37 Cork

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Contents

37.1 Introduction

Cork is a natural product obtained from the bark of the cork oak tree (*Quercus suber L.*) found primarily at the western end of the Mediterranean in Portugal, Spain and North Africa. The bark thickens and develops with age and can be harvested as a regular crop (every 9–12 years) from commercial plantations and natural forests. As a vegetable tissue, cork bark is composed of cells that are five-sided, impermeable and contain a large proportion of air. The cellular structure allows cork to be compressed and to recover its original dimensions without extrusion – a property yet to be equalled by synthetic products used in this field. Cork is, therefore, a perfect natural insulant.

Natural cork is harvested from the tree in sheets and they are steam treated to flatten them. It may then be laminated to any thickness. Cork is a natural material that regenerates itself without depletion of its source. It is ubiquitous and has a place in every phase of building.

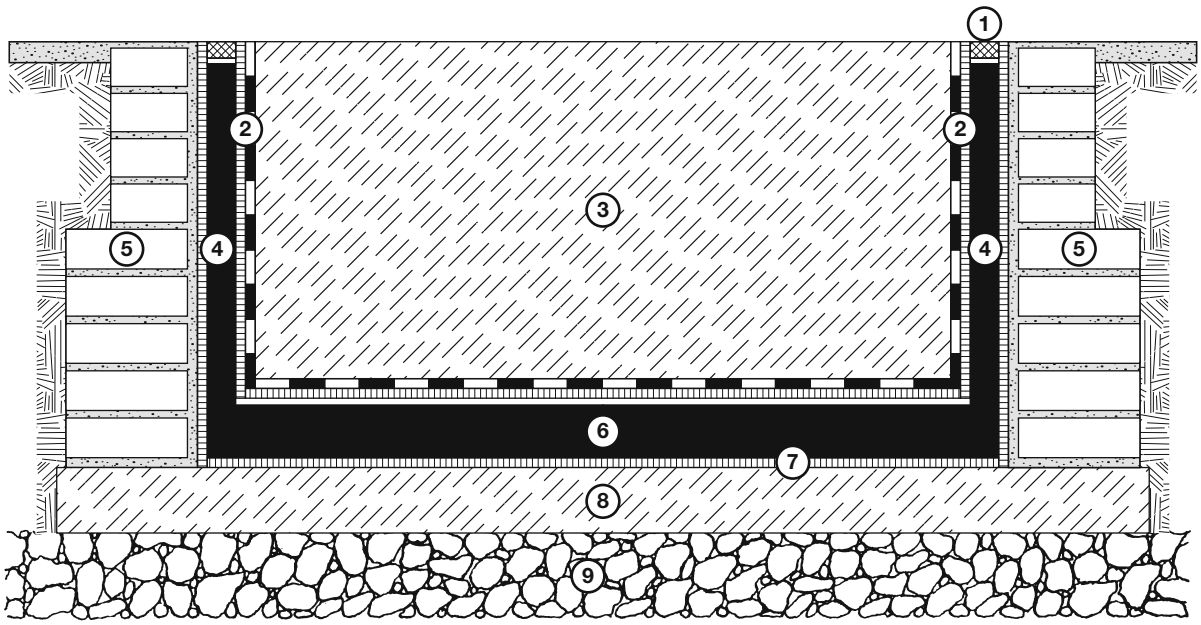
Cork is unique in both its cellular form and its ability to combine functions, and has the following characteristics:

- compressibility
- recovery after compression
- sound-deadening
- anti-vibration
- thermal insulation properties
- non-carcinogenicity
- impervious to liquids
- resistant to most chemicals
- no insects, rodents, etc. live off it
- it is biodegradable without resort to processing other than mixing with soil in an outdoor environment
- low energy use during manufacture
- non-abrasive
- ease of removal
- 'grip' on surrounding materials (clutch action)
- ease of drilling and cutting
- softness
- environmentally friendly.

Material containing natural cork may be used for:

- pads for isolating columns
- wall and roof insulation
- anti-vibration products (see Figure 37.1)
- acoustic applications
- decorative purposes.

The material can combine low weight with great mechanical and structural strength. Natural cork is also granulated and this becomes the basis for a wide variety of cork-based materials. Many types and forms are used in construction.



1. Seal
2. Waterproofing and protection of corkboard
3. Reinforced concrete
4. Normal insulation corkboard (105/130 kg/m³)
5. Supporting wall
6. Heavy density corkboard
7. Gluing of the corkboard
8. Concrete slab (heavily reinforced)
9. Rock foundation

Figure 37.1 Typical cork acoustic vibration insulation detail

37.2 Agglomerated corkboard

Corkboard is manufactured by baking granules (usually with superheated steam) at a temperature of 350°C and a pressure of 30,000 kg/m^2. There is no contact with air during this process and the cork's natural resins are released from the cells causing the granules to bond together, becoming dark brown in colour. After an appropriate period of 'cooking', a block of corkboard usually 1000 × 500 × 300 mm is produced; higher density boards, typically 914 × 305 × 300 mm are also produced. After 'baking' the compressed board is cooled, rested, trimmed to size and slabs of any thickness from 12 mm to 300 mm produced. Thicker sheets can be produced by post-laminating. The baking process causes natural cork granules with a density of approximately 200 kg/m^3 to undergo a large expansion in volume with the release of volatile elements and a commensurate decrease in density. At the same time, the expanded cork granules are restrained, causing their agglomeration to form a cork block with a higher density than that of freely expanded granules. This density can vary from a minimum of 80 kg/m^3 to over 600 kg/m^3 depending on:

- degree of compression
- quality of cork
- granule size
- purity of granulation
- manufacturing process
- temperature.

The combination of these variable factors enables the manufacture of different types and densities for numerous purposes. Low and medium densities are best for insulation of walls and roofs. Higher densities should be used for rooftop walkways and for machine bases in order to change the frequencies of vibrating machinery. Typically such products should have a minimum density of 176 kg/m^3. It is recommended that extra care be taken to scrutinise the intended use of any material with density below 96 kg/m^3. The ideal quality will be achieved where the manufacturer selects the material and eliminates the heavier woody inner part of the bark, which increases the weight at the penalty of reduced performance. The supplier must ensure that this has been achieved. For a chosen application the aim should be to achieve minimum density with maximum mechanical strength.

Corkboard insulation may also be used internally under a pitched roof.

The recovery of material should be tested on the basis of a loading test of 4 s duration at a load of 0–140 kN/m^2 repeated 1200 times with a maximum loss of thickness of 0.12 mm of the 60 mm sample tested

The thermal diffusivity (a measurement of heat flow calibrated against time), used in assessing the overall performance of a material, shows cork to be a good insulant and having resistance to changes in temperature (Figure 37.2 shows thermal insulation values of INS-OLL board). It can be used in conjunction with oil-based plastics foams to improve performance further. These composite boards recover after loading significantly better than oil-derived single component insulation products such as polystyrene foam.

The dimensional stability of cork is indicated by an expansion of 0.03 mm/m for a temperature rise of 1°C which equates to a maximum expansion (in the UK climate) of 0.9 mm/m. The corresponding values for foam plastics are considerably greater. Corkboard can therefore be described as benign, making it the ideal companion to other components of a roof structure. Material such as polyurethane when loaded and unloaded does not recover as well.

Cork cannot be successfully specified by density alone; it requires the judgement of a specialist to assist in the

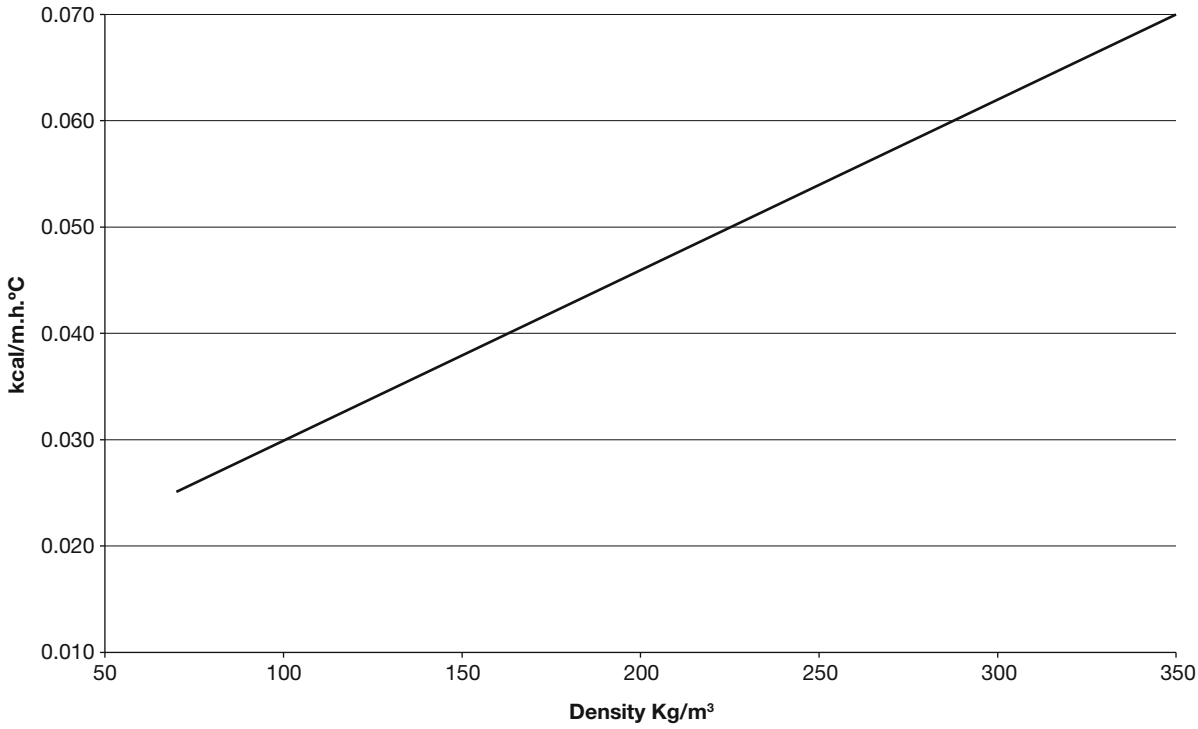


Figure 37.2 Thermal insulation value of INS-OLL board at various densities

selection process to ensure that performance needs are properly met.

It is important when considering fire behaviour to take a holistic view of the performance of the whole construction, not just the cork being used as an insulant. However it can be stated that cork does not emit toxic fumes and, after a short period of smouldering, it will self-seal once a fire source has been extinguished.

37.3 Cork in flat roofing

In addition to its generally good properties discussed above, an attractive option for cork's use is the ability to cut the cork blocks to a taper, thereby creating a dry-construction roof to falls. Falls are essential for rapid shedding of rainwater from a roof.

37.4 Handling and storage

Material should be handled with care to avoid damage to board edges. Slabs are usually delivered to site shrink-wrapped in polythene or corrugated cardboard export cartons which provide some short-term protection. For long-term storage slabs should be stored indoors or off-ground under a waterproof cover.

For bitumen-based multi-layer 'built-up' roofing, corkboard is normally fully bonded to a roof with hot bonding grade bitumen using a staggered arrangement of joints. A vapour-resisting layer should always be installed below the insulation and the specification carefully chosen to suit the individual project. A vapour escape sheet fixed by partial bonding is not recommended with corkboard. All day-work joints should be fully sealed to prevent moisture ingress. In particularly exposed environmental conditions, additional mechanical fastenings may be required.

Corkboard is suitable for use with most single ply membranes, but it is recommended that the corkboard product is supplied with a sealed finish compatible with the adhesives to be used. The manufacturer's instructions for applying the membrane should be closely adhered to.

For roofs waterproofed by mastic asphalt there is often a requirement for a thermal protection layer between the insulation board and the hot applied asphalt. For corkboard insulation no thermal barrier layer is required. A loose laid standard mechanical isolation sheet membrane can be laid over the corkboard prior to application of asphalt to the recommendations of MACEF (Mastic Asphalt Council and Employers Federation)

Insulation requirement and design for buildings will normally be controlled by local or national Building Regulations and specific reference should be made to them. Cork insulation can be used to upgrade the performance of existing installations, and again reference to Regulations is advised.

37.5 Composition cork

Composition cork is made by the incorporation of a low volume (~0.02% by volume) of resin binder together with cork granules – dust to 6 mm – and subjecting them to heat and pressure. This approach permits the development of grades with tailored properties for particular applications, such as expansion joint filling or for decorative applications. It is usually produced in sheet sizes of 914 × 610 × 0.8 to 200 mm thick, although greater thicknesses can be achieved by laminating. Reels are also available up to a maximum thickness of 9 mm; grades vary from 110 kg/m^3 to 560 kg/m^3. Two types of composition cork are as follows.

Expand-O-Jointing is a composition cork with the ability to expand from 1 to 2 inches and is suited for road and tunnel construction. This material should be sealed until placed in situ. The appropriate standard is ASTM 1752.84 Parts 1 & 2.

Cork conforming to BS4332 is a high-density composition cork for use in construction. Only 29 to 35 lb material should be used for flooring, as this will resist foot traffic.

It is prudent to request a *certificate of conformity* of the supplier; in addition, for all industrial or domestic uses, a sample should be requested.

Some compressed cork will satisfy Class 2 of BS476:1971 as a surface with a very slow spread of flame and is therefore assessed as having a good resistance to fire. To achieve Class 1, cork panels and granules need to be treated by the COS-FP1 process.

Cork is also used as part of the construction of sky lights, where the material will absorb moisture but will then stabilise, forming a snug seal, without rotting. Natural and composition cork panels with a taper may be used to form a variable gap seal against, say, concrete or coatings.

A further use of cork is for the lining of containers used for the storage of sensitive materials such as nuclear waste. For typical material specification see Tables 37.1 and 37.2.

37.6 Cork rubber

Cork rubber provides another family of products that are made into sheets of cork with a rubber binder. These materials may, for example, contain a number of synthetic rubbers, e.g. nitrile. Sheets are usually 1000 × 1000 or 1200 × 1200. Reels are also available up to 1240 mm in width; lengths will depend on thickness and EU weight restrictions. Thicknesses vary from 0.8 mm to 150 mm for sheets and from 0.8 mm to 8 mm for reels. Applications include:

- gaskets
- seals
- anti-vibration pads
- flooring
- underlays
- electrical insulation mats
- machine mountings.

For typical properties of these products, see Table 37.3. The material will vary from soft for example for use as an underlay to hard for heavy duty use.

Cork-based product quality is important, as it is for all materials. Therefore manufacturer certification to quality assurance systems such as ISO9001:2008 should be sought. This will give recognition that the supplier and the manufacturer of these materials, of whatever specific type, have monitored the material sourcing and manufacture and can demonstrate it has the properties claimed.

From humble beginnings as ancient Egyptian fishing floats to the Apollo space programme – as part of the re-entry shield – cork has proved ideal for solving a range of problems.

37.7 Standards

- BS EN 233:1999. *Wall coverings in roll form – specification for finished wall-papers, wall vinyls and plastics wall-coverings*. BSI, London, UK.
- BS EN 1815:1998. *Resilient and textile floor coverings – assessment of static electrical propensity.* BSI, London, UK.
- BS4332:1989. *Specification for phenol formaldehyde resin bonded cork jointing.* BSI, London, UK.
- BS EN 12455:1999. *Specification for corkment underlay.* BSI, London, UK.

Table 37.1 Example of cork material specification

Cork composition COS24	
Grade defined as dense, resin-bonded, composition cork. The grain is pre- and post-mould treated to enhance performance consistency – including moisture stability.	Applications – high-performance anti-vibration pads, packings, polishing wheels, seals.
Physical properties	*Requirements*
Thickness: up to 2.50 mm	ASTM F104 Type 2 material +0.25 mm
Over 2.50 mm	+10%
Density	380–460 kg/m^3
Conditioning	ASTM F104 Type 2
Compressibility	ASTM F36 procedure F 10–20%
Recovery	ASTM F procedure F 75% minimum
Tensile strength	ISO 7322 1700 kPa minimum
Flexibility factor	ASTM F147 Type 2 material. × 5 maximum (as received)
Thermal conductivity	CPTM No. 37 (Lees disc) 0.055 W/m K maximum
Boiling water resistance	No disintegration
Specification compliance	ASTM F104 F219000M9

The specification used for the above applications has passed the following tests: (i) fire, (ii) drop, (iii) density, (iv) moisture. Each batch must carry a certificate for full specification both at block production and at finished product stage. The certificate should be held by the product supplier. This material can be made 'fireproof' to BS476 Part 7 Class 1 and NES 804 Part 1 issue 2.

Table 37.2 Example of cork material specification

Cork composition COS13F	
Grade defined as general-purpose fine-grain bonded composition cork. The grain is pre- and post-mould treated to enhance performance consistency, including moisture stability.	Applications – multi-situations.
Physical properties	
Thickness: up to 2.50 mm	ASTM F104 Type 2 material +0.25 mm
Over 2.50 mm	+10%
Density	170–240 kg/m^3
Conditioning	ASTM F104 Type 2
Compressibility	ASTM F36 procedure F 30–50%
Recovery	ASTM F procedure F 75% minimum
Tensile strength	ISO 7322 400 kPa minimum
Flexibility factor	ASTM F147 Type 2 material. × 5 maximum (as received)
Thermal conductivity	@ 25 C: 0.038–0.042 W/m K
Specification compliance	ISO 7322

Table 37.3 Composition cork with rubber binder

Test method	*Test type*	*Units*	*Grade reference*				
			Cor 66	*Cor 65*	*Cor 58*	*Cor 658*	*Cor 14*
ASTM F1315	Density	kg/m^3	700–800	850–950	600–700	550–650	850–1000
ASTM D2240	Hardness	Shore A	65–75	65–85	50–70	40–55	65–75
ASTM F36	Compressibility @ 400 psi	%	25–35	15–25	40–55	55–65	15–25
ASTM F36	Recovery (min)	%	80	75	75	80	80
ASTM F152	Tensile strength (min)	MPa	20	17.5	10.5	8.0	26.4
ASTM F147	Flexibility F5	–	No cracks	No cracks	No cracks	No cracks	No cracks

(Continued)

Table 37.3 *(Continued)*

Test method	*Test type*	*Units*	*Grade reference*				
			Cor 66	*Cor 65*	*Cor 58*	*Cor 658*	*Cor 14*
ASTM F146	Volume change after immersion in ASTM No. 1 oil 70 hours @ 100°C	%	–5 to + 10	–5 to +10	–10 to +10	–15 max	–5 to +5
ASTM F146	IRM 903 oil 70 hours @ 100°C	%	–2 to +15	–2 to +15	–5 to +30	–15 max	+10 to +38
ASTM F146	Fuel A, 22 hours @ 23°C	%	–2 to +10	–2 to +10	O–to +10	–5 to +10	Not applicable
	Compliance	–	BS 21F66	–	–	–	–
	Binder	–	Nitrile	Nitrile	Nitrile	Chlorosulfonated polyethylene	Silicone
	Colour	–	Grey	Brown	Black	Various	Various
	Cork granule size	–	0.5–1.0 mm	0.5–1.0 mm	2.0–3.0 mm	0.5–1.0 mm	0.5–1.0 mm

Synthetic rubber binders are incorporated primarily to increase cork's natural resilience for sealing, flexibility and anti-vibration applications. The data in this table were resourced by C. Olley & Sons Ltd. The grade colour reference indicates the binder type used, helping to distinguish different grades with different properties. The ASTM oil and fuel figures are standard requirements and show the degree of alteration caused by the oils and fuels.

- BS EN 12105:1998. *Resilient floor coverings – determination of agglomerated composite cork.* BSI, London, UK.
- BS EN 12149: 1998. *Wall coverings in roll form – determination of migration of heavy metals and certain other elements of vinyl chloride monomer and of formaldehyde release*. BSI, London, UK.
- BS EN 12956:1999. *Wall coverings in roll form – determination of dimensions, straightness, spongeability and washability*. BSI, London, UK.
- BS EN 13187:1999. *Thermal performance of buildings – qualitative detection of thermal irregularities in building envelopes – infrared method*. BSI, London, UK.
- BS EN ISO 13786: 1999. *Thermal performance of building components – dynamic thermal characteristics – calculation methods.* BSI, London, UK.
- BS EN ISO 13789: 1999. *Thermal performance of buildings – transmission heat loss coefficient – calculation method.* BSI, London, UK.
- BS EN ISO 14683: 1999. *Thermal bridges in building construction – linear thermal transmittance – simplified methods and default values.* BSI, London, UK.
- ISO1997:1972. *Granulated cork and cork powder – specifications*. BSI, London, UK.
- ISO2030:1990. *Granulated cork – size analysis by mechanical sieving.* BSI, London, UK.
- ISO2031:1991. *Granulated cork – determination of bulk density.* BSI, London, UK.
- ISO2066:1986. *Expanded pure agglomerated cork – determination of moisture content.* BSI, London, UK.
- ISO2067:1988. *Granulated cork – sampling*. BSI, London, UK.
- ISO2077:1979. *Pure expanded cork board – determination of the modulus of rupture by bending.* BSI, London, UK.
- ISO2189:1986. *Expanded pure agglomerated cork – determination of bulk density.* BSI, London, UK.
- ISO2190:1988. *Granulated cork – determination of moisture content.* BSI, London, UK.
- ISO2191:1972. *Cork – expanded pure agglomerated – deformation under constant pressure*. BSI, London, UK.
- ISO2219:1989. *Expanded pure agglomerated cork for thermal insulation – characteristics, sampling and packaging.* BSI, London, UK.
- ISO2509:1989. *Sound-absorbing expanded pure agglomerated cork in tiles*. BSI, London, UK.
- ISO2510:1989. *Sound-reducing composition cork in tiles.* BSI, London, UK.
- ISO2569:1985. *Cork stoppers – types and general characteristics.* BSI, London, UK.
- ISO2582:1978. *Cork and cork products – determination of thermal conductivity – hot plate method.* BSI, London, UK.
- ISO3810:1987. *Floor tiles of agglomerated cork – methods of test.* BSI, London, UK.
- ISO3813:1987. *Floor tiles of agglomerated cork – characteristics, sampling and packing.* BSI, London, UK.
- ISO3863:1989. *Cylindrical cork stoppers – dimensional characteristics, sampling and packing.* BSI, London, UK.
- ISO3867:1982. *Agglomerated cork material of expansion joints for construction and building-test methods.* BSI London
- ISO3869:1981. *Agglomerated cork – filler material of expansion joints for construction and buildings-characteristics, sampling and packing.* BSI, London, UK.
- ISO4707:1981. *Cork – stoppers – sampling for inspection of dimensional characteristics.* BSI, London, UK.
- ISO4708:1985. *Cork – composition cork gasket material – test methods.* BSI, London, UK.
- ISO4709:2000. *Cork – composition gasket material – specifications.* BSI, London, UK.
- ISO4711:1987. *Agglomerated cork discs – specifications*. BSI, London, UK.
- ISO4714:1986. *Composition cork – test methods.* BSI, London, UK.
- ISO7322:1986. *Cork – composition cork – test methods.* BSI, London, UK.
- ISO8507:1985. *Agglomerated cork discs – methods of test.* BSI, London, UK.
- ISO8724:1989. *Cork decorative panels – specification.* BSI, London, UK.
- ISO9148:1987. *Composition cork in rolls for decoration – test methods.* BSI, London, UK.
- ISO9149:1987. *Composition cork in rolls for decoration – specifications.* BSI, London, UK.
- ASTM C640-83. *Standard specification for corkboard and cork pipe thermal insulation.* ASTM, West Conshohocken, PA.
- DIN 18 161 Pt 1: 1976 *German standard: Cork products as insulating building materials.* DIN, Berlin, Germany.
- ASLIB 6621:1998. *Guidance on the new European test method standards for thermal insulation materials.* ASLIB, Bingley, UK.
- ASTM C353-84. *Standard test method for adhesion of dried thermal insulating or finishing cement*. ASTM, West Conshohocken, PA