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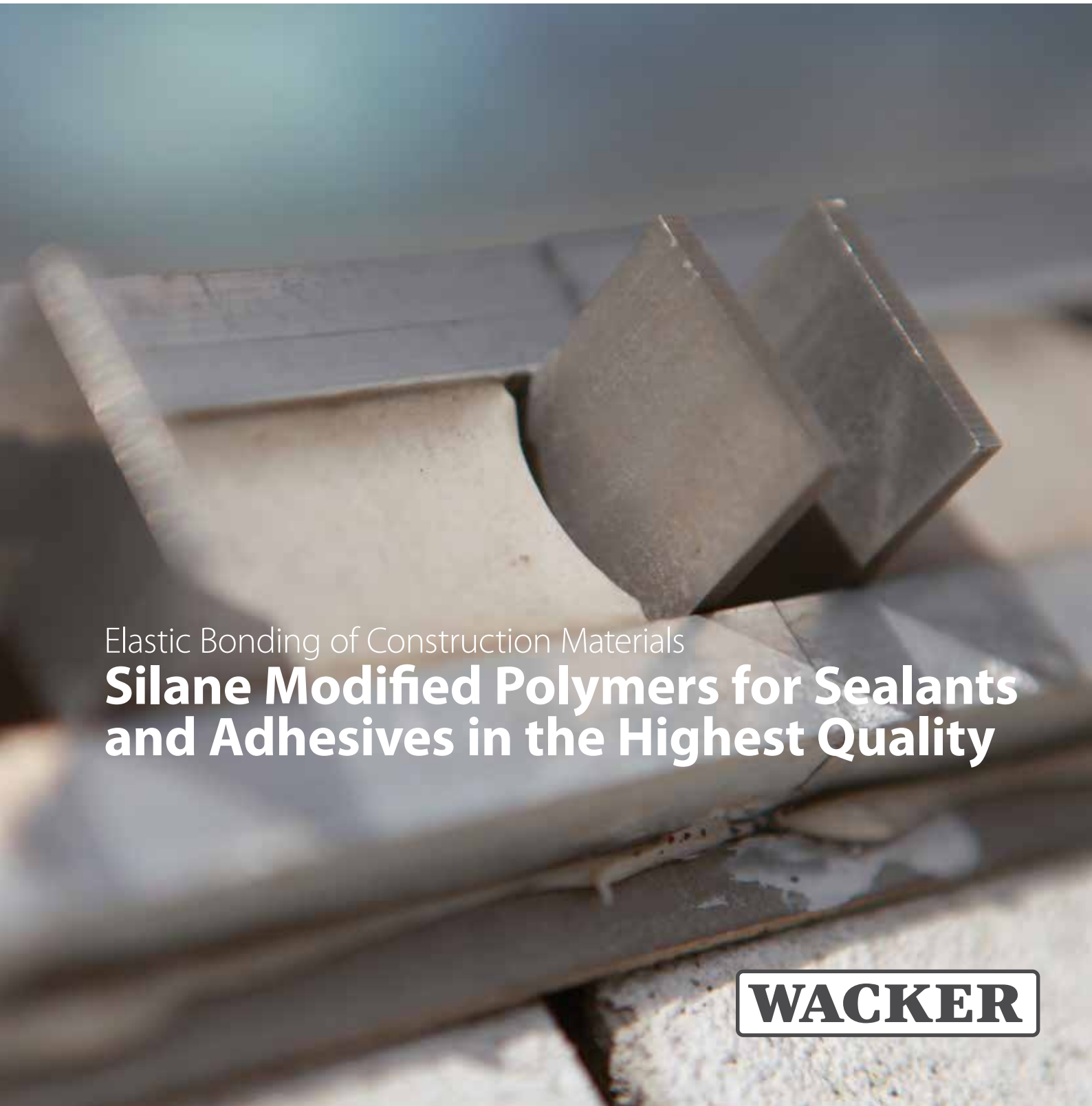

Elastic Bonding of Construction Materials

Silane Modified Polymers for Sealants and Adhesives in the Highest Quality

Good Adhesion, Low Modulus New Silane-Terminated Polymers

To provide building materials with an elastic bond or seal, construction workers need particularly flexible and elastic sealing compounds.

Lars Zander, Jack Peng

When building components meet, they inevitably form a joint. It is generally sealed to keep water, air, dust or other media out. Here, the difficulty lies in the detail. The gap that needs to be bridged can vary widely, depending on to what extent the components expand or contract when exposed to heat or cold. So, for the joint to remain permanently sealed, the sealant must be able to accommodate the changes in joint dimensions again and again without tearing or detaching from the surface.

Especially in construction engineering, joints are often located between components with sensitive substrates that are prone to crumbling (Fig.1 and 2). Typical examples include plasters, aerated concrete and external thermal insulation composite systems. A sealant with high tensile strength and low elongation poses a problem for sensitive substrates. If the joint expands, this kind of sealant is unable to accommodate the movement adequately. In the worst case scenario, it pulls – as long as it sticks – so strongly on the joint edges that these are then damaged.

Low Modulus – Ideal for Sensitive Substrates

That's why such cases call for low-modulus elastic sealants that require only a little force to stretch or compress. When the strain is removed, they largely return to their original form. These types of sealants absorb the components' movements

Fig. 1 > In construction engineering, joints are often found between components with sensitive substrates that are prone to erode and detach from the surface.

Fig. 2 > When building components meet, they inevitably form a joint. For the joint to remain permanently sealed, the sealant must be able to accommodate the changes in joint dimensions again and again without tearing or detaching from the surface.

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Fig. 3 > GENIOSIL® XM 25 yields low-modulus sealants with exceptionally high elastic recovery.

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Fig. 4 > Tests show that GENIOSIL® XM 25 yields low-modulus sealants with reliable adhesion to a wide range of substrates.

and thus lessen the strain on the joint edges.

In practice, a sealant may also be required to bond the two substrates together. Experts refer to this as an adhesive sealant or elastic adhesive. While such an allrounder should be capable of transferring forces, it should also be elastic, so that it can accommodate the component's movement. This is the case for assembly adhesives, for example, which should be strong yet elastic.

Silane-Terminated Polymers

In construction engineering, workers so far usually resort to polyurethane or silicone products when they need low-modulus sealants. Both substance classes have proven their merit in countless applications over decades. Polyurethane sealants can be painted over and have good mechanical properties. Silicone sealants are known for their excellent aging, weathering and temperature resistance, their high elasticity and their low-temperature flexibility.

However, such products also have some drawbacks. Polyurethane sealants often contain solvents to allow them to be squeezed out of the cartridge better, especially at low temperatures. Silicones, on the other hand, cannot be overpainted. Inexpensive standard formulations can additionally cause unsightly staining on absorbent substrates.

These problems do not arise when silane-terminated polymers are used as binders for such sealants. However, with conventional silane-terminated polymers, it is not easy to produce sealants with a modulus of less than 0.4 newton per square millimeter and elastic recovery of over 70 percent. Since the introduction of the CE marking construction sealants have to comply with ISO 11600 – a specification that must be certified by an external institute. Only construction sealants that conform to this standard may bear the CE mark, which is important when marketing in Europe.

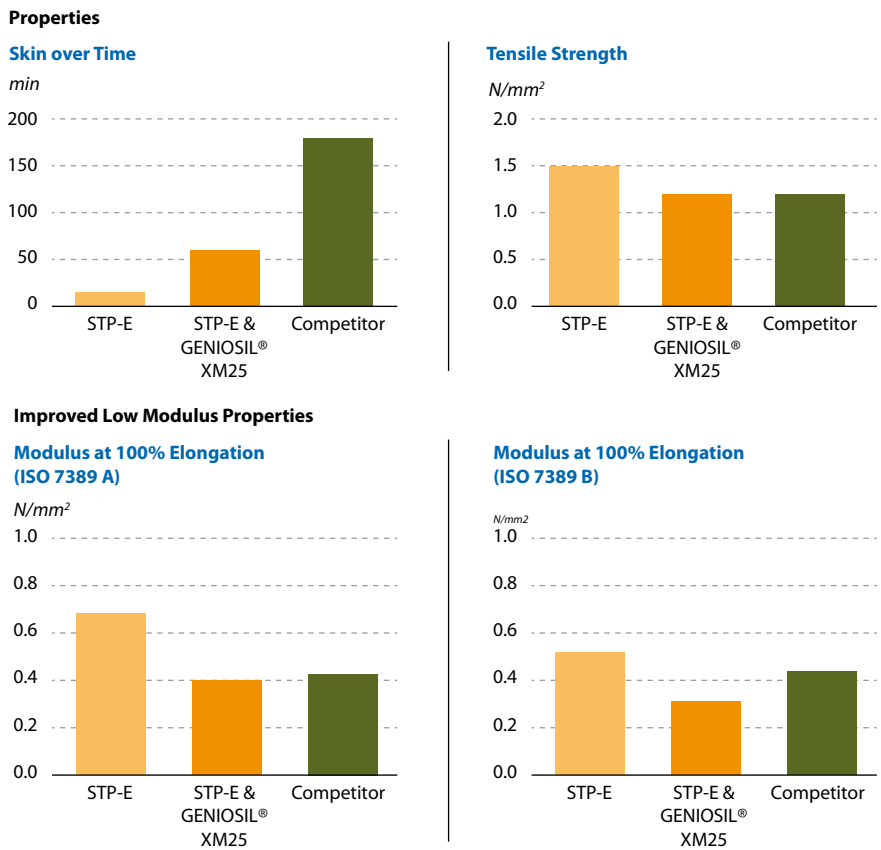

Fig. 5 > Tests show that sealants formulated with GENIOSIL® XM 25 have a longer skin over time (SOT) (Diagram 1) and a lower modulus than comparable products (Diagram 2). This provides better protection for vulnerable joint faces, for example of prefabricated concrete parts or window frames.

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Fig. 6 > Weathering tests show that sealants based on GENIOSIL® XM 25 retain their elasticity for years. The test samples were manufactured according to DIN ISO 7389 and were stretched twice their original length.

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Fig. 7 > GENIOSIL® XM 25 was developed for stressed expansion and connection joints. A typical application are expansion joints in buildings made of industrially prefabricated concrete parts, which are built in large numbers all over the world.

New Silane-Terminated Polymers: Versatile and Easily Mixable

The new silane-terminated polymers GENIOSIL® XM 20 and GENIOSIL® XM 25 meet both requirements and therefore open up applications in the adhesives and sealants sector that had previously been inaccessible to silane-crosslinking polymers The products are suitable as binders for one-component adhesives and sealants and offer many different formulation options. This versatility stems not only from their low viscosity, but also from their compatibility with all other silane-modified polymers from WACKER, with which they can be blended to the desired ratio.

Such blends offer scope for tailoring the properties of the binder system to the application. The two new polymers can serve either as the main binder or as a co-binder. On curing, they are chemically incorporated into the resulting network. Thanks to their low viscosity, GENIOSIL® XM 20 and GENIOSIL® XM 25 can be processed into sealants and adhesives that can be squeezed out of cartridges easily without the need for additional solvent. Compared to many conventional binders, such as polyurethanes, the low viscosity is an advantage.

High Elasticity, Low Modulus

Like all silane-terminated polymers marketed under the GENIOSIL® brand, the GENIOSIL® XM grades are silane-terminated polyethers. As is typical of silanes, they cure under the influence of atmospheric humidity.

Their molecules, unlike those of conventional silane-terminated polymers, only have a silane group at one of the two chain ends. The other end is inert to the crosslinking reaction. As a result, a wide-meshed network with long polymer chain segments develops. It takes only a little force to deform this. GENIOSIL® XM thus ensures high elasticity and a low modulus in the cured end products (Fig. 3).

So, formulators have the choice: they can use GENIOSIL® XM as a reactive plasticizer for migration free and high grade formulations especially intended for use in marine or industrial applications. Or they can substitute part of the standard polymer with GENIOSIL® XM, in order to modify its mechanical properties – a significant advantage when it comes to low modulus sealants.

GENIOSIL® XM 20 and GENIOSIL® XM 25 are slightly less polar than traditional silane-terminated polymers and consequently feature a broad adhesion spectrum. Furthermore, the absence, or reduction, of conventional plasticizers has a positive effect on the bonding properties. Formulations always contain bonding agents that compete with plasticizers for free bonding spaces on the substrate surface. Using GENIOSIL® XM as a reactive plasticizer and reducing the use of traditional plasticizers can improve the adhesion considerably.

WACKER applications engineers tested the adhesion on various substrates (Fig. 4). They found that formulations containing GENIOSIL® XM 20 and GENIOSIL® XM 25 adhere well not only to concrete, wood, aluminum and glass, but also to difficult substrates such as polyvinyl chloride (PVC), polystyrene (PS) and cured ethylene propylene diene monomer (EPDM) rubber. Here, the substrates were only cleaned in order to have them dust and oil-free.

Expansion Joints and Windows

GENIOSIL® XM 25, a gamma-silane-terminated polyether, is the binder component of choice for formulating low-modulus sealants with exceptionally high elastic recovery. If used as a co-binder, the sealants can exceed ISO 11600 specifications for low-modulus sealants. In the laboratory, test formulations achieved a modulus of less than 0.3 newton per square millimeter and a recovery of 80 to 90 percent, determined as per ISO 7389 (method B). (Diagrams 1+2, Fig. 5)

Possible applications for GENIOSIL® XM 25 include sealants for thermally stressed expansion and connection joints, especially where vulnerable joint edges need to be protected. A typical application is expansion joints in buildings made of industrially prefabricated concrete parts, which are built in large numbers all over the world (Fig. 6 and 7). Low-modulus sealants are also needed for connection joints – the joints between window frames and walls. The required sealants can be tailor-made with GENIOSIL® XM 25.

Binder for Universally Applicable Adhesives

GENIOSIL® XM 20 is an alpha-silane-terminated polyether. This grade opens the door to plasticizer-free, elastic adhesives with extremely high elasticity. In the lab-

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Fig. 8 > Application of a low modulus sealant based on GENIOSIL® STP-E35 and GENIOSIL® XM 25. These sealants are especially suited for stressed expansion and connection joints

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Fig. 9 > GENIOSIL® XM 20 is an alpha-silane-terminated polyether that allows the formulation of plasticizer-free, elastic adhesives with extremely high elasticity. Typical applications include wood-flooring adhesives and all-round adhesive sealants.

oratory, elongation at break values of over 700 percent were measured, depending on the formulation. The tested adhesive formulations achieved tensile strengths of up to 4 newton per square millimeter. Furthermore, GENIOSIL® XM 20 can extend skin-over time, a fact which is particularly beneficial for large-scale applications. This provides the user with sufficient tooling time. GENIOSIL® XM 20 is thus ideal as a binder component in wood-flooring and assembly adhesives (Fig. 8). It makes solvent- and plasticizer-free wood-flooring adhesives possible that do not require classification as a hazardous substance. Moreover, GENIOSIL® XM 20 allows the formulation of adhesives that feature a virtually universal bonding profile. With this kind of universal solution, construction workers are well-prepared for any adhesive sealant task that may arise on the building site. //

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Modulus

The modulus provides information on the stress-strain behavior of a material. To say that a material has a high modulus basically means that it is rigid. A large amount of force would be needed to deform it. This would involve a high build-up of mechanical stress. The modulus is determined by means of a tensile tester with the aid of precisely defined, dumbbell-shaped test pieces of the material under examination. In the sealants sector, the modulus is defined as the mechanical stress that builds up in a test piece when it is stretched to twice its length, i.e. by 100 percent. The terms tensile stress value, modulus 100 or just M100 are synonyms. The modulus is measured in newton per square millimeter.

Elastic Recovery

The elastic recovery provides information about the elasticity of the sealant and about how well it recovers after prolonged exposure to a tensile force. The test is performed as per ISO 7389, which permits two methods. For method A, a test piece of the sealant under examination is stored for 28 days at room temperature at 50 percent relative humidity, then stretched and relaxed again. In method B, several further alternating procedures – storage at 70 degrees Celsius in a drying cupboard and immersion in water – follow on from storage as per method A, before the test piece is relaxed. In both cases, the length of the test piece after relaxation is measured. This length is given as a percentage of the original length of the test piece. For example, a recovery of 70 percent (method B) means that, following storage as per method B and relaxation, the test piece regains 70 percent of its original length.

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