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Construction Fibres

Technical Note

Durability assessment Durus® S500

Service lives for 25, 50 and 100 years

In this technical note the durability of Durus® S500 is investigated by means of accelerated aging tests. The durability of the fibres is determined on fibre level, not on composite level (concrete — polymer).

Strength loss over time

PP degrades principally by oxidation, which is a reaction between the polymer and molecular oxygen. The molecular result of oxidation is the breakage of polymer chains, leading ultimately to a loss of strength and to an increase in the number of reactive functional groups. Oxidation of PP is a chain reaction whose initiation requires a source of energy for the generation of radicals which start the reaction. The source of energy is most commonly thermal energy, represented by the temperature of the material, but can also be provided by ultraviolet light or other high energy radiation.

The lifetime of existing polyolefin fibres under ambient conditions in concrete is usually so long that up to now there has been little experience of long-term changes in properties. This knowledge will no doubt increase with time. In addition, fibres once added to contrete are difficult to access or inspect, let alone do they allow for samples to be removed.

Life prediction therefore requires accelerated testing. To accelerate the tests, samples are put into an oven where the temperature is at a constant high level to determine oxidation resistance. Leaching test samples are stored in hot water. In this way the chemical reaction for both processes is speeded up and a prediction regarding life time can be made.

Screening test

Oven and leach tests are performed according to EN ISO 13438. The test conditions are as follows:

The test specimens are stored in water at 80 °C for 28 days before testing. The medium shall be changed every 7 days and moved once per day.
Test temperature of the oven is 100 °C.
Test duration depends on the service live:
- For service lives up to 25 years: 28 days
- For service lives up to 50 years: 56 days
- For service lives up to 100 years: 112 days

According to the annex B mentioned in the application norms EN13249 to 13257 and EN 13265 the strength after exposure should at least be 50% of its initial value to pass CE requirements.

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Alkaline resistance

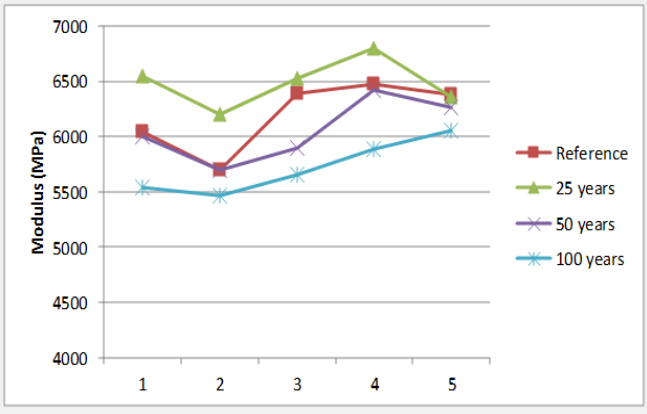
As these tests are designed to determine the degradation of synthetic products surrounded by soil, the resistance of the fibres to the alkaline environment of concrete needs to be taken into account.
In the paper "Durability of Polypropylene fibres in Portland cement based composites: eighteen years of data" of D.J. Hannant several beams were casted, cracked and subjected to natural weathering, storage in laboratory air, and storage under water for periods up to 18 years.
The beams subjected to natural weathering and laboratory air lost strength due to oxidation. The beams stored under water did not virtually loose strength. Water only contains approximately 1/5 of the oxygen compared to air. So the fibres were better protected against oxidation which shows that PP is not affected by the alkaline environment.

Fibre performance

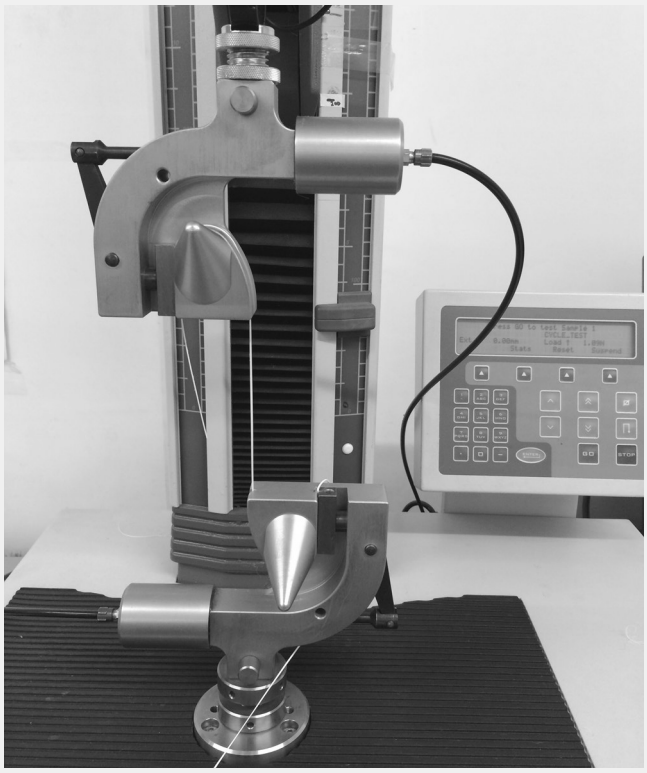
To determine the tensile strenght and modulus reduction, 10 different filaments were aged and tested for each service live in order to minimise measurement deviation. In total 30 monofilaments were aged and tested and compared with the inital values of the monofilament.

After ***aging to 25 years***, the tensile strength and the modulus of the fibre were determined. It was observed that the strength of the fibres only dropped with 12%. The Modulus of the fibre however remained unchanged, in fact it increased with 4.5%.

After ***aging to 50 years***, the tensile strength dropped with 20% of the initial strength. Once again the modulus of the fibre was hardly effected. A reduction of modulus of 2.6% was observed. The fact that the modulus is not affected in the same way can be explained. The modulus depends on the tensile strength and the elongation of the fibre. The tensile strength drops due to the degradation of the polymer chains



Effect on Modulus 10-30%Fmax Durus® S500



Tensile test of Durus® S500 filament according to EN

in the fibre, this has a negative effect on the modulus. However, the shorter the molecular chains, the more brittle the fibre becomes. Less elongation has a positive effect on the modulus of the fibre. So while the fibre is degrading it has little effect on the modulus of the fibre.

After ***aging to 100 years***, the tensile strength dropped with 32% of the initial strength. The modulus of the fibre was reduced with 7.1%.

Conclusion

According to the Annex B of the previous mentioned application norms, the retained strength after exposure according to EN 13438 should at least be 50% of its initial value.

As the Durus® S500 range stays well above the limit of 50% retained strength, the product proves to be durable enough to withstand the degradation process in time.

For a fibre which satisfies the requirements of this annex the service life represents a minimum indication. The real service life, for normal conditions of use, may turn out to be considerably longer without major degradation affecting the essential requirements of the works defined in the CPR.

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