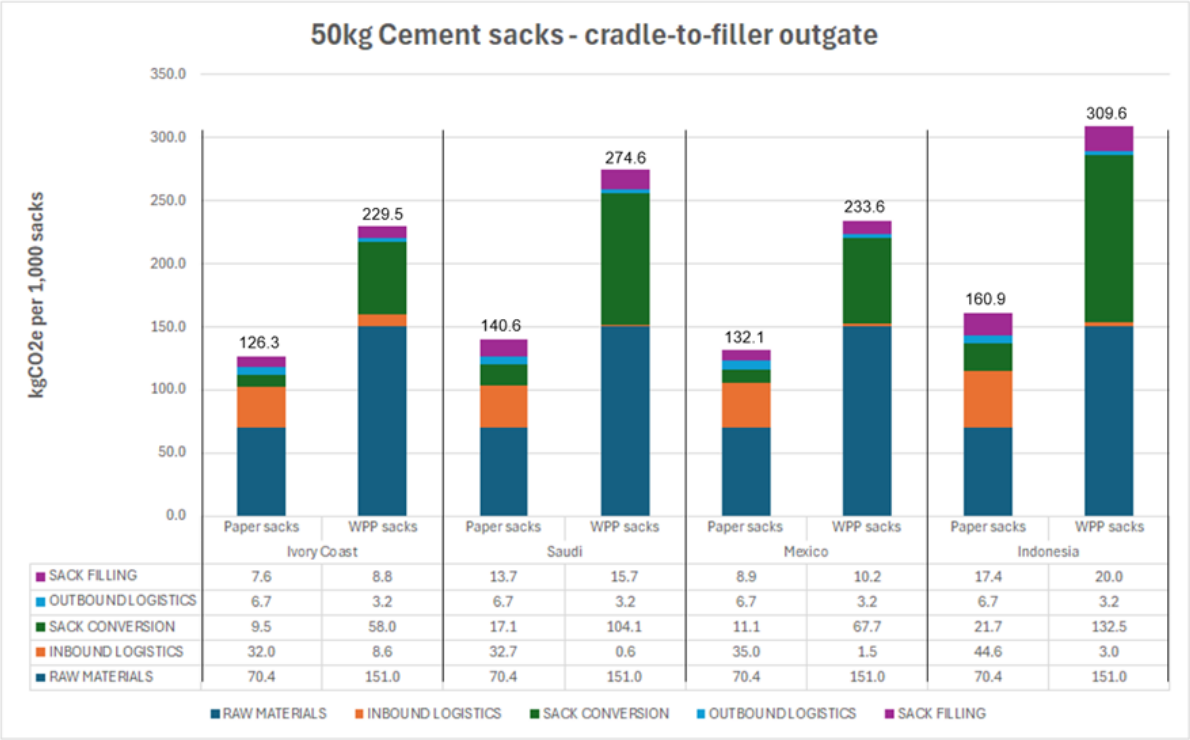

Figure 1. *Cradle-to-filler out gate results for paper sacks and WPP sacks.*

- For both packaging solutions, production of raw materials makes the highest contribution to the fossil global warming potential. In the case of paper sacks, most of this impact is due to the production of sack kraft paper ready for conversion into paper sacks. In the case of WPP sacks, most of this impact is due to the production of polypropylene granules ready for conversion into WPP sacks.
- Sack conversion has a higher impact for WPP sacks compared to paper sacks, due to the higher electricity demand for converting PP granules into sacks in an integrated process compared to converting sack kraft paper into sacks.
- Inbound logistics has a higher impact for paper sacks compared to WPP sacks. This is because the sack kraft paper is produced in Europe and must be transported long distances to the converter, whereas PP granules are produced more locally. Furthermore, the paper sacks are heavier compared to the WPP sacks and therefore more weight of raw materials must be delivered to the converting site.
- Outbound logistics has a higher impact on paper sacks compared to WPP sacks. This is because the paper sacks are heavier compared to the WPP sacks and therefore more weight of packaging must be distributed.

Conclusion

Across all market case studies analysed, the total fossil-based global warming potential - measured from raw material extraction to the point when sacks are filled and ready for dispatch - is approximately twice as high for WPP sacks compared to paper sacks when packaging 50 kg of cement. This significant difference highlights the lower environmental impact of paper sacks, making them a more sustainable choice.[3]

[3] Comparative carbon footprint study: Paper sacks versus woven PP sacks in markets outside Europe

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MORE INFORMATION

For more information, contact your sack kraft paper producer or CEPI Eurokraft secretariat.

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