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Development
Originally the Soilfracturing process was used in the oil industry to frac sub soils to create paths for the oil to flow toward the oil wells. In the sixties, Keller engineers adapted this process and developed several solutions to problems in the geotechnical field. Soilfrac® is a registered Trademark of the process used by Keller.

Position in the market
Where classical grouting techniques for voidfilling for foundations or restoration of structures is not suitable or the lifting of structures is required, the Soilfrac-process fills the gap within the circle of different grouting techniques. Together with the newly developed measuring and control techniques as well as special observation devices it is possible to lift structures by several decimeters.
The Soilfrac® Process

In using this process fractures in the soil are created which are then filled with grout. Each soil formation may be improved by multiple grouting treatments and controlled lifting may be induced.

Application limits for the grouting processes

<table>
<thead>
<tr>
<th>Process</th>
<th>Clay</th>
<th>Silt</th>
<th>Sand</th>
<th>Gravel</th>
<th>Cobbles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soilfrac®</td>
<td>lv</td>
<td>lv</td>
<td>hv</td>
<td>lv</td>
<td>lv</td>
</tr>
<tr>
<td>Soilcrete-Jet Grouting®</td>
<td>lv</td>
<td>lv</td>
<td>hv</td>
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<tr>
<td>Compaction Grouting</td>
<td>lv</td>
<td>lv</td>
<td>hv</td>
<td>lv</td>
<td>lv</td>
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<tr>
<td>Synthetic Solutions</td>
<td>lv</td>
<td>lv</td>
<td>hv</td>
<td>lv</td>
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<tr>
<td>Sodium Silicate Solutions (lv)</td>
<td>lv</td>
<td>lv</td>
<td>hv</td>
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<tr>
<td>Silicate Gel (hv)</td>
<td>lv</td>
<td>lv</td>
<td>hv</td>
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<tr>
<td>Ultrafine Cement</td>
<td>lv</td>
<td>lv</td>
<td>hv</td>
<td>lv</td>
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<tr>
<td>Cement suspension</td>
<td>lv</td>
<td>lv</td>
<td>hv</td>
<td>lv</td>
<td>lv</td>
</tr>
<tr>
<td>Mortar</td>
<td>lv</td>
<td>lv</td>
<td>hv</td>
<td>lv</td>
<td>lv</td>
</tr>
</tbody>
</table>

Partical size (mm)

Passing-Weight (%)

Clay: 0.002, 0.006, 0.02, 0.06, 0.2, 0.6, 2.0, 6.0, 20, 60
Silt: 0.002, 0.006, 0.02, 0.06, 0.2, 0.6, 2.0, 6.0, 20, 60
Sand: 0.002, 0.006, 0.02, 0.06, 0.2, 0.6, 2.0, 6.0, 20, 60
Gravel: 0.002, 0.006, 0.02, 0.06, 0.2, 0.6, 2.0, 6.0, 20, 60
Cobbles: 0.002, 0.006, 0.02, 0.06, 0.2, 0.6, 2.0, 6.0, 20, 60

lv = low viscous
hv = high viscous
**Construction site installation**

**Installation point**

1. **Sleeve pipe installation**
   Sleeves are installed into the soil formation to be treated and the annular space between the borehole wall and sleeve pipe sealed with a stiff cement-bentonite mixture.

2. **Soil fracturing**
   To allow the injection of the Soilfrac® suspension a grout hose equipped with a double packer at the tip is inserted into the sleeve pipe. The double packer seals the sleeve pipe on either side of the sleeve, thus allowing the grouting of each single sleeve along the section to be treated.

3. **Multiple grouting**
   The sleeves along the grout pipe may be grouted once—or several times—according to the technical requirements. The grout quantity, the max. grout pressure—and in case of repeated grouting—the setting times are maintained according to instructions. Sleeve pipes may remain reusable for long periods.
**Foundation Restoration**

Individual footings and subsoils are components of the foundation of a structure. In the course of time both may fail due to a number of reasons. This occurs quite often in the case of historical buildings.

In the event of excessive settlements – Soilfrac® is a suitable process to restore the link between the base of the structure and competent soil formation.

For the treatment of natural stone foundations, which have either moved or cracked or the mortar has decomposed or been removed, the classical grouting technique may be applied by adapting the type of grout mix. Lifting of structures in a poor condition is seldom required – but also possible.

Specific working parameters are illustrated separately

- **A** Grid
- **B** Deformation foundation level
- **C** Grout pressure
- **D** Grout quantity
- **E** Foundation
- **F** Sleeve pipe fan

The Soilfrac®-process is used for foundation restoration where settlements have to be stopped such as, where natural and artificial soil distortion occurs, mining activities create problems, non-load bearing soil exists, or partial sections must be lifted.
Restoration of the steeple by means of the Soilfrac®-process and cement stabilization of the nave.
Lifting of Structures

Settlement of structures can be rectified by the Soilfrac®-process. Depending to the condition of the building and the soil the lifting speed is adjusted accordingly.

Precise partial lifting within a millimeter is combined and added to a total lifting in the decimeter range without damaging the structure. Lifting of structures is normally performed without restricting their use.

1. Insertion of the grout hose into the sleeve pipe.
2. Partial repositioning and rehabilitation of the river pier of a highway – bridge.
3. Lifting of the discharge ramp of a refuse incineration plant.

Restoring leaning structures to a vertical position is a spectacular event such as the efforts in connection with the leaning tower of Pisa. In some cases only a partial restoration is sufficient to achieve a satisfactory technical result as well as improving the esthetic view of the structure.
High rise building restored to the vertical position

Preparatory works for an extension caused the leaning of a high rise building. After installation of an extensive control point system to measure the vertical movements a sleeve pipe fan was installed in accordance with the lifting requirements. Within 5 months a total lifting of 60 mm was achieved.
Protection of Structures

To protect structures against predictable settlements during tunnel construction horizontal sleeve pipe fans between tunnel roof and the building foundation will be installed from temporarily shafts. The building to be protected will be equipped with an electronic measuring system for registration of vertical movements.

Primary grouting - up to appearance of lifting tendencies-consolidate the soil mass, followed by a predetermined lifting operation reflecting the size and form of the expected settlement trough due to tunnel driving.

According to the local situation the tunnel will be excavated in one operation or in a number of segments. The settlement occurring during the tunneling works will be adjusted – either partially or to the full amount. The quick reaction in respect of the developing deformations reduces larger differential tensions within the structures, an advantage of the Soilfrac® process compared with other technical solutions.

The protection of structures against settlements from tunnel and mining activities is an important application of the Soilfrac® process. This technique was used for the first time by Keller for a subway project in the Ruhr area of Germany in 1985.
Structure protection during subway construction in a large European city. Installation of horizontally located sleeve pipes from shafts to protect the old town.