Buzzi Unicem

Buzzi Unicem SOLIDUR®

Pre-mixed, ready-to-use for self-hardening plastic mixtures

Special products

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Solidur® is a pre-mixed, ready-to-use product consisting of cementitious mineral binders, clay and Bentonite components in addition to special additives. The formula contains only high-quality Bentonite, without the use of chemical additives.

Solidur® is made up exclusively of mineral components, and it can be prepared on-site thanks to a a specific production technology.

Solidur® is delivered in powder form, with the plastic mixture being produced at the worksite by quickly mixing the powder with water, in special high-speed mixers equipped with automatic dosing systems. In just a few minutes, a stable, self-hardening mixture is obtained, ready for use. The suspension stays workable for a sufficient period of time, which varies depending on the application, and can be pumped even to distances exceeding one kilometer. Once the plastic slurry hardens, it will have acquired the waterproofing and resistance characteristics required by the job. Thanks to **Solidur®**, the benefits obtained in terms of economic management of the worksite are significant, since:

- No need for curing tanks for the Bentonite, as required by conventional systems, thus saving space and time

Requirements of Solidur® self-hardening plastic mixtures

Generally you must provide a fitness pre-qualification. for materials used in the production of a mineral plastic mixture for waterproof barriers.

When requested for specific worksites, a preliminary study is carried out, taking soil, groundwater or percolate samples of the site where jobs need to be carried out, followed by laboratory analyses aimed at pinpointing the best mix of components for the specific location, and such as to meet the technical specifications of the project.

Additional advantages of using **Solidur®** are represented by the simple and cost-effective worksite tools, in addition to the excellent homogeneous quality of the pre-mixed product. The quality checks are simple and quick: the product is mixed with regular water, and can be used immediately.

In order to obtain a stable waterproof barrier, the suspension has to achieve pre-established density and viscosity values. For each construction procedure a stability test needs to be carried out, taking into account the respective framework conditions. In addition to the soil and load conditions, one needs to take into account the characteristics of the suspension, such as density, viscosity, stability, workable time and environmental friendliness. Certain simple test methods characterize a suspension for waterproof barriers: viscosity determination through Marsh funnel, suspension density through Barroid scale (or electronic scale + graduated cylinder) and decantation with a graduated cylinder.

When the slurry for waterproof barriers hardens, depending on the production procedure, the waterproof barrier forms; the barrier must have minimum compression strength and be waterproof. Additional requirements are the deformability and resistance to erosion, as well as long-term durability and environmental-friendliness. In specific applications, a certain resistance to seeping water is also necessary, for example in the case of belting of landfills as passive protection against floods or surrounding water-bearing stratum.

- It cuts down on labor
- It simplifies the worksite system as it takes up limited space
- It reduces checks thanks to constant product characteristics.

Solidur® avails itself of a wide range of tested and certified recipes under both the "permeability" hydraulic profile and the profile of environmental chemical-physical "resistance to chemical attacks, erosion".
The product "families" are made up of: **Solidur®** 274, **Solidur®** 274 Speciale and **Solidur®** 273 which differ depending on the density of the plastic mixture and on the performance characteristics of the hardened material.
Completing the range, **Solidur®** 270 specifically developed for hydraulic engineering works. **Solidur® Erdbeton** used for the packaging of plastic concretes.

Onsite tests:
- Workability test using a Marsh funnel
- Density check using a Barroid scale
- Decanting test with cylinder

Reference standards concerning control tests and characterization of the self-hardening plastic mixture

Tests	at the worksite Fluid plastic slurry	in the laboratory hardened plastic slurry
Suspension preparation	DIN 4127	-
Density	UNI 11152 Part 6 DIN V 4126-100	-
Marsh funnel	UNI 11152 Part 13 DIN V 4126-100	-
Decantation	UNI 11152 Part 11 DIN V 4126-100	-
Permeability	-	DIN EN ISO 17892-11
Cutting force	-	BS 1377 Part 7
Shrinkage / Expansion	-	UNI 8996
Compression resistance	-	UNI 11152 Part 21 UNI EN196-1 prism 40x40x160mm DIN EN ISO 17892-7 prism /cylinder
Initial set time	UNI 11152 Part 19	-
Practical duration of suspension use	UNI 11152 Appendix A	-

Casting of **Solidur®**

Reference standards concerning the building of barriers
• UNI EN 1538 •Province of Milan Guidelines • DIN V 4126-100 • DIN 4127 • ÖNORM B 4452

Current uses

Plastic barrier with trenching

- Barriers excavated with grab bucket
- Barriers excavated with drag shovel
- Barriers excavated with hydro milling machine
- Barriers consisting of secant piles
- Composite barriers using mixture and HDPE membrane
- Thin barrier excavated by means of the vibro-piling of steel formworks

Plastic barrier using trenchless technology

- Thin barrier built with Vibro-Jet technology
- Composite thin barrier with Vibro-Jet sheet piles and HDPE membrane
- Thin barrier built by means of one-way laminated jet grouting

Vertical and horizontal barriers

- Vertical waterproof barriers built with Jet Grouting technology
- Horizontal waterproofing with "bottom plug" through high or low pressure injections

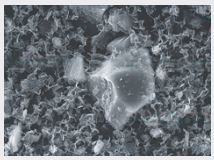
Filling in and isolation of underground gaps

- Injection and filling of urban underground gaps and cavities using a product that can be dug up in the future, if necessary, just like compact clay
- Filling of underground power lines, between the cable and protective conduit (gas, etc.)

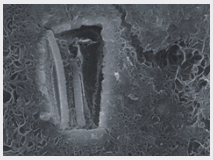
Advantages

- **Solidur®** is a ready-to-use mixture with quality guaranteed by the producer
- Direct product use, with no need for curing storage tanks. Solidur® is mixed with water only, to obtain a ready-for-use, stable, self-hardening mixture in just a few minutes
- Simplicity of the worksite system, with lower investments and limited occupation of space, guaranteeing large productions
- Reduction in labor
- High impermeability, superior to the one obtainable with common mixtures for the same thickness
- Quality of materials and, consequently, of the finished work
- Highly resistant to erosion
- Highly resistant to chemical attacks
- Stable over time
- Compliance with the most stringent technical specifications
- Constant product characteristics, with relevant reduction of control testing at the worksite
- Mixture can be prepared ad hoc, according to the worksite characteristics and the technical specifications of the project
- Skilled technical assistance

Solidur® under the microscope



after 1 day



after 28 days

Examples of recipes			Solidur® 270 for hydraulic engineering	Solidur® 274	Solidur® 274 speciale	Solidur® 273
Dose rate		kg / m³	250	250	480	800
Water		kg / m³	910	910	820	700
Suspension density		g / cm³	1,16	1,16	1,30	1,50
Marsh funnel flow time		s / dm³	34	34	43	< 70
Decantation		vol. – %	< 2	< 2	< 2	< 2
Permeability	after 28 days	m / sec	< 1E – 8	< 5E – 10	< 1E – 10	< 5E – 10
	after 90 days	m / sec	< 5E – 9	< 1E – 10	< 5E – 11	< 1E – 10
Strength	after 28 days	N / mm²	ca. 0,6	ca. 0,8	ca. 1,2	ca. 1,0

Construction technique

Waterproof plastic barrier, with TWO-PHASE excavation

The two-phase construction process makes it possible to build plastic barriers. The excavation operations are similar to the ones for structural barriers, however in this case the Bentonite slurry is replaced by a self-hardening plastic mixture with jet from the bottom up, collecting the initial jet in special tanks subject to depuration of the fine particles, which must be suitably disposed of by taking them to special landfills. It is easy to see the increase in costs and labor required by this procedure. In order to make the self-hardening plastic mixture, **Solidur®** can be used, although the procedure with single-phase excavation would seem to be more cost-effective and simpler from a technological standpoint.

Waterproof plastic barrier, with SINGLE-PHASE excavation

In this case, a self-hardening plastic mixture carries out both the role of perforation fluid and, once it has set, the role of low-permeability septum. It also allows the construction of underground works in a single phase, combining the excavation and casting operations. This procedure is the most popular one and it is by far the simplest and most cost-effective (one-phase construction process); it is adopted, for example, in the construction of landfills or to secure them by means of belting barriers, to waterproof water defense works, to reclaim contaminated sited, etc. The **Solidur® 270**, **Solidur® 274**, il **Solidur® 274 Speciale** or il **Solidur® 273** are used for these jobs. At times, special membranes in HDPE (High Density PolyEthylene) are inserted in these waterproof plastic barriers to better withstand the hydraulic pressure or, in order to fight the active horizontal push of the soil, trench sheets or anchored steel profiles may be added.

Building of barriers with single-phase excavation

Securing of industrial sites

60-cm barrier. Barriers up to 1.2 m wide can be built

Solidur® for environmental engineering [landfills and contaminated sites]

When constructing and reclaiming landfills, vertical barriers are built similar to the ones used to consolidate foundations. Usually, a special layer of horizontal clay (natural pre-existing or artificial), waterproofs the bottom of the landfill. The waterproof plastic barrier used to contain the site has to prevent, on the one hand, groundwater from penetrating inside the landfill and, on the other, the percolate from leaking out. The isolation techniques of landfills and sites to be reclaimed must be classified into the following categories:

Passive perimeter containment system:

- barrier wall anchored in the underlying waterproof substrate
- barriers suspended in the aquifer

Passive base isolation systems:

- Waterproofing using "bottom plug" by means of high or low pressure injections. In Italy and in the rest of Europe, barriers consisting of self-hardening mixtures are the ones most frequently used.

Several parameters affect the performances of such systems:

- the type and dosage of the individual materials employed
- the mixing procedures
- the application techniques

This means that many preliminary tests are needed in order to qualify the materials and the construction techniques for the barriers.

The use of **Solidur**®, as testified by the numerous references, has shown itself to be the ideal technical-economic solution, ensuring compliance with the most restrictive specifications requirements.

Solidur® Erdbeton based plastic concrete

Solidur® Erdbeton (from the German ERDE = earth or ground) is used to make impermeable plastic concrete by mixing the product in the mixing plant with aggregates of suitable particle size (preferably 0-8 mm).
A plastic concrete is used when it is necessary to obtain a very high density, approximately 1800 to 2000 kg/m3, which cannot be achieved with the normal self-hardening plastic mixtures without compromising the features of very low permeability (k< 5E-11 m/s) and maintaining an ultimate compressive strain ≥ 1% on average.
The use of **Solidur® Erdbeton** - based plastic concrete is especially indicated in the formation of very deep barriers created in two phases, where, in order to cast the concrete from the bottom up by means of jet pipe, it is necessary to have a high density product to replace the bentonite slurry of the excavation of the barriers, without mixing of the two materials mixing. **Solidur® Erdbeton** can also be used in cases in which the soil is sandy or not compact and with moving groundwater, to prevent the washout of the impermeable septum just created and to better support the excavation.
Solidur® Erdbeton makes it possible to obtain plastic concrete with extremely low permeability (using aggregates sourced on site) and high resistance to chemical attack, avoiding phenomena of segregation in the concrete (slump class S5) despite the high percentage of bentonite in the formula, which is necessary for ensuring low permeability.

Construction of an impermeable barrier using cased secant piles. Casting of **Solidur®** Erdbeton plastic concrete

Solidur® for hydraulic engineering

For hydraulic defense works, containment banks are built, which, depending on the soil used to build them, at times need waterproof barriers. The function of these vertical barriers is mainly to prevent the water current to flow through, but also to avoid siphoning phenomena ("hydrological outflows"), preventing water from flowing underneath the bank, a situation that, over time, would cause the risk of instability of the work due to the prolonged erosive action. In hydraulic engineering works, **Solidur®** is also used to waterproof excavations in the presence of water and in the deep barriers of dams with considerable hydraulic loads. These hydraulic barriers can be built by applying the trenchless thin barrier technique with thickness of 10÷25 cm, using **Solidur® 273**, or through trenched barriers with thickness of 30÷120 cm, using **Solidur® 270**, **Solidur® 274** or **Solidur® 274 Speciale**.

Solidur® for special foundations

Solidur® self-hardening plastic mixtures have been used for many years now in Germany and in Northern Europe to build composite barriers of self-hardening slurry + steel (for example, "Larssen", "Hoesch", "HEB"profiles). The plastic slurry initially acts as a drilling fluid and stabilizer of excavation walls. Afterwards, before the plastic mixture of the final barrier has set, steel sections are inserted. After setting, the system acquires the requested mechanical and hydraulic properties for the finished work.

Trench sheet paced inside the barrier with **Solidur®** still in the liquid state

Technical specifications

Plastic mixture for waterproof plastic barrier

The self-hardening plastic mixture used to make the barrier will consist of a **Solidur**® -type mixed product made of mineral binders such as special cements, clay components, furnace slag and special additives, with composition verified beforehand and maintained constant during the course of the processing. The mixture will have to guarantee certain performances: in other words it will be required to meet functional requirements requested by the project and demonstrated by suitable documentation to be submitted during the tender phase. This documentation will include the results of permeability tests in triaxial cell (according to DIN EN ISO 17892-11) proving the performances of the mixture and the results of breaking compression tests. During the preliminary phase, the contractor will proceed to verify the characteristics of the mixture to be employed, carrying out volumetric yield, density, viscosity, simple compression strength and permeability tests.

The specimens prepared for the preliminary tests will be made using aqueduct water or water from another procurement source, while for the aging of samples and the permeability tests, water possessing the same characteristics of the groundwater that will wet the barrier walls will be used; to this end, in case of contaminated sites, piezometers will be available, carried out during the characterization process for the taking of water samples. The specimens must be aged completely immersed in groundwater, at a constant temperature of 20°C, and subjected to the tests described above after 28 days from the date on which they were prepared.
Once the composition that satisfies the requirements for building the barrier have been determined, such composition having to be approved by the Jobs Supervisor, the mixture will be delivered in powder form on a tractor-trailer, equipped with document confirming its origin, the certification and relevant quality checks of the transported products, drawn up by the Supplier's plant.

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La miscela plastica autoindurente, prelevata all'impianto di confezionamento, dovrà presentare le seguenti caratteristiche:

- Marsh viscosity ….. seconds
- Decantation after 2 hours < 2%
- Density ….. g/cm^3

The solidified suspension will have the following characteristics:

- Simple compression resistance after 28 days ….. N/mm^2
- Permeability in triaxial cell after 28 days ≤ ….. m/s

As time goes on, no. 3 mixture samples must be taken every 300 m^3 from the production plant, in special cylinder-shaped containers to be sent to a qualified laboratory. After 28 days of aging from the production date, the following tests must be carried out: density, volumetric yield, simple compression resistance and permeability. The samples must be aged completely immersed in water, at a temperature of 20°C.

The specimens for permeability tests must have a cylindrical shape, with diameter 100 mm and height 100 mm. For simple compression resistance tests, specimens with a prism-like shape 40x40x160 mm can be used, or cylindrical shape with diameter 50÷100 mm and height that is double the diameter. All cylindrical-shaped specimens must be obtained from the longest samples.

Nota: *The instructions provided above are the result of our best experience and are merely indicative. No responsibility is taken for defects or damages caused by misuse of the product or when the conditions of its use differ from our instructions. The Technical Assistance Department is always available for any advice and suggestions concerning proper use of the product and for the performance of technical tests.*

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