

SIGNIFICANCE OF THE SHRINKAGE-COMPENSATING AND NONSHRINK LABELS ON PACKAGED REPAIR MATERIALS

Keywords: cracking; expansion; nonshrink; packaged; prestress; repair material; restraint; shrinkage-compensating; tensile stress.

Question

What does it mean when a packaged repair material is labeled as shrinkage-compensating or nonshrink?

Answer

The terms 'shrinkage-compensating' and 'nonshrink' are both intended to describe materials that exhibit no or little net contraction as a result of shrinkage. In practice, however, these terms are of limited use in the selection of repair materials without supporting test data on time-dependent volume changes.

Discussion

Many proprietary repair materials are described as shrinkage-compensating or nonshrink. In most cases, the manufacturer's data sheets do not explain the meaning of such terms. Given the restraint conditions typically provided by the concrete substrate, accurate expansion and shrinkage data are essential for selection of shrinkage-compensating or nonshrink materials that will provide durable repairs. This Technote provides clarifications on the actual significance of the labels 'shrinkage-compensating' or 'nonshrink' found in technical data sheets.

Moisture loss is unavoidable in cement-based materials as soon as they are exposed to a relative humidity less than 100 percent. This moisture loss results in drying shrinkage and volume changes within the material. In addition to shrinkage that occurs due to drying, the hydration reactions will cause some unavoidable chemical shrinkage. Consequently, significant efforts have been made to counteract shrinkage and its undesirable effects, such as tensile stresses and cracking. Expansive cements were first introduced more than half a century ago to produce so-called shrinkage-compensating concretes. Shrinkage-compensating is defined by the ACI CT as:

A characteristic of grout, mortar, or concrete made using an expansive cement in which volume increases after setting and, if properly elastically restrained, induces compressive stresses which are intended to approximately offset the tendency of drying shrinkage to induce tensile stresses.

In these materials, a chemical agent added to the cement reacts during curing to produce an expansive compound, resulting in a net volume increase of the material. The dosage of expansive agent has to be selected such that the initial expansion will offset subsequent shrinkage, as depicted in Fig. 1.

The shrinkage-compensation process for repair materials is similar to that for shrinkage-compensating concretes. The latter are often made with Type K cement (ASTM C845/C845M) and sometimes with the use of other types of expansive agents added during the mixing operations, generally calcium sulfoaluminate-

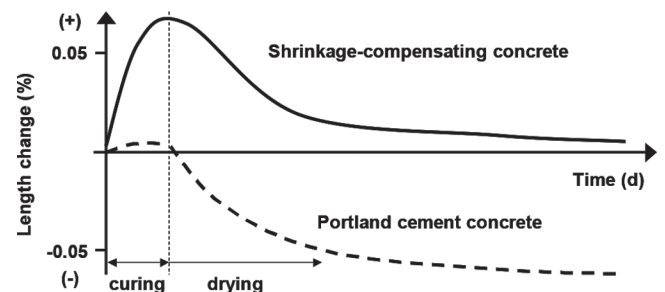


Fig. 1—Typical length change behavior of shrinkage-compensating and portland cement concretes (adapted from ACI 223R).

based (CSA) or lime-based (CaO). The various proprietary shrinkage-compensating repair materials available can differ significantly in composition, especially when it comes to the nature of the expansive compound. In addition to the aforementioned CSA-based and CaO-based agents, other additives such as gas-liberating agents (nitrogen, hydrogen, and oxygen, for example) and diols (dihydric alcohols) are also used. Some dual-action materials even contain two forms of expansive agents; for instance, one agent that produces a gas to counteract shrinkage occurring while the material is still in a plastic state, and another that leads to the formation of a compound that produces expansion in the hardened state.

The term ‘nonshrink’ is often, if not always, used in place of the probably more suitable expression ‘shrinkage-compensating’. Hydraulic-cement nonshrink grout is defined in [ASTM C125](#) as:

A hydraulic-cement grout that produces a volume that, when hardened under stipulated test conditions, is greater than or equal to the original installed volume, often used as a transfer medium between load-bearing members.

There will be some shrinkage as long as cementitious materials are part of the system; thus, strictly speaking, a cement-based material cannot be nonshrinking. The term is used by many manufacturers, however, to describe the shrinkage-compensating behavior of their materials. It is also used in [ASTM C1107/C1107M](#) for packaged dry, hydraulic-cement grouts. The important thing to know is that when a prepackaged material is labeled as ‘nonshrink’, it means that during the life of the material, under given environmental conditions, the dimensional balance (expansion minus shrinkage) is supposed to remain positive; there should be no net contraction resulting from drying (Fig. 1). It does not mean that there will be no volume changes.

Because the induced expansion and shrinkage are generally not synchronous, the effectiveness of a shrinkage-compensating system is dependent on restraint during the expansive process to produce a compressive prestress that will decrease with subsequent shrinkage. In new construction, a minimal amount of reinforcement is used to provide this restraint, as recommended in [ACI 223R](#). There is no such provision for repair materials, and it certainly requires some attention, especially in the case of bonded surface repairs without reinforcement where the restraint is provided by simple interface bond with the substrate and, depending on the configuration of the repair (partial-depth versus overlay work), by abutment to the vertical edges.

Information on the dimensional behavior of shrinkage-compensating or nonshrink repair materials is generally insufficient or absent from the manufacturer’s data sheets. This lack of information is due, in part, to the absence of explicit standardized test procedures and specifications for shrinkage-compensating materials. ASTM C1107/C1107M requires that the height change of moist-cured hardened hydraulic-cement grout be within the range of 0 to +0.3 percent when tested in accordance with [ASTM C1090/C1090M](#). In the case of rapid-hardening cementitious materials for concrete repairs ([ASTM C928/C928M](#)), many of which are also claimed to be shrinkage-compensating, the maximum allowable increase in length change is 0.15 percent after 28 days in water and the maximum allowable decrease is –0.15 percent after 28 days in air. This range for maximum allowable expansion and contraction is so permissive that most materials fall between the limits. Also, there are no requirements for rate of volume change for rapid-hardening cementitious repair materials. The rate of volume change is important in repairs and is addressed for other types of materials in [ASTM C845/C845M](#) and C1107/C1107M.

As illustrated in the following examples, which are excerpts from actual data sheets downloaded from two different manufacturers’ websites, the information provided to the customer can be quite confusing (see the commentary provided at the bottom of each example).