# The RSS® Flüssigboden method according to RAL quality mark 507 (RAL-GZ 507)

A development of the Forschungsinstitut für Flüssigboden (Research Institute for Liquid Soil) FiFB – since 1998

## Technical basics and planning opportunities

Information on the liquid soil method – as of 26.06.2019

# What is RSS® Flüssigboden?

## Basics

1. **A new method** for the preparation and use of **any excavated soil without the formation of foreign bodies** under the road, and for the first time suitable to obtain properties typical for soil.
2. **A backfill material** for various applications in the field of infrastructure and geotechnology.
3. **A development** of the research institute for liquid soil (FiFB), now in use for about 20 years.

# RSS® Flüssigboden according to RAL-GZ 507, construction material group of TFSB (ZFSV)

## **T**emporarily **f**lowable, **s**elf-compacting **b**ackfill materials

cohesive, frictional solidification (liquid soil)

material without forcing, rigid foreign structures

hydraulic setting

material with forcing, rigid foreign structures (eg cement stone)

**Regulation on RAL Quality and Testing Specifications**

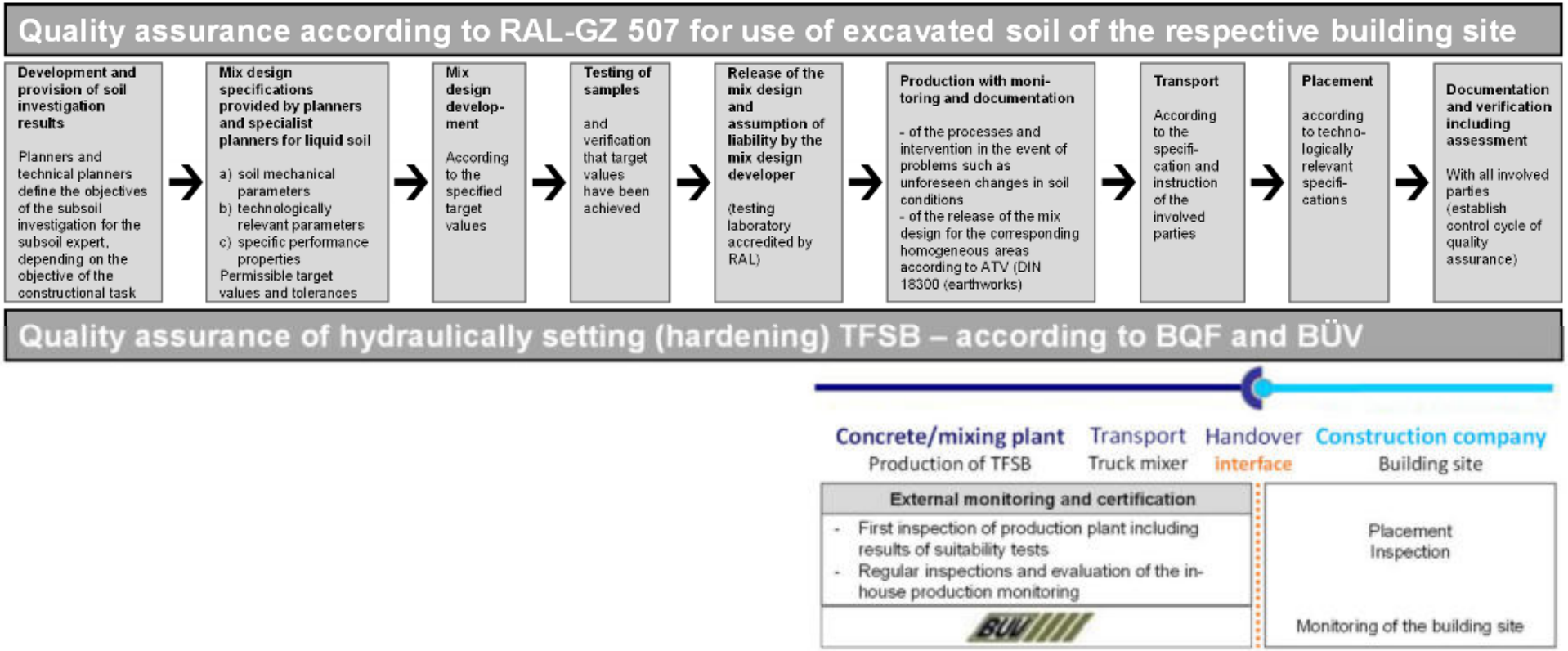
**First regulation on FGSV information sheet**

System of the temporarily flowable self-compacting backfill materials

Source: Wikipedia - Flüssigboden (German)

# Differences between the two groups of TFSB

Differences between Flüssigboden according to RAL-GZ 507 and other TFSB from the quality assurance process with implementation of the requirements of the new ATV DIN 18300 for homogenous areas and the (German) Circular Economy Act (Kreislaufwirtschaftsgesetz, KrWG)



# RSS® Flüssigboden according to RAL-GZ 507 provides us with three tools

## Possibility to maintain important properties of the excavated soil

- In terms of construction physics its behaviour is similar to the surrounding soil
- Same load bearing capacity as surrounding soil
- Same consolidation behaviour as surrounding soil
- No different settlements
- Therefore no cracks in the road
- “Foreign bodies" in the ground are avoided

## Possibility to adjust relevant properties

- Duration of resolidification
- Pumpability
- Buoyancy behaviour
- Retention capacity in corresponding placement situations
- Thixotropy and other rheological properties
- Stability against segregation etc.

## Possibility of targeted modification of properties

- Elasticity behaviour
- Flexural and longitudinal tensile strength
- Shear strength
- Cohesion can be modified
- Adhesion can be controlled
- Vibration damping
- Density
- Water permeability
- Good relaxation properties as basis of permanent frictional forces
- Heat storage
- Heat dissipation
- Heat insulation
- Improved protection against corrosion
- Frost-thaw behaviour can be modified
- Resistance against suffosion
- Resistance against abrasion

# What is RSS® Flüssigboden?

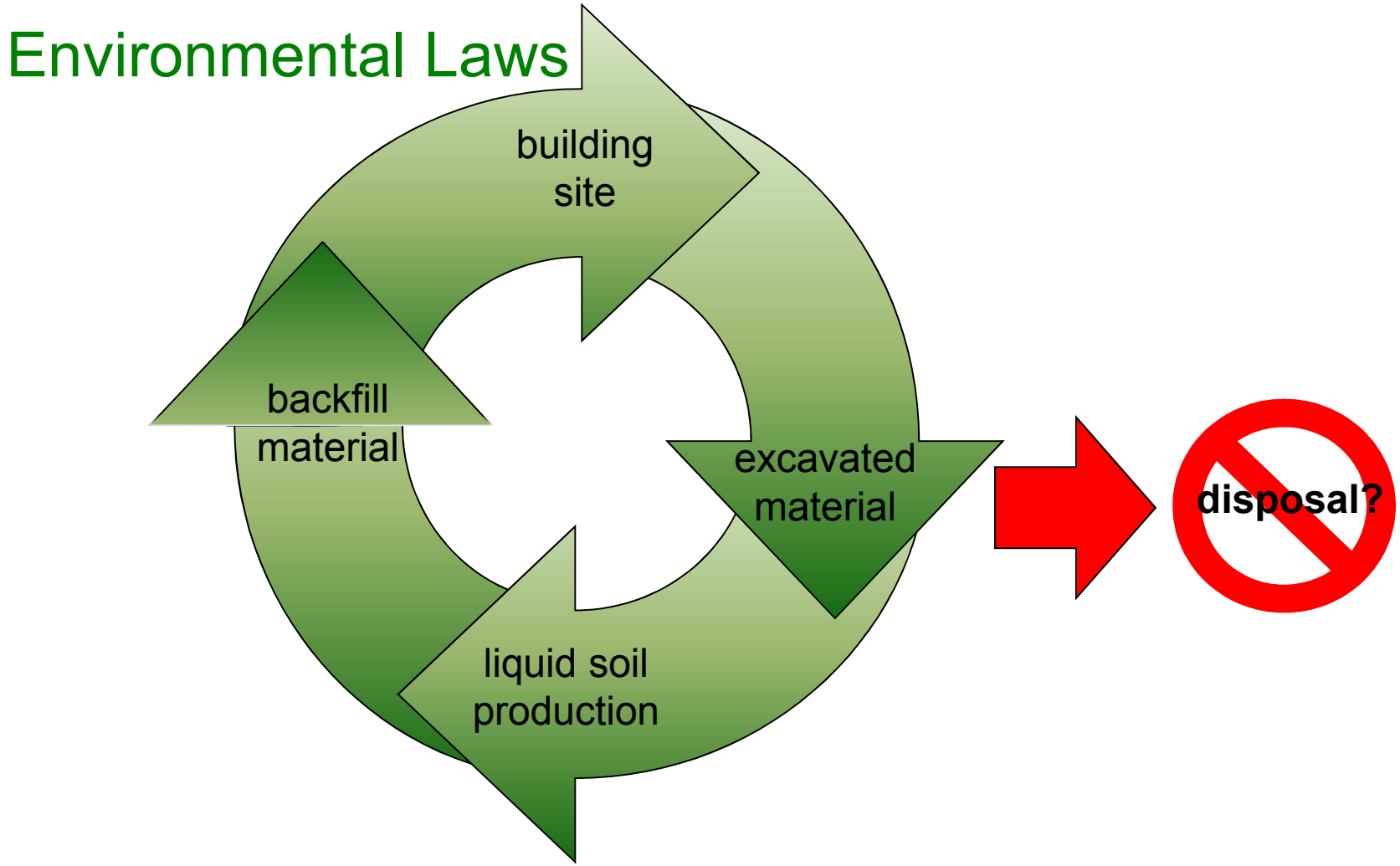
## Development since 1998

- developed by the Forschungsinstitut für Flüssigboden GmbH (FiFB) in the framework of more than 40 research and development projects to date with national and international partners, eg:
  - Siemens and practice partners – thermally stabilizing liquid soil since **2004 resp. 2009**
  - RWTH, Aachen, Germany – vibration damping, avoidance of pipe deformation **since 2005**
  - FFI Fernwärme Forschungsinstitut, Hannover, Germany (district heating research institute) amongst other things – district heating applications **since 2006**
  - TU Dresden and other partners – immobilisation **since 2006 resp. 2008**
  - SP Technical Research Institute Sweden – Application of liquid soil in winter **since 2007**
  - City of Dortmund, Ruhr University Bochum, Office Stein – combined conduits and liquid soil **since 2007**
  - State Technical Petroleum University, Ufa - winter construction and pipeline construction **since 2009**
  - Regensburg University of applied sciences – Basic research and other subjects **since 2009**
  - EBA as a partner for the testing of railway applications – after 12 years – used **since 2013** with the required certificates of suitability

    and may other partners **and subjects**

# Why RSS® Flüssigboden ?

*Liquid Soil and Environmental Laws*

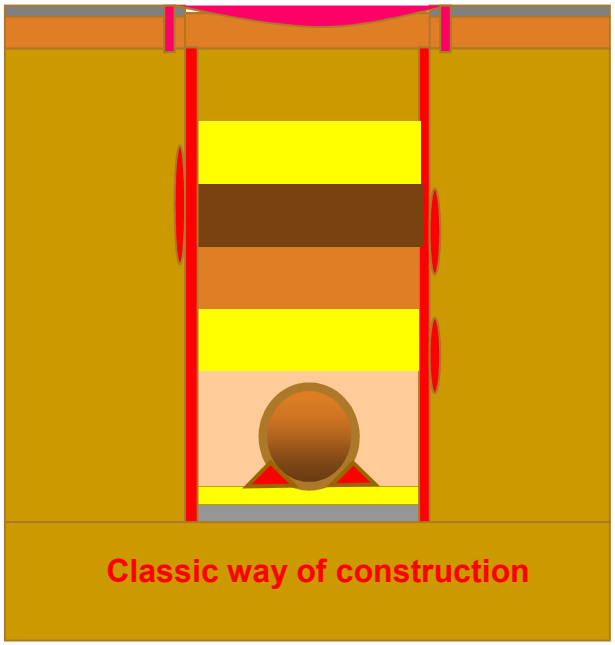



**Protecting the environment and takeing advantage of that!**

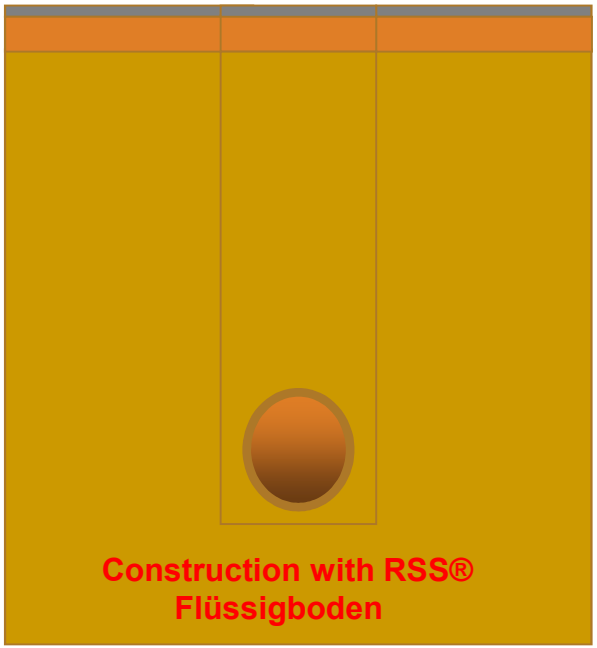
# Why RSS® Flüssigboden ?

*Liquid soil – underground grids and road construction*

***Possible for the first time** – the preservation of soil-typical properties and their significance for the failure-free service life of roads and networks*




backfill area with:
**non-soil** behaviour




backfill area with:
**soil-like** behaviour

see eg ZTVA 12 StB or damage analyses by
Zeller und Kottmann, Stuttgart, Germany

# Why RSS® Flüssigboden ?

*Liquid soil – safe problem solutions by means of technical planning*

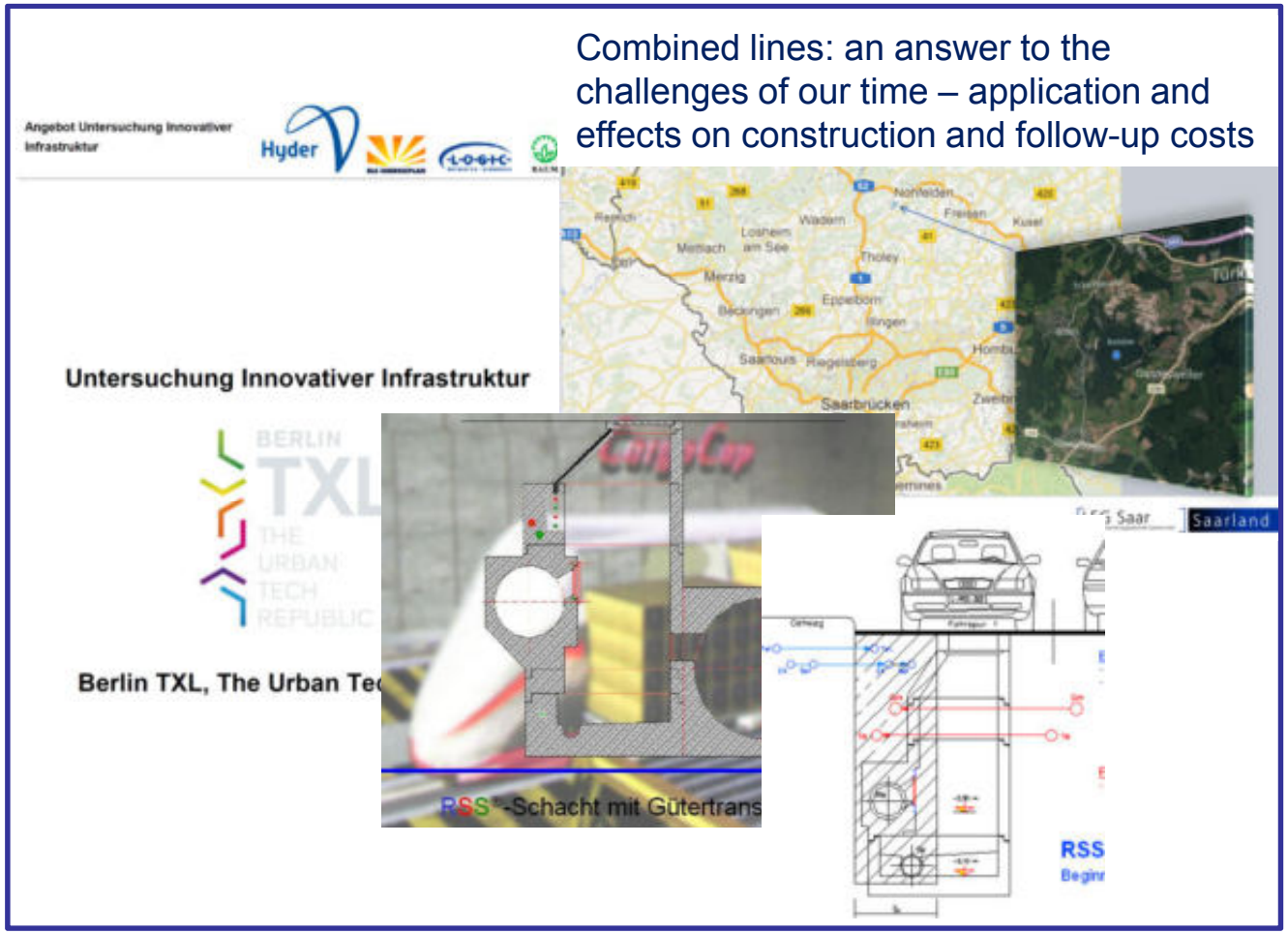
*There are already more than 170 options available for solving structural tasks, some of them in completely new ways – technical planner assumes liability*

- *Starting 22 years ago with sewer and pipeline construction*
- *Later also road, motorway, tunnel and railway construction applications*
- *Today with technologies for construction in and under water*
- *Hydraulic engineering, port construction, coastal protection, off shore tasks*
- *Building on unstable substrates, on slopes*
- *Civil engineering and special underground engineering up to landfill construction*
- *Slope stabilization, prevention of ground breakage, etc.*
- *Redevelopment of industrial brownfields and contaminated soils*
- *Excavation pits under complicated conditions, eg groundwater, limited space, etc.*
- *and many other applications – some examples are presented*

# Why RSS® Flüssigboden ?

*Liquid soil and urban planning*

## Opportunities for urban planning



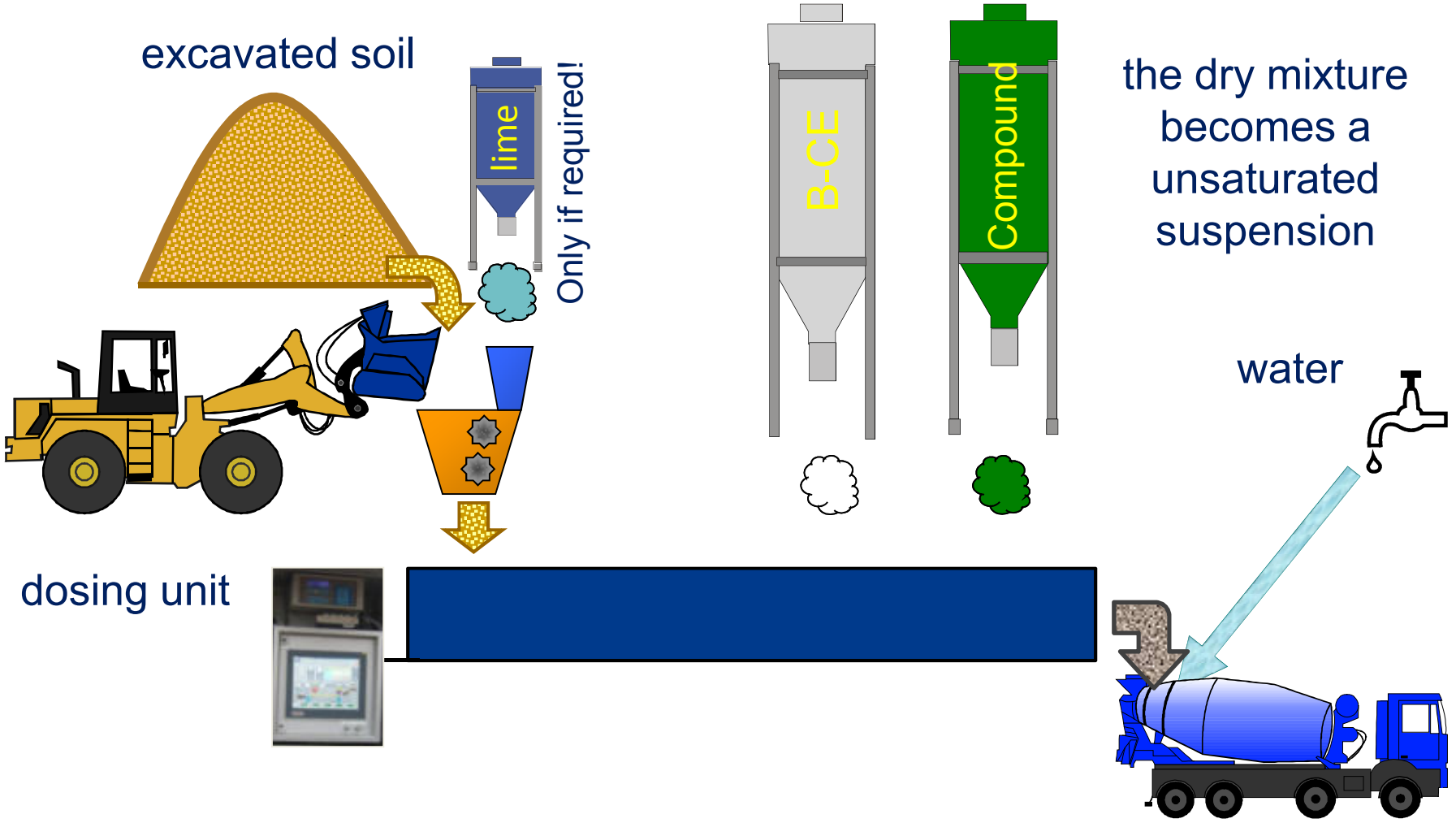

**Urban planning:**

Advising municipalities on the urban planning opportunities associated with the application of the liquid soil method, supplemented by flexible combined lines and intelligent concepts for construction, operation and maintenance.

eg space for new traffic solutions, flexibly adaptable networks and more will be possible for the first time

# RSS® Flüssigboden according to RAL-GZ 507

## Liquid soil production



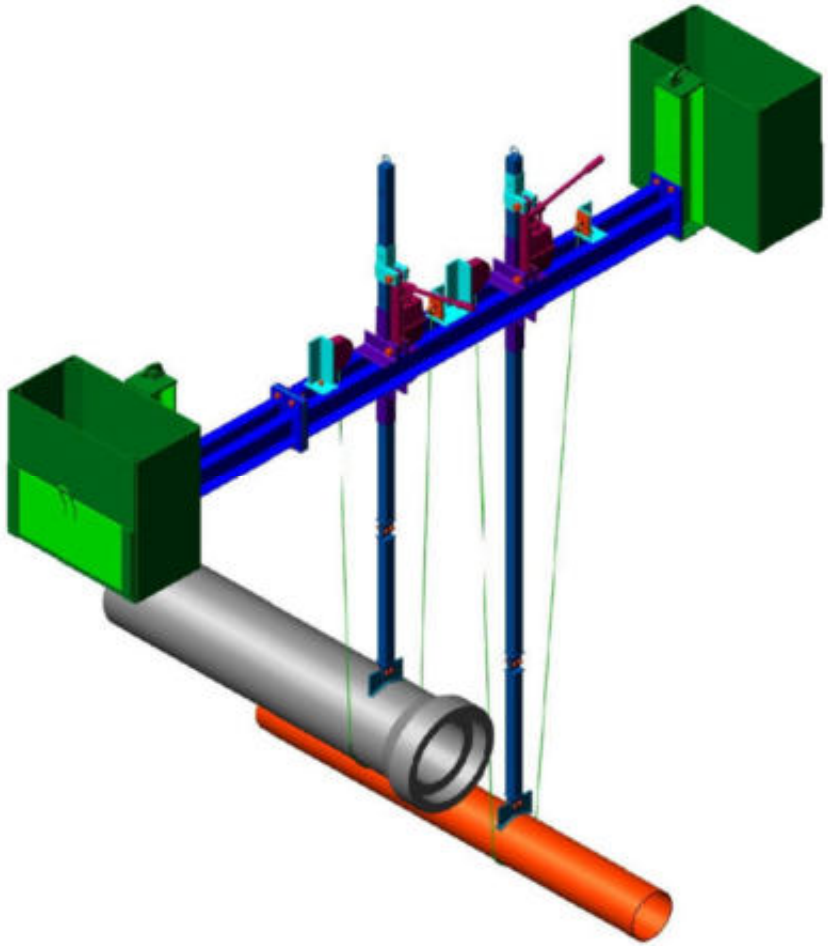
# Production equipment – compact unit


**Source: -PROV- Produktions- und Vertriebsgesellschaft mbH – RSS Maschinentechnik**

# Production equipment – shovel separator


**Source: -PROV- Produktions- und Vertriebsgesellschaft mbH – RSS Maschinentechnik**

# Placement equipment – Pipe laying aids anti-buoyancy and measurement devices



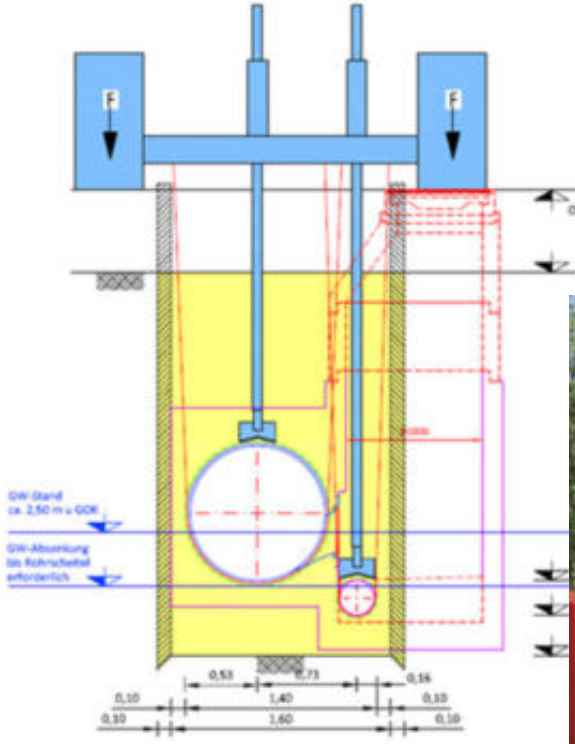
**Source: -PROV- Produktions- und Vertriebsgesellschaft mbH – RSS Maschinentechnik**

# Placement tools – pipe laying aids as part of the system technology for constructions with RSS® Flüssigboden

**- a modern aid for economic working with RSS® Flüssigboden -**

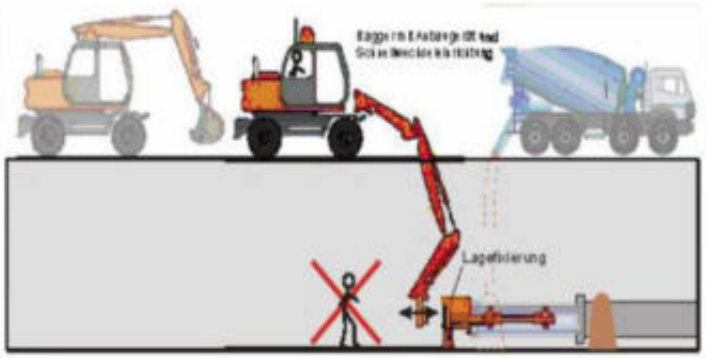
## Pipe laying with higher groundwater levels

using the **RSS Pipe Laying Aid**




# … and even more technical innovations

## Pipe laying without workers in the trench – remote controlled from the excavator and with pipe laying aids:



**New technical solutions** with high efficiency and as a basis for high construction quality – here for building with new technologies

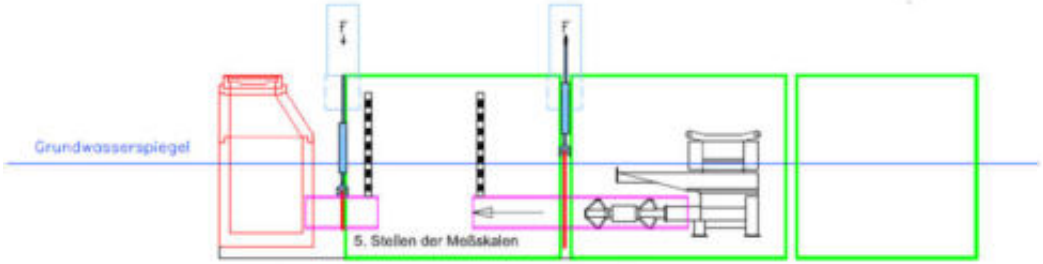
Source: -PROV- Produktions- und Vertriebsgesellschaft mbH – RSS Maschinentechnik

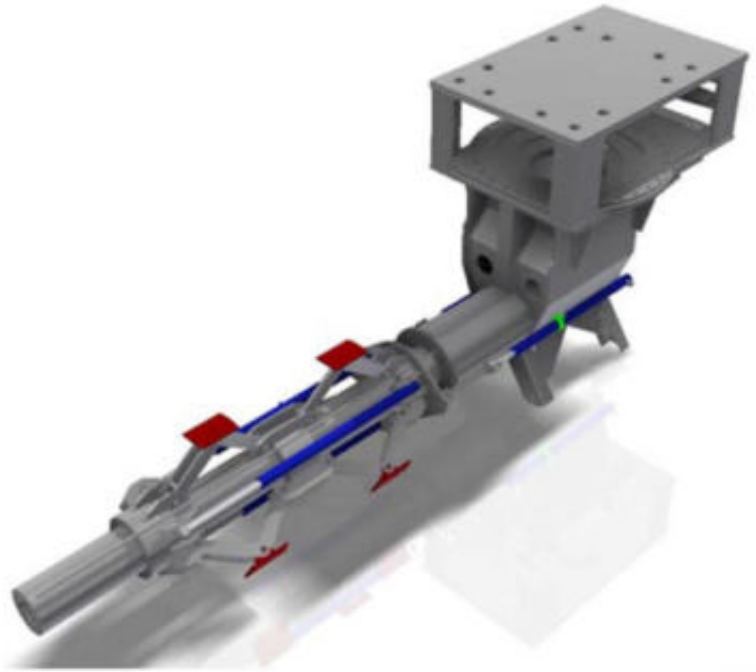
# Placement equipment – Pipe laying manipulator as part of the system technology for constructions with RSS® Flüssigboden

**- a modern aid for economic working with liquid soil -**

## Pipe laying in water (RSS PLM and RSS PLA)

schematic representation of a type solution with the **RSS pipe laying manipulator (PLM)** in combination with the **RSS pipe laying aid (PLA)**

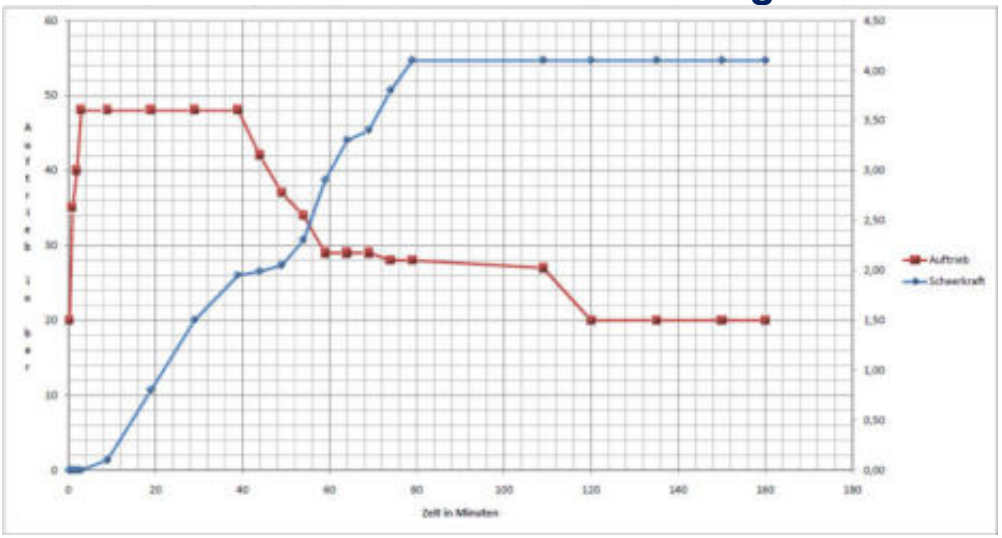


# Alternative solutions with verification – here of the lining – task of the technical planner for RSS® Flüssigboden applications

## alternative lining solutions are possible if one can secure their application:

eg when using liquid soil, it is possible apply a lining with slabs instead of a sheet pile wall (verification required – refixing, shearing force, etc.) – **after the removal of the lining, the liquid soil assumes the function of the lining.**




**Source: Archive RSS® Flüssigboden building sites**

# Experiences with RSS® Flüssigboden

## Possible applications of RSS® Flüssigboden according to RAL-GZ 507

Source: Archive RSS® Flüssigboden building sites

- Material, which does not shrink in placed conditions,
- enables a permanently good pipe bedding with a 180° bearing.
- Thus, load relief of the pipe and no settlements
- basis for a long operating life of the pipe without damages

# Experiences with RSS® Flüssigboden

## Possible applications of RSS® Flüssigboden according to RAL-GZ 507 – Source soils of all kinds

"London Clay" as source material for liquid soil

Soil with a high content of humins as source material for liquid soil

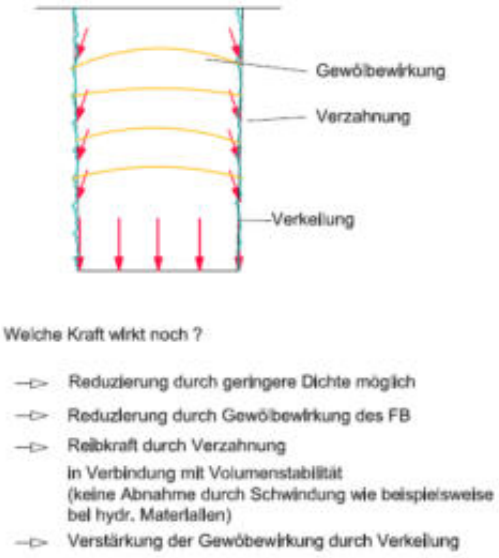
Blue clay as source material for liquid soil

**Reuse of all relevant soil types** for the production of liquid soil as a possibility of fulfilling the legal environmental requirements

**Source: Archive RSS® Flüssigboden building sites**

# Experiences with RSS® Flüssigboden

## Possible applications of RSS® Flüssigboden according to RAL-GZ 507




**New technologies,** eg the floating laying in groundwater by means of specially adjusted liquid soil on the basis of a special verification and planning

**Need for verifications** to ensure usability, such as the verification of no shrinkage occurring permanently, and the necessary relaxation capacity of the applied liquid soil, as the basis for the permanent position stability of the pipe under static and dynamic loads.

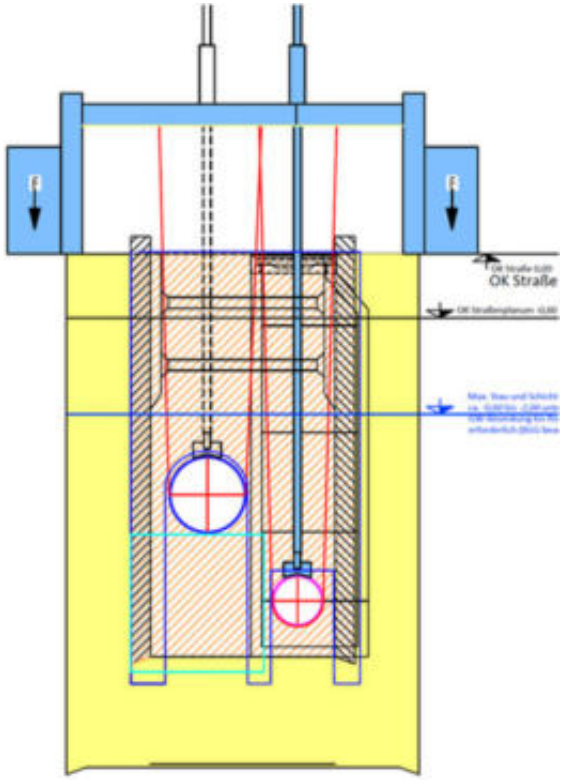
# Experiences with RSS® Flüssigboden

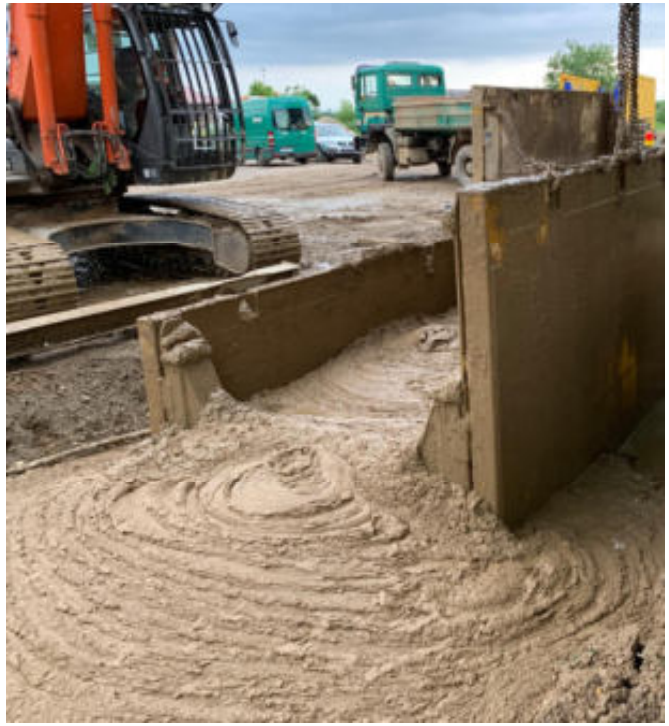
## Possible applications of RSS® Flüssigboden according to RAL-GZ 507 – sewer construction under water

# Experiences with RSS® Flüssigboden

## Possible applications of RSS® Flüssigboden according to RAL-GZ 507 – sewer construction under water

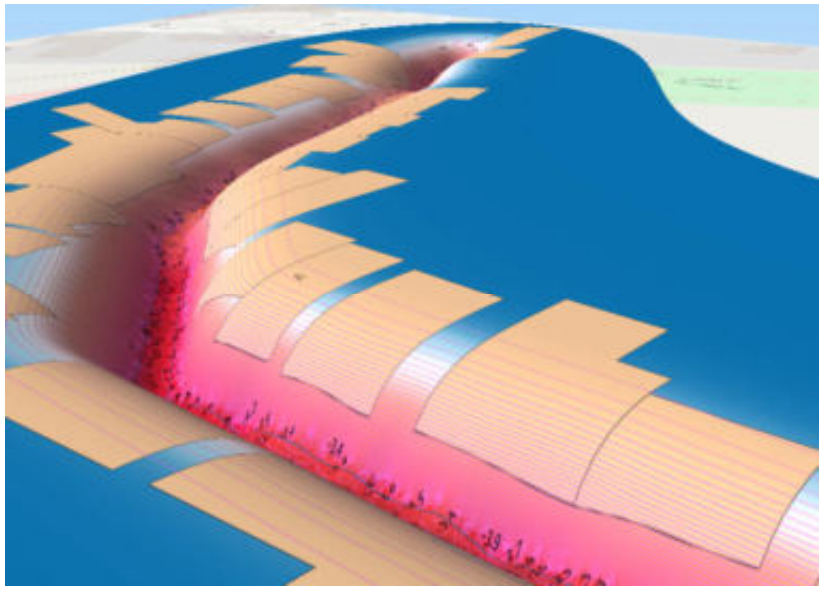
**New technologies** such as the so-called Dutch construction method in groundwater with very high water levels and/or many crossings in the area of groundwater impact and small nominal diameters of sewage pipes



# Experiences with RSS® Flüssigboden

## Comparison of conventional dewatering with the possibilities of the RSS® Flüssigboden method

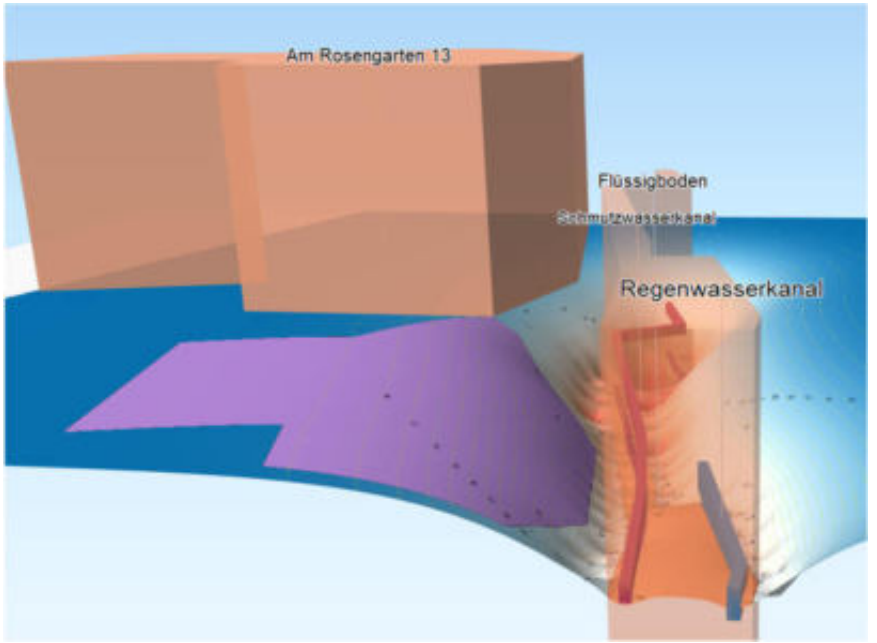


**Loss of load-bearing capacity under buildings**

- settlements occur under the buildings as a result of the groundwater lowering
- high costs due to groundwater lowering
- high risk of unplanned consequential damage
- high workload and long construction time

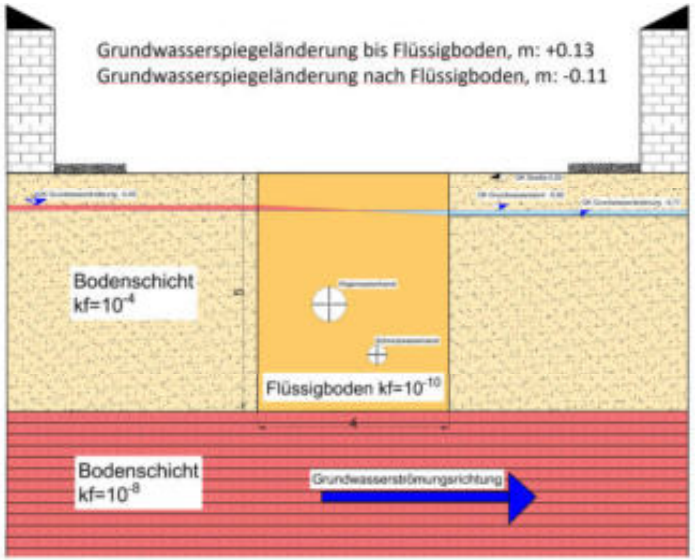
**Lowering funnel for groundwater lowering by means of filter wells:**

- Lowering of the groundwater level to 0.5 m below the bottom of the trench is necessary for conventional compaction
- Loss of incompressibility of the water-filled pore spaces of the ground under the buildings



# Experiences with RSS® Flüssigboden

## Safeguarding the use of RSS® Flüssigboden when working below the groundwater level

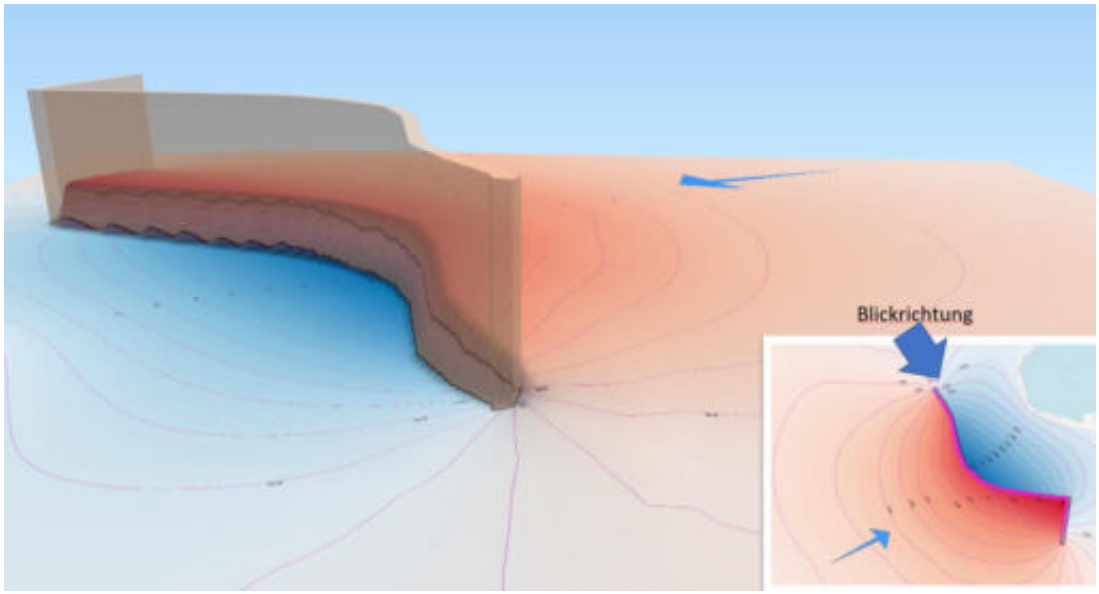



**Alternative liquid soil construction method and results of the use of a hydrogeological model**

- No loss of load-bearing capacity under the buildings, as no lowering of the groundwater level is required
- Costs of groundwater lowering do not arise
- No risk of unplanned consequential damages
- Reduced effort and shorter construction time

**Results of hydrogeological modelling**

- Quantifications of backwater as a result of different water permeabilities of the soil layers and the liquid soil
- Derivation and planning of the necessary measures to prevent backwater



# Experiences with RSS® Flüssigboden

## Possible applications of RSS® Flüssigboden according to RAL-GZ 507

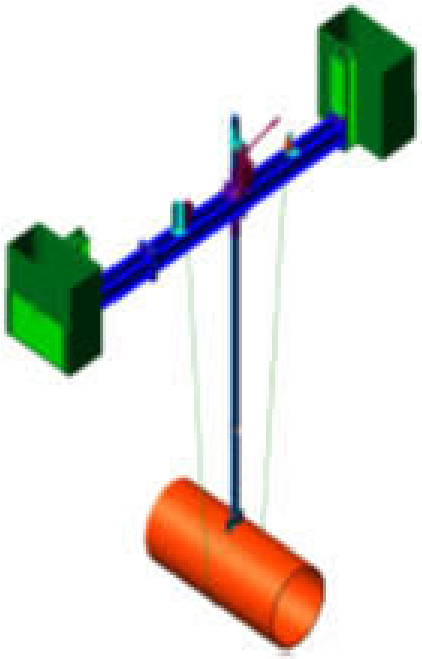
**Timed construction instead of long open trenches:** targeted and technologically relevant properties of the liquid soil allow for quick, timed construction processes (Also suitable for ground cables in an adapted form!)

Source: Archive RSS® Flüssigboden building sites

# Experiences with RSS® Flüssigboden

## Possible applications of RSS® Flüssigboden according to RAL-GZ 507

**Combination of liquid soil** here with suction dredger technology to ensure high construction performance even in the case of crossings and subterranean obstacles



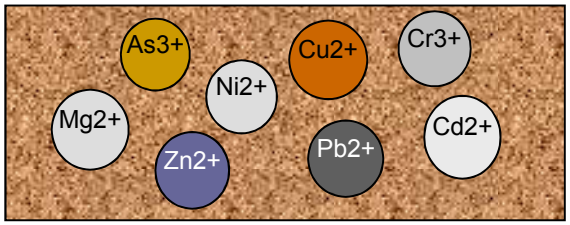
Source: Archive RSS® Flüssigboden building sites

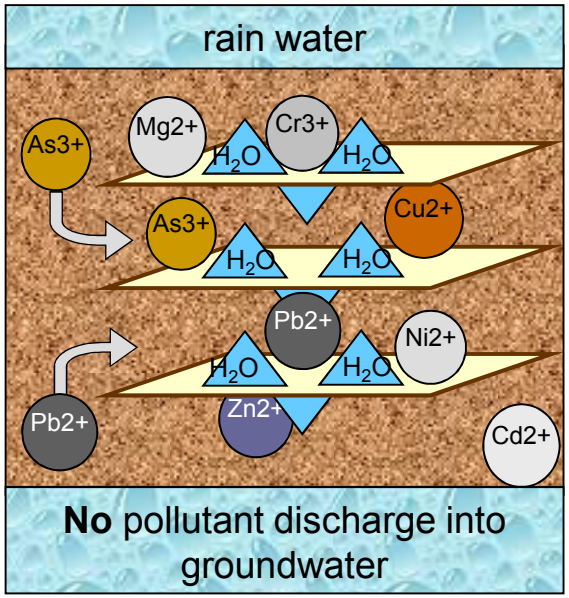
# Experiences with RSS® Flüssigboden

## Possible applications of RSS® Flüssigboden according to RAL-GZ 507

**Dealing with contaminated soils:**

- Immobilisation of contaminated soils with different types of contaminations using the example of heavily contaminated sludge and slag
- here: Luxembourg – Arcelor/Mital Esch Belval




**Source: Archive RSS® Flüssigboden building sites**

# Experiences with RSS® Flüssigboden

## Possible applications of RSS® Flüssigboden according to RAL-GZ 507

**Subsoil stabilisation and alternative foundation concepts:**

- Production of stable grounds built on and made of conventionally unsuitable material

**Source:** Fa. Die Bau GmbH, building site Rheinfelden, Germany

**Source:** Archive RSS® Flüssigboden building sites – Offenburg, Germany

# Experiences with RSS® Flüssigboden

## Possible applications of RSS® Flüssigboden according to RAL-GZ 507

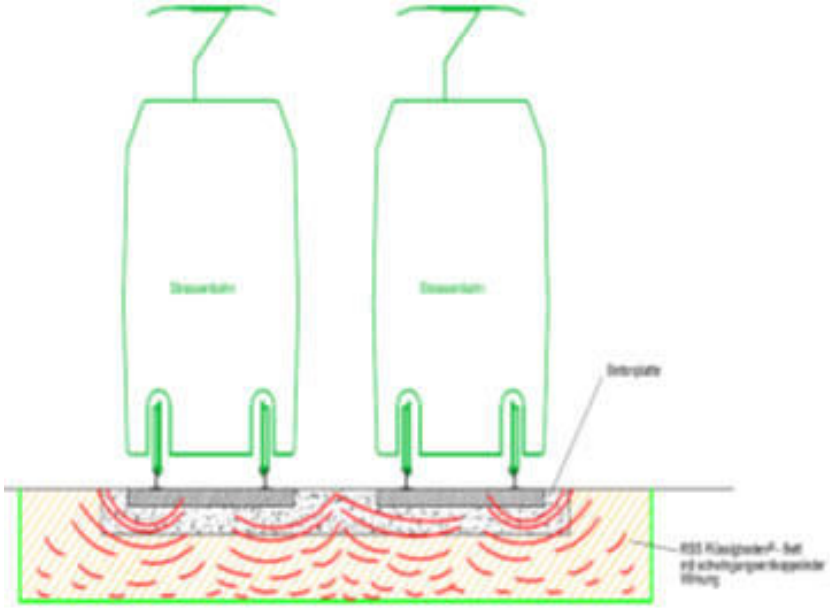
**Control of technologically relevant properties:**

- Backfilling of a high-pressure gas pipeline on a slope with liquid soil according to RAL-GZ 507
- Working at a slope of 40-45 degrees with pump – the material does not flow off
- Securing the abutment function
- Significant reduction of construction time

**Source:** Archive RSS® Flüssigboden building sites

# Experiences with RSS® Flüssigboden

## Possible applications of RSS® Flüssigboden according to RAL-GZ 507



## Vibration isolation and damping:

Protection of materials, buildings and people from the effects of dynamic loads eg from tramway construction

# Experiences with RSS® Flüssigboden

## Possible applications of RSS® Flüssigboden according to RAL-GZ 507

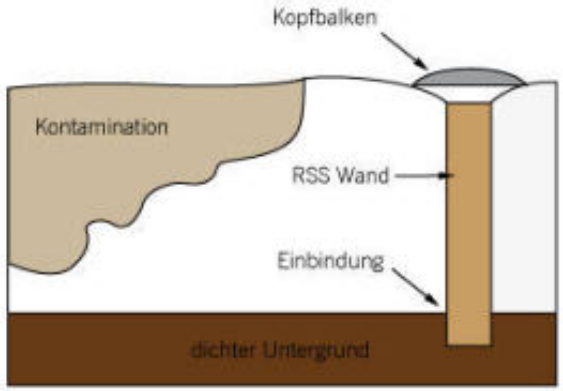
**Applications in monument conservation:**

eg protection of old, listed buildings against vibrations and water by the use of liquid soil

**Source: Archive RSS® Flüssigboden building sites**

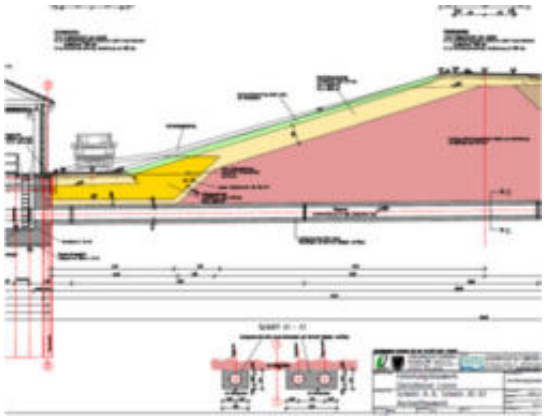
# Experiences with RSS® Flüssigboden

## Possible applications of RSS® Flüssigboden according to RAL-GZ 507




### Applications in civil engineering:

- Construction of supporting walls and sealing walls
- Landfill construction, eg encapsulation of contaminated areas
- Core seals for dams,
- trough design etc.

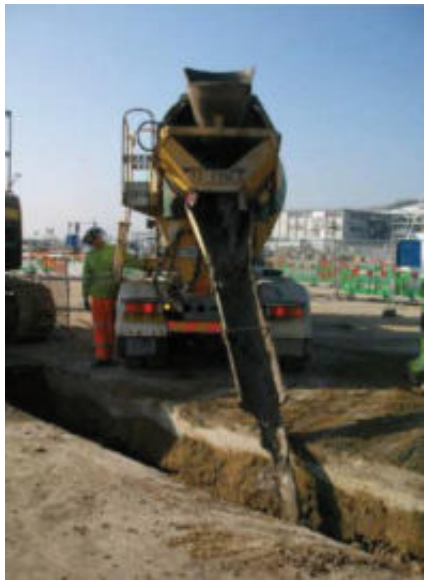



# Experiences with RSS® Flüssigboden

## Airport construction with RSS® Flüssigboden according to RAL-GZ 507

# Experiences with RSS® Flüssigboden

## Airport construction with RSS® Flüssigboden according to RAL-GZ 507



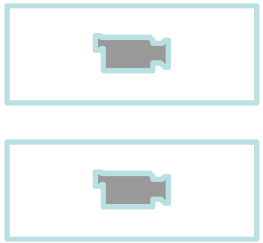
**Various applications at airports:**

- Constructing on poorly load-bearing grounds
- Constructing in and under water
- Construction of support walls and sealing walls
- Vibration damping
- Re-use of the excavated soil without replacement and disposal outside the airport
- Reuse of contaminated soils, e.g. de-icing agents, kerosene, etc.


# Experiences with RSS® Flüssigboden

## Possible applications of RSS® Flüssigboden according to RAL-GZ 507

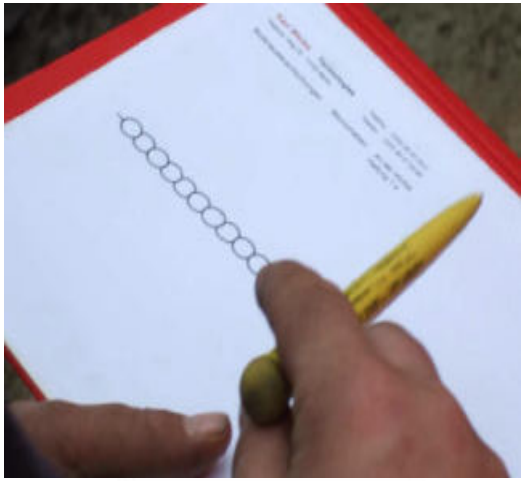
- **Sealing wall**
- **Core seal**

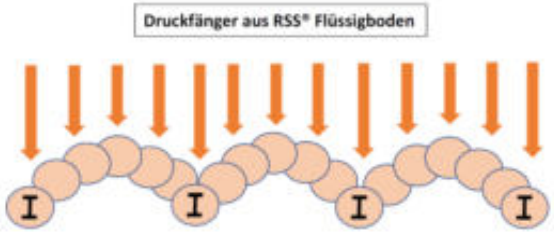


# Experiences with RSS® Flüssigboden

## Possible applications of RSS® Flüssigboden according to RAL-GZ 507

Overlapping bored pile walls with particularly high load bearing capacity with additional reinforcement and high relaxation






# Experiences with RSS® Flüssigboden

## Possible applications of RSS® Flüssigboden according to RAL-GZ 507

RSS® wall as a sealing excavation pit lining, supplemented by an also water-tight foundation slab made of liquid soil underneath the concrete slab – grouted anchors not become unnecessary

# Experiences with RSS® Flüssigboden

## Possible applications of RSS® Flüssigboden according to RAL-GZ 507


RSS® wall as sealing excavation pit lining, supplemented by a waterproof slab made of RSS® Flüssigboden, thus no need for tieback, waterproof sheet piling, and recovering any reinforcement

# Experiences with RSS® Flüssigboden

## Possible applications of RSS® Flüssigboden according to RAL-GZ 507

**Source:** Archive RSS® Flüssigboden building sites

**Railway applications:**

Use of liquid soil to achieve high load bearing capacity with simultaneously usable vibration decoupling and solubility

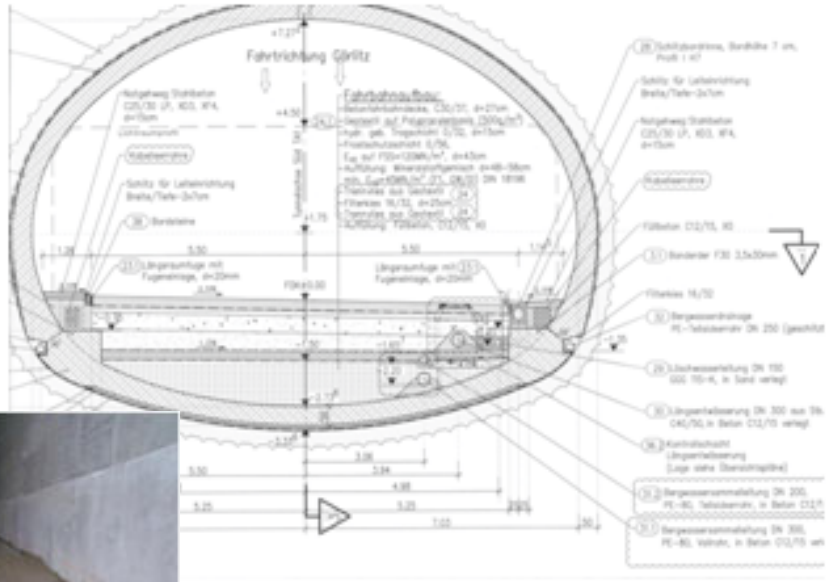
# Experiences with RSS® Flüssigboden

## Possible applications of RSS® Flüssigboden according to RAL-GZ 507 in tunnel construction

**Applications in tunnelling:**

- base layers
- backfilling of cavities
- relocating lines
- problems with water
- vibration decoupling

etc.



**Source: Archive RSS® Flüssigboden building sites**

# Experiences with RSS® Flüssigboden

## Possible applications of RSS® Flüssigboden according to RAL-GZ 507

Road construction on "floating" slab made from RSS® Flüssigboden  example project train station Offenburg, Germany

# Experiences with RSS® Flüssigboden

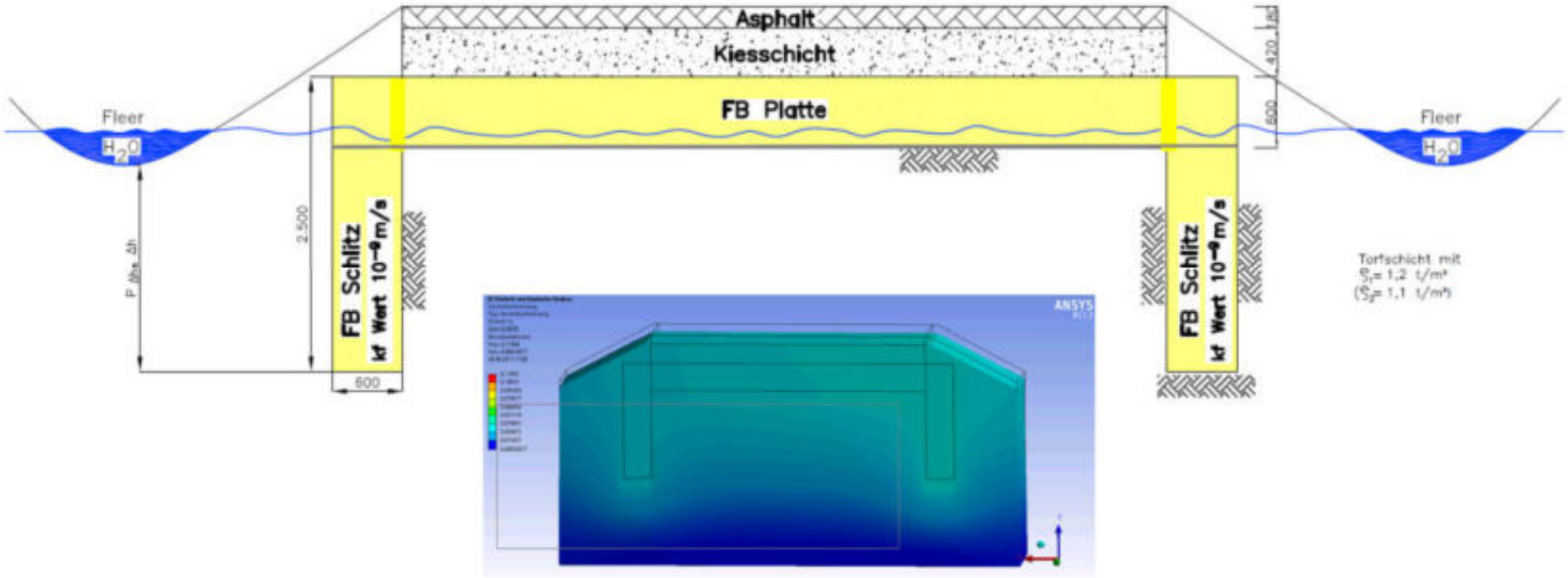
## Possible applications of RSS® Flüssigboden according to RAL-GZ 507

Road construction on soft plastic subsoils or mud

# Experiences with RSS® Flüssigboden

## Road construction with RSS® Flüssigboden according to RAL-GZ 507

Foundation slab laterally framed to minimise settlements via counter-pressure controllable by slot depth



# Experiences with RSS® Flüssigboden

## Road construction with RSS® Flüssigboden according to RAL-GZ 507

Protection of the existing buildings as well as of the installed pipes against dynamic loads from road traffic due to high absorption of vibrations by liquid soil – example: Project Barth, Germany

Darstellung der Geschwindigkeit aus den Versuchen am Messpunkt 2

| Einzelwerte | f < 10 Hz | | f = 10..50 Hz | | f = 50..100 Hz | |
|---|---|---|---|---|---|---|
| Grenzwert | 5 mm/s | | 5 ... 15 mm/s | | 15 ... 20 mm/s | |
| Messdatum | 24.11.03 | 01.12.03 | 24.11.03 | 01.12.03 | 24.11.03 | 01.12.03 |
| X-Achse | 1,62 mm/s | 0,04 mm/s | 5,23 mm/s | 0,15 mm/s | 1,41 mm/s | 0,14 mm/s |
| Y-Achse | 1,50 mm/s | 0,09 mm/s | 4,80 mm/s | 1,02 mm/s | 1,82 mm/s | 0,47 mm/s |
| Z-Achse | 1,58 mm/s | 0,05 mm/s | 7,21 mm/s | 1,07 mm/s | 2,31 mm/s | 0,26 mm/s |
| Maximalwert auf Achse: | X | Y | Z | Z | Y | Y |
| mit Wert | 1,62 mm/s | 0,09 mm/s | 7,21 mm/s | 1,07 mm/s | 2,31 mm/s | 0,47 mm/s |
| Abstand zum Erreger | 2,0 m | 2,0 m | 2,0 m | 2,0 m | 2,0 m | 2,0 m |

Messung am 24.11.03 ohne eingeordneten Flüssigboden
Messung am 01.12.03 mit eingeordneten Flüssigboden

**Source:** Archive RSS® Flüssigboden building sites

# Experiences with RSS® Flüssigboden

## Road construction with RSS® Flüssigboden according to RAL-GZ 507

Slope protection with liquid soil – front side subject to pressure lateral surfaces transfer load via frictional forces

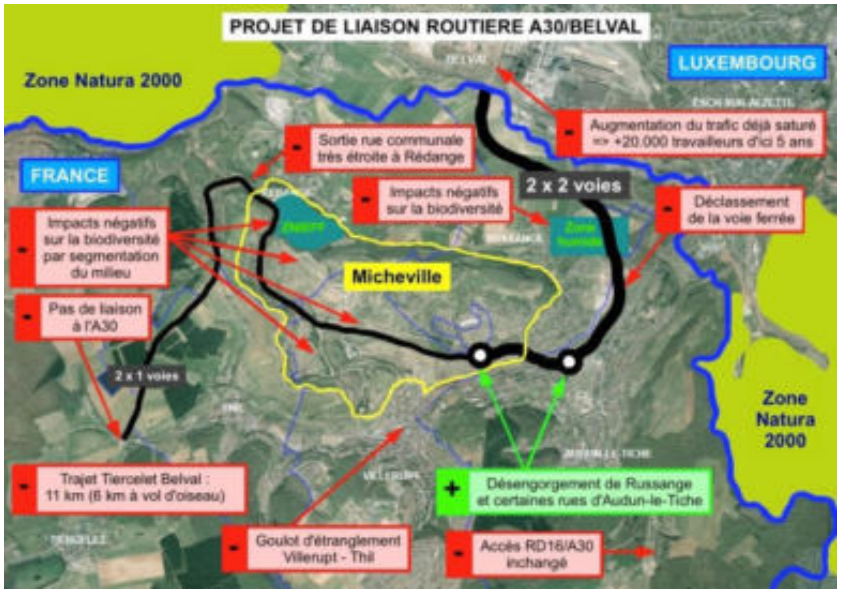

**Source:** Archive RSS® Flüssigboden building sites

# Experiences with RSS® Flüssigboden

## Road construction with RSS® Flüssigboden according to RAL-GZ 507

Liquid soil as a load-distributing layer under motorways, tramways, etc.

**Source:** Archive RSS® Flüssigboden building sites

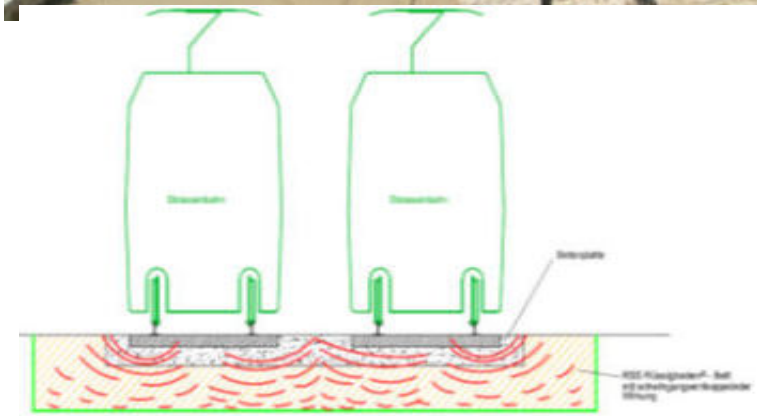



Motorway construction Luxembourg – France

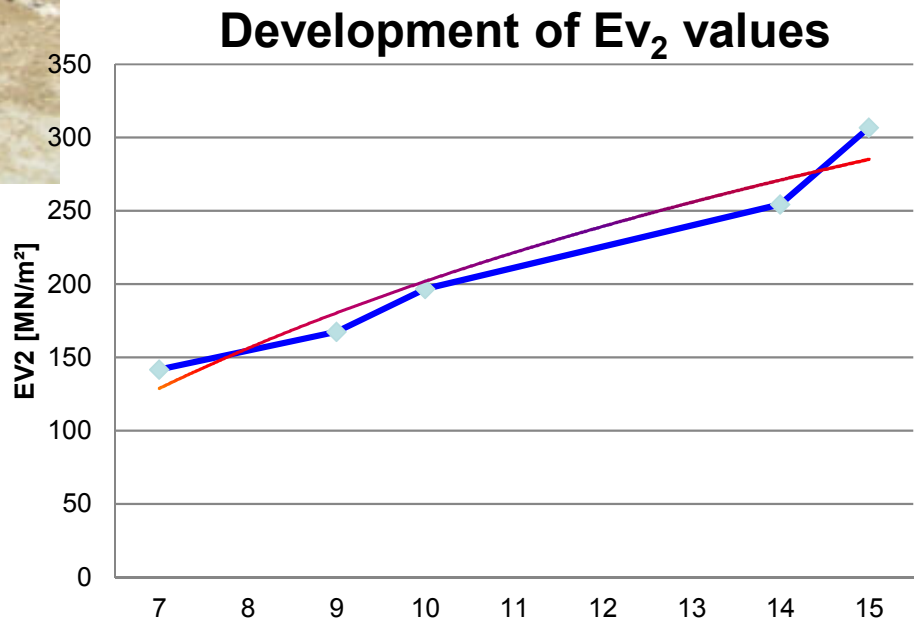
# Experiences with RSS® Flüssigboden

## Road construction with RSS® Flüssigboden according to RAL-GZ 507

**Source:** Archive RSS® Flüssigboden building sites



Example of a foundation slab made of RSS Flüssigboden under a city railway track in Stuttgart, Germany



# Experiences with RSS® Flüssigboden

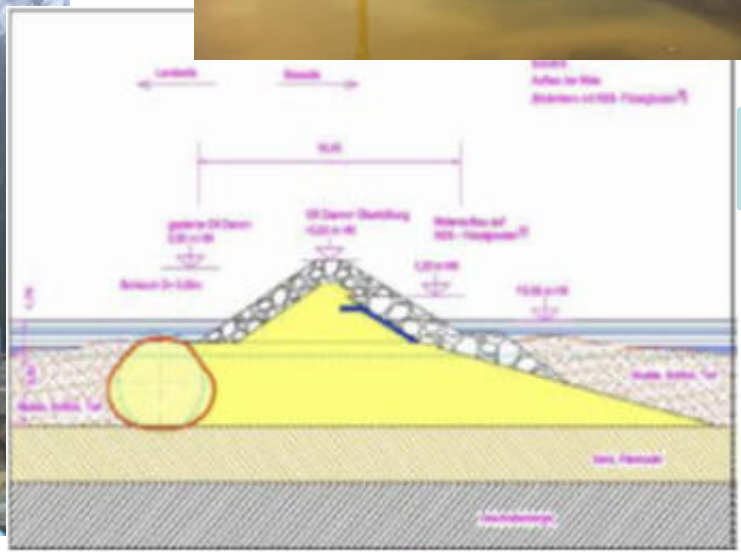
## Dyke construction with RSS® Flüssigboden according to RAL-GZ 507

### Constructions of dams, dykes, water engineering

- Construction of dams, slopes, and dykes, as well as stabilisation and renewal of existing structures in the field of coastal and flood protection
- Here: Oder dykes and dyke wall in Bavaria, Germany

**Source:** Archive RSS® Flüssigboden building sites

**Source:** Archive RSS® Flüssigboden building sites



# Experiences with RSS® Flüssigboden

## Avoiding base failure/ground heave with RSS® Flüssigboden according to RAL-GZ 507

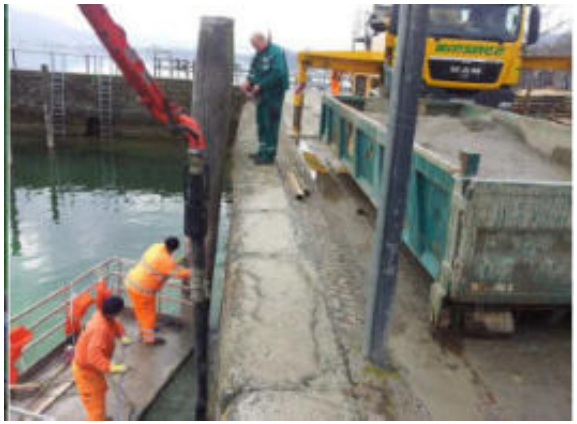
**Source:** Archive RSS® Flüssigboden building sites

### Water engineering / harbour facilities

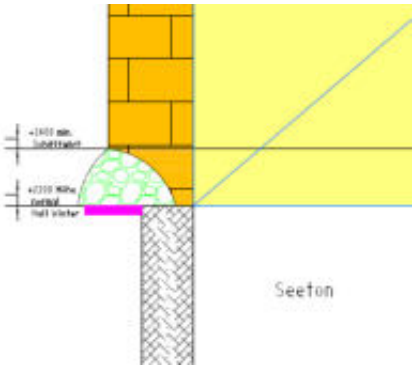
- Backfilling of scourings behind sheet piling
- Vibration damping and thus the prevention of base failure as a result of dynamic loads eg through propellers or traction pull
- Backfilling in and under water independently whether fresh or salt water
- Prevention of damage in the subsoil as a result of "false" backfilling, which are caused by different densities in the case of energy input
- Re-stabilisation of old walls

# Experiences with RSS® Flüssigboden

## Solving static problems with RSS® Flüssigboden according to RAL-GZ 507

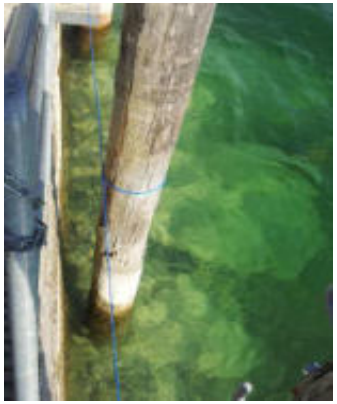


**Source:** Archive RSS® Flüssigboden building sites




### Renovation of an old harbour wall

- Restoration of historical buildings in and under water
- Restoration of historical buildings in and under water
- Application of a solution which allows to statically determine the results of the restoration
- Active protection against subsidence and base failure through the restoration solution



# Experiences with RSS® Flüssigboden

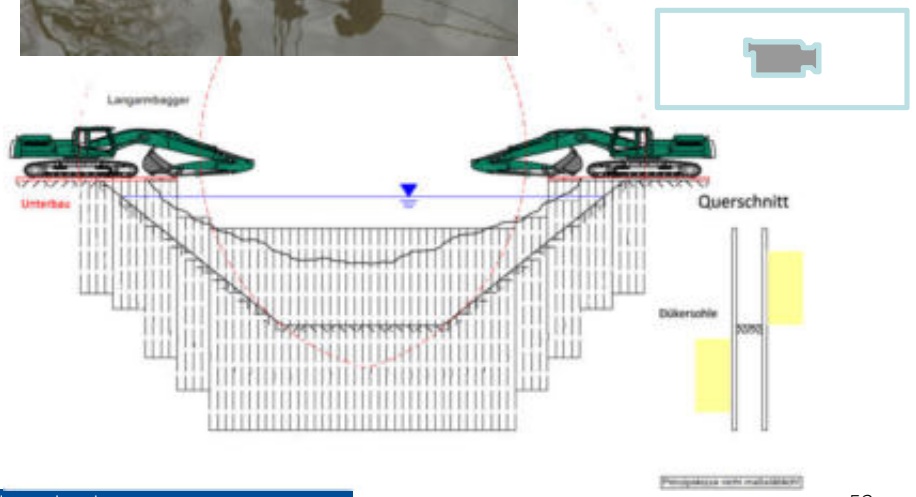
## Culvert construction in running water with RSS® Flüssigboden according to RAL-GZ 507

### Culvert construction in running waters

- Costs and construction time-saving construction of culverts in rivers without impoundments or by-pass solutions
- No external abutments and supports required
- Use of the so-called "floating laying"

**Source:** Archive RSS® Flüssigboden building sites

**Source:** Archive RSS® Flüssigboden building sites



# Experiences with RSS® Flüssigboden

## Possible applications of RSS® Flüssigboden according to RAL-GZ 507 for supply lines

| Medium | Problem | Solution |
|---|---|---|
| High and ultra-high voltage | • Electric cables submit heat to the environment | • Targeted optimisation of thermal conductivity with the aim of higher transmission capacities and longer lifetime |
| District heating pipes | • They need frictional forces with defined upper and lower limits | • Targeted adjustment of the friction forces via the optimisation of the relaxation |
| Gas pipes | • Longitudinal flow of gas | • Creation of increased adhesion |
| Drinking water | • Warming due to climate change | • Possibility to produce liquid soil with insulating properties |
| Fibre optic cables (FOC) etc. | • Position in the area of frost penetration depth | • Choice of a suitable mix design and its constituents |

**Complex conduits as a result of the energy transition:**

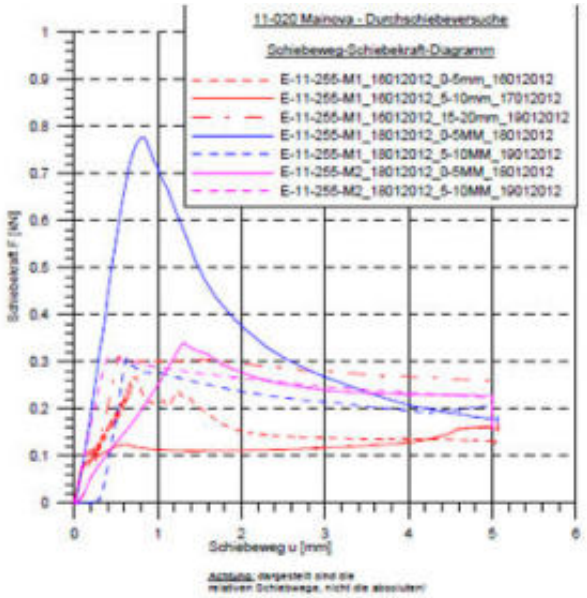
Advantages for municipalities or waste water companies: Applications for municipal supply and disposal companies in the fields of all supply lines like gas, drinking water, to high voltage lines, FOC or district heating, but also rain and waste water

# Experiences with RSS® Flüssigboden

## District heating

## Quality assurance and verification

**Source:** Archive RSS® Flüssigboden building sites

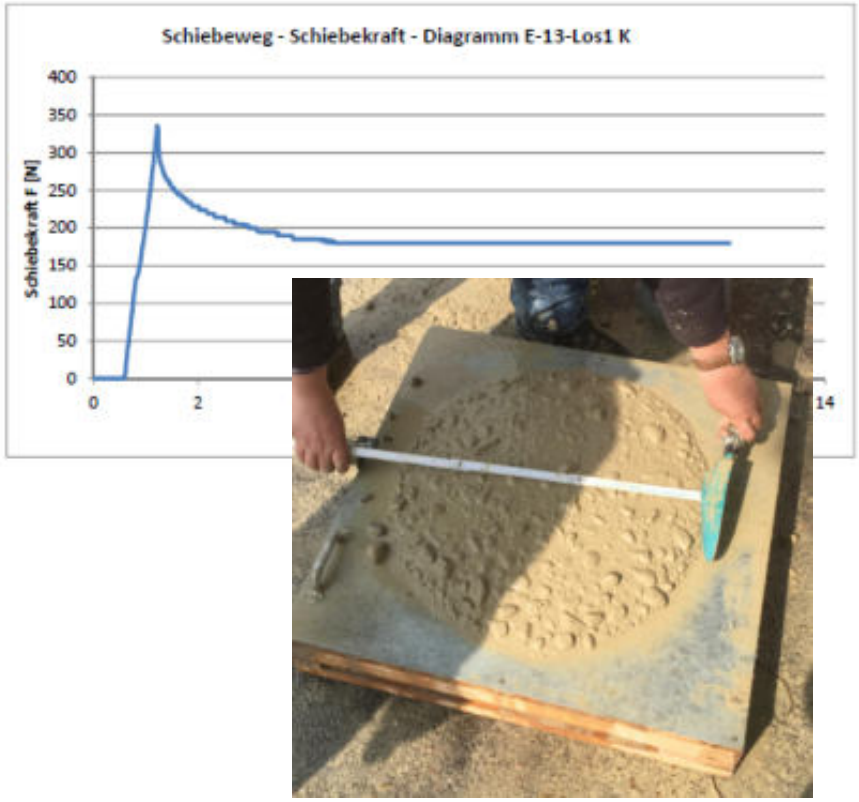



**Durable friction forces** with a defined upper and lower limit on the district heating pipe – basis for a long lifetime of the pipe without any damages – Berlin, Unter den Linden, plastic sheath pipe DN 400

# Experiences with RSS® Flüssigboden

## District cooling

## Quality assurance and verification




**Durable friction forces** with a defined lower limit on the district cooling pipe – basis for a long lifetime of the pipe without any damages – combined with good waterproofness and low thermal conductivity – Munich, Zschokkestraße – DN 500

# Experiences with RSS® Flüssigboden

## Gas pipes and pipeline construction

**Source:** Archive RSS® Flüssigboden building sites

- Relaxation properties prevent longitudinal flow of gas
- Improved corrosion protection
- Minimizes or prevents Joule–Thomson effect
- Chemical resistance of the odorants to the search for leakages
- precise search for leakages possible, since no longitudinal flow of the gas
- new technologies in pipeline construction are possible
- Alternative solutions to technical problems, eg culverts possible
- Construction in winter at low temperatures possible
- Abutment functions can be adopted by defined adjustable frictional forces

(see R & D activities and project experience based on tests with RSS® Flüssigboden)

# Experiences with RSS® Flüssigboden

## Construction of high and ultra-high voltage lines

- **Consequences of the energy revolution**
  - Construction of new high-voltage lines with good heat dissipation (here Frankfurt Kelsterbach, Germany, with 380–420 kV) with thermally stabilizing Flüssigboden TS
  - Avoiding a reduced power transmission performance even in warm seasons
  - Avoid problems with local residents and farmers
  - Reduction of costs
  - Reduction of construction time
  - High environmental acceptability

**Source:** Archive RSS® Flüssigboden building sites

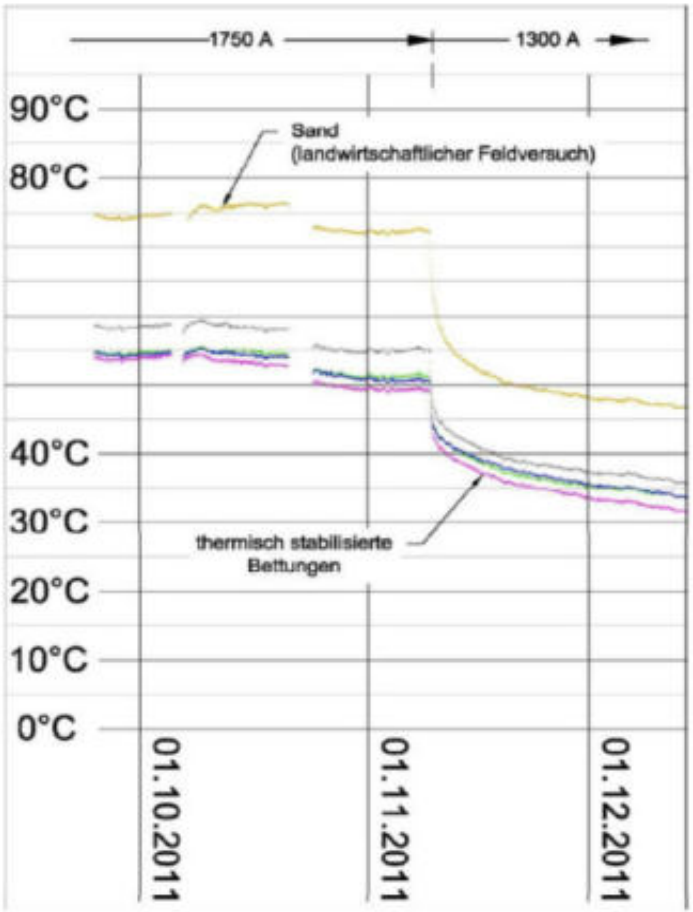
# Experiences with RSS® Flüssigboden

## Construction of high and ultra-high voltage lines

### Temperature curve: transition of the cable limit load to dimensioning load

Sand as a conventional bedding material leads to high temperatures in the cable.

Thermally stabilizing liquid soil significantly reduces the temperature in the cable.




42 380-kV-Pilotkabelstrecken

# Experiences with RSS® Flüssigboden
## Construction of solar heat storage reservoirs

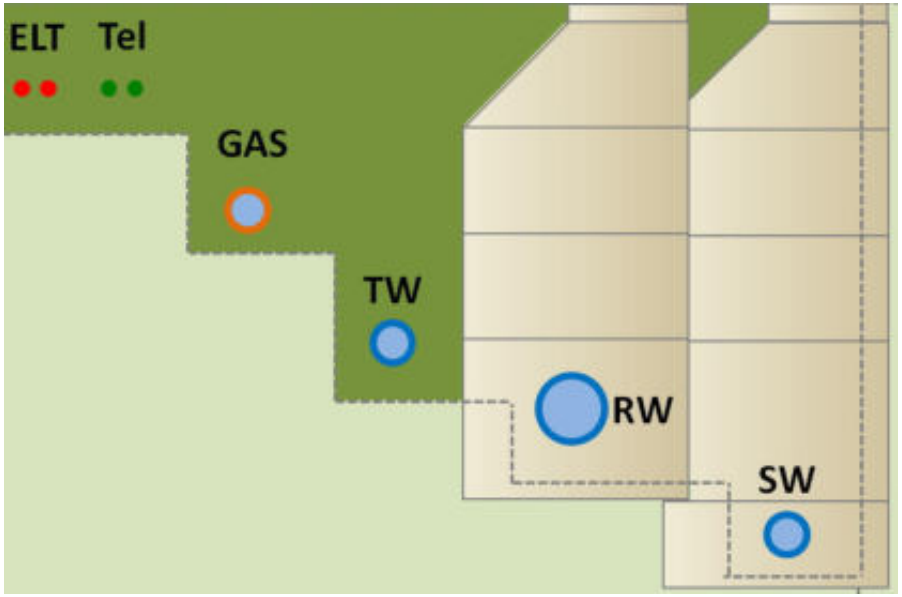
with a 0.8m thick, perimeter slurry wall made of heat-insulating RSS® Flüssigboden, with high watertightness and a core made of heat-storing and also water-tight RSS® Flüssigboden.

**Source:** Archive RSS® Flüssigboden building sites

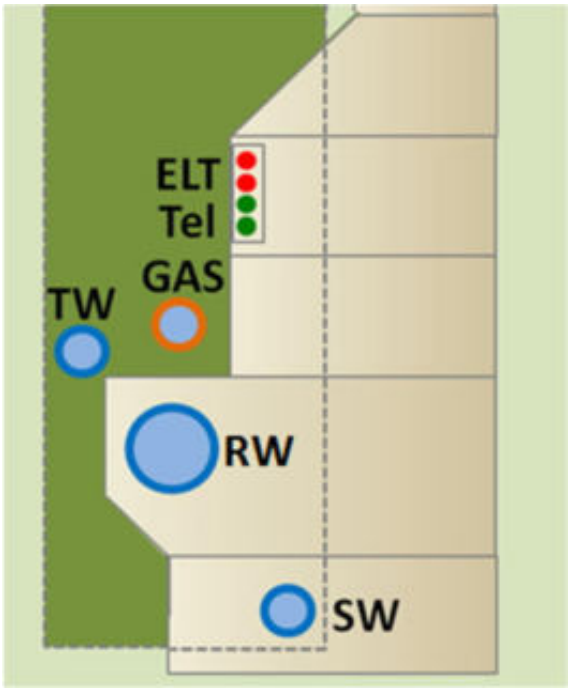
- **Insulation and storage**
- Construction of solar heat storage reservoirs with thermally insulating RSS® Flüssigboden in the outer ring and thermally stabilizing RSS® Flüssigboden as storage reservoir with simultaneous cooling of photovoltaic systems to increase the efficiency of the systems

# Energy revolution and RSS® Flüssigboden

*Combined conduits – flexible solution for urban planning*




ELT = electricity
TW = drinking water
RW = rain water
SW = waste water



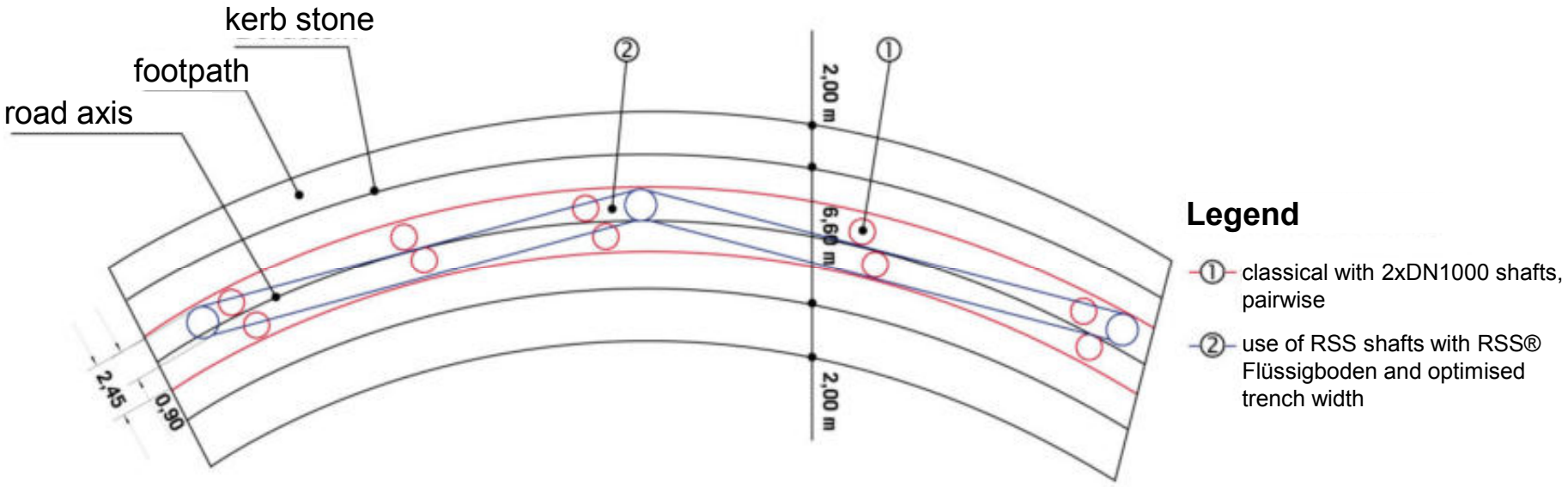

Increasing effort in the maintenance of the grids required new solutions

**Energy revolution and location competition**
as additional factors in the search for flexible infrastructure systems

**Advantages for roads and their preservation**

# Main goal – Improvement of economic efficiency

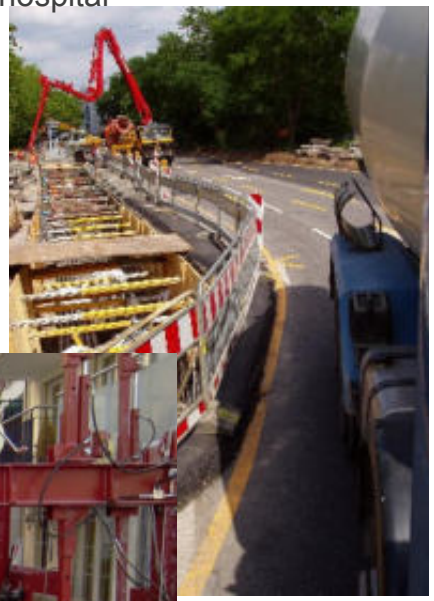
A prerequisite for a high economic benefit is to minimise the number of shafts in roads while maintaining access to all media and a solution in order not to have to pick up the road surface layer

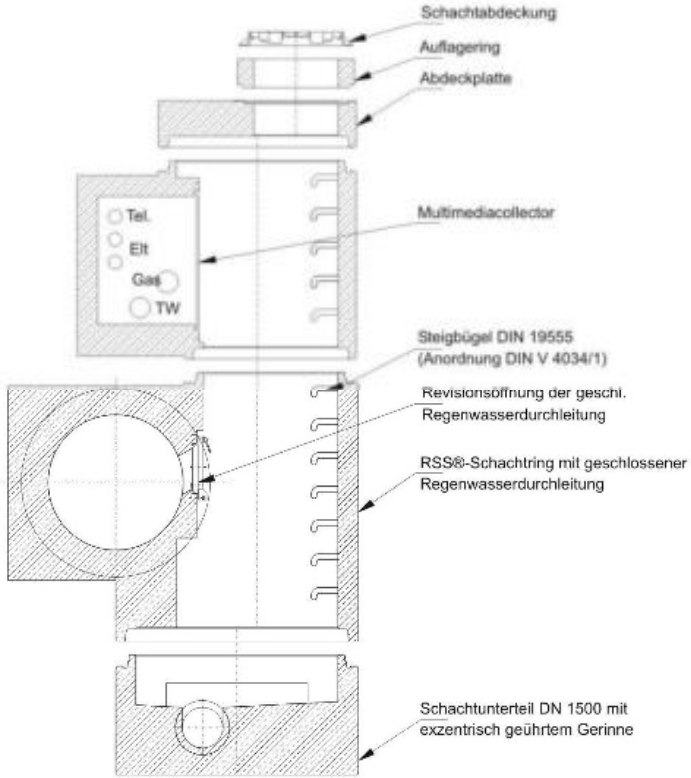


# Experiences with combined conduits and RSS® Flüssigboden according to RAL-GZ 507

**Source:** Archive RSS® Flüssigboden building sites

**Source:** engineering office LOGIC, project Stuttgart, Katharinen hospital






Source: Fa. Bau GmbH, project, Lachen, Switzerland

# Experiences with combined conduits and RSS® Flüssigboden according to RAL-GZ 507

**For the construction of combined conduits with liquid soil:**

- less construction space is required
- less construction time is required
- subsequent costs during operation and maintenance of the conduit are reduced
- subsequent costs for the maintenance of the road are reduced
- location advantages are created as flexible systems can be used and new urban planning solutions become possible
- new, more advantageous cost structures are created that can be used to reduce costs and contributions

**This is shown by numerous projects for new construction and renovation!**

# Experiences with RSS® Flüssigboden

## Need for expertise with planners and construction companies

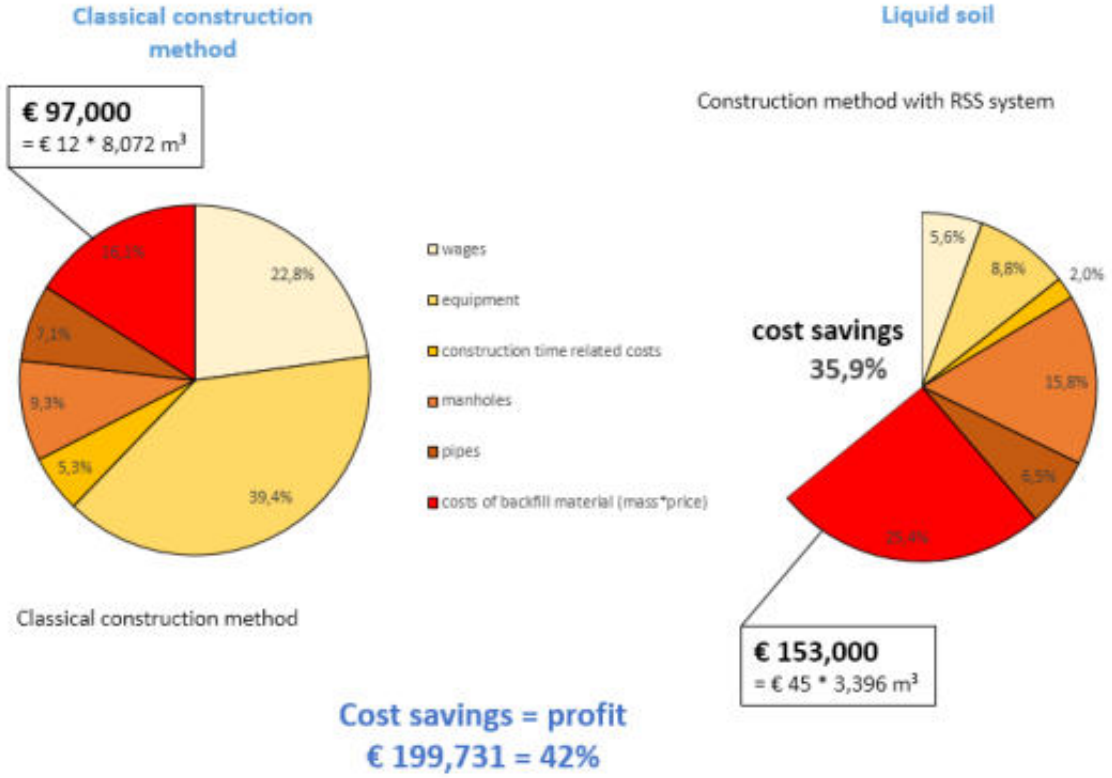
- With increasing expertise with planners and construction companies, technologically more sophisticated solutions can be applied that have been developed in recent years.
- This is important, because the liquid soil method is a fundamentally new procedure with completely new technological solutions and corresponding requirements in quality assurance

Source: IB Vogel Ingenieure, project Stuttgart, central castle garden

# Why technical planning for liquid soil applications?

**New technologies result in changes of cost structures and**
**Thus become the basis of the benefit for builders and contractors**

Calculation of costs as part of the technical planning




**New technological solutions result in new cost structures**

1. This requires a technology-based cost calculation
2. The planner or the calculator must know the technological processes and the technical aids very well
3. There are already software tools helping to calculate the cost differences of different technical solutions

# Technological concept as part of the technical planning

The technological concept allows for new cost structures and provides completely new solutions – eg construction in and under groundwater


**The technological concept makes the processes and the necessary resources transparent and calculable**

1. Representation of the construction technology and all steps of the construction process
2. Indication of required resources and possible processes
3. Specification of technological peculiarities of liquid soil technology
4. Optimization of processes
5. Basis of calculability of the benefits

# Technical concept as part of the technical planning

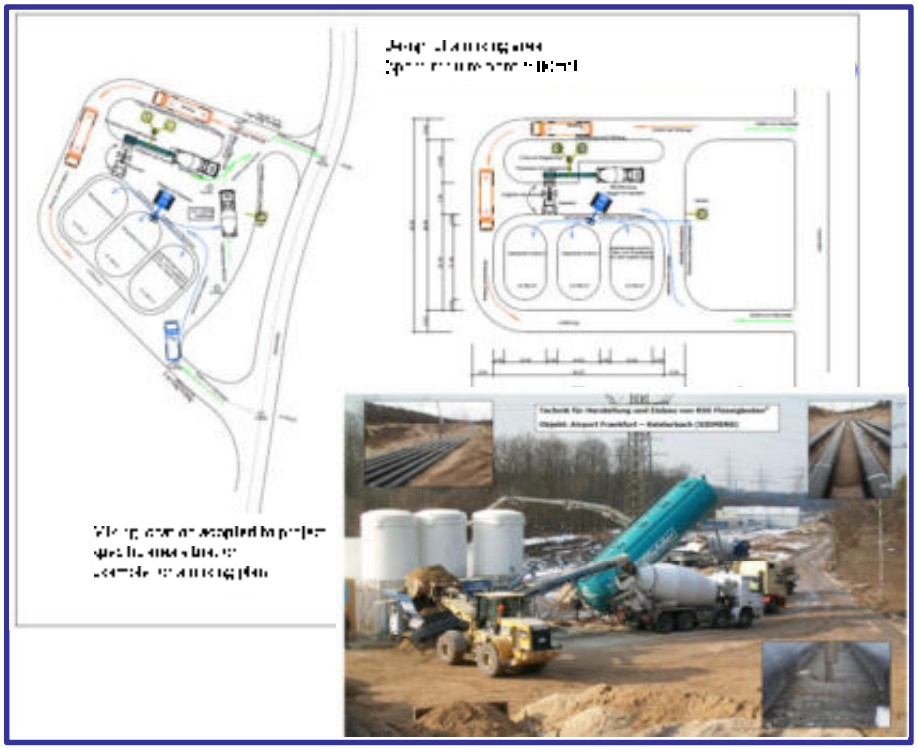
The technical concept makes new technologies feasible and thus helps to optimize processes and make them safe

**The technical concept develops the demands of the required technology**

1. Compilation of the necessary technical aids and parameters
2. Indication of required resources and possible processes
3. Specification of the technological particularities of the liquid soil technology
4. Optimisation of processes
5. Basis of the calculability of the benefits of the liquid soil method and the optimal use of technological benefits

# Logistic concept as part of the technical planning

The logistic concept optimises auxiliary processes of construction and thus helps to reduce the costs of new liquid soil applications

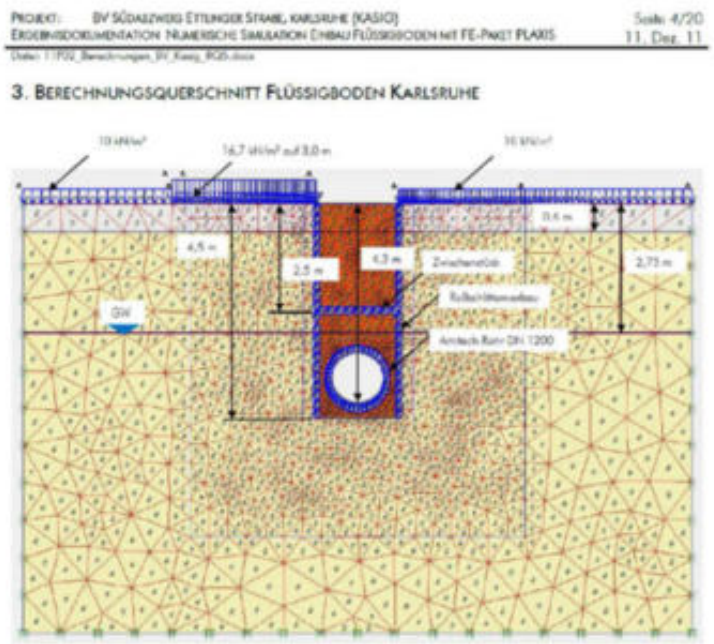


**The logistic concept for safeguarding optimised main construction and auxiliary construction processes**

1. Ensuring optimal processes for supply, production, transport, and placement on the construction site
2. Helps to reduce construction time
3. Minimisation of the effort in transport and auxiliary processes
4. A relevant part of the opportunity to reduce construction costs

# Functional verifications as part of technical planning, eg static verification during construction on peat and in groundwater

The technical planning provides all functional verifications for safe construction and a safe application of the solutions of the liquid soil method




Subsoil information and models as basis for correct and reliably functioning mix design development in several steps:

- Modelling of the subsoil
- Application of a liquid soil with assumed target values in the model
- Exposure to load under operating conditions
- Observation of the behaviour of the tube-liquid soil system
- Correction of the liquid soil values if necessary
- Derivation of the target parameters of the required liquid soil
- Mix design development
- Checking the mix design on the basis of test specimens for compliance with target values
- Release of the mix design in case of success

# Functional verification as part of technical planning, eg hydrogeological modelling of the groundwater situation

The technical planning provides all necessary functional verifications for safe construction and safe use of the solutions of the liquid soil method.

Pumpkosten

| Bedingung | Zeitraum | Pumprate, l/min | Zeit, Tage | Abgepumptes Wasservolumen, m³ |
|---|---|---|---|---|
| Best case | bis zur gewünschten Tiefe des Absenktrichters | 135.864 | 2 | 391.29 |
| Best case | während der Bauarbeiten | 52.02 | - | 74.91 m³ pro Tag |
| | | | | |
| Worst case | bis zur gewünschten Tiefe des Absenktrichters | 253.744 | 5 | 1841.36 |
| Worst case | während der Bauarbeiten | 172.8 | - | 248.83 m³ pro Tag |

Gefahren für Gebäude

| Bedingung | Absenkung unter den Gebäuden, m | Hubkraftverlust, in Tonnen | Dauer der Gefährdung, Tage |
|---|---|---|---|
| Best case | 0.0002 2.17 | 13.85 187.26 | 2 + bis zum Ende der Bauarbeiten |
| | | | |
| Worst case | 0.28 - 2.39 | 226.81 - 568.93 | 5 + bis zum Ende der Bauarbeiten |

Soil information and models as a basis for a decision for or against groundwater lowering:

- Modelling of the hydrogeological situation of the subsoil
- Representation of the installation situation with 2 scenarios (dewatering and liquid soil)
- Determination of risks of conventional dewatering (suffosion, settlement…..)
- Determination of consequences of the use of liquid soil under groundwater influence
- Cost and risk assessment of the two alternatives (dewatering or liquid soil technology)
- Calculation of technical solutions for the avoidance of backwater effects

# Development of the required mix design or mix design matrix for safe construction and performance of the liquid soil

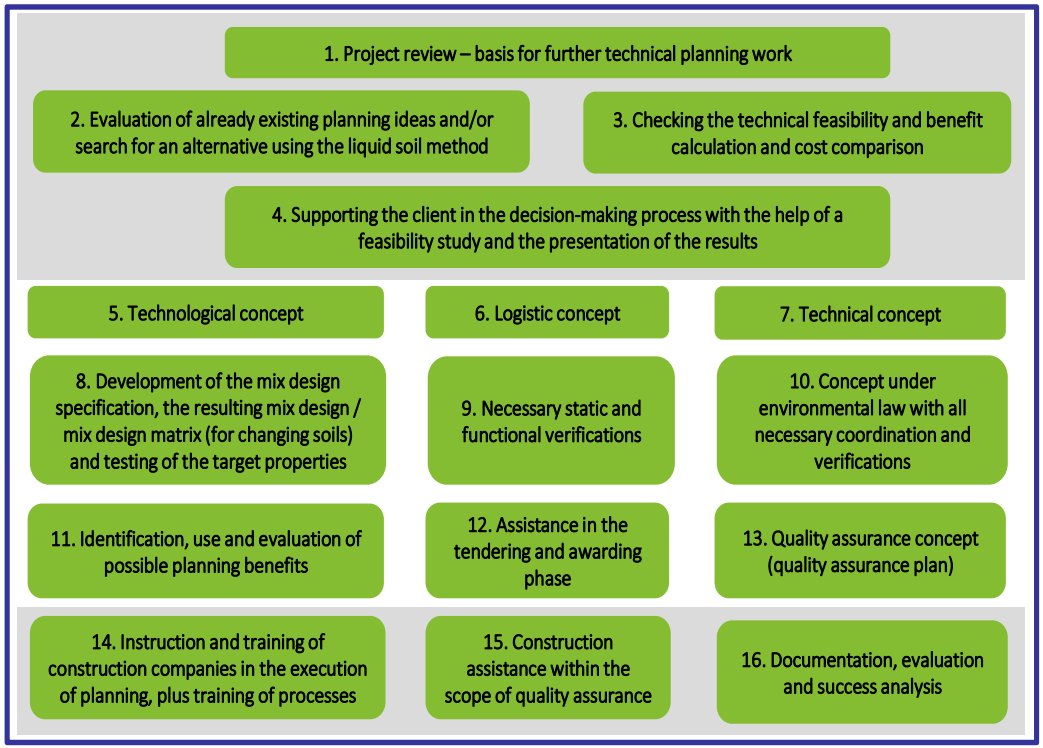
The required mix design or mix design matrix makes working with soils of all types and even changing soil types controllable


## The mix design/mix design matrix ensures the functionality of the liquid soil within 3 groups of properties

1. Soil-mechanical properties to prevent damage to roads, grids and underground structures
2. Technologically relevant properties to support and optimise construction processes and reduce costs
3. Special usage properties that the original soil does not have, but that are required for later use

# Technical planning of liquid soil applications

## Examples of planning services for liquid soil applications

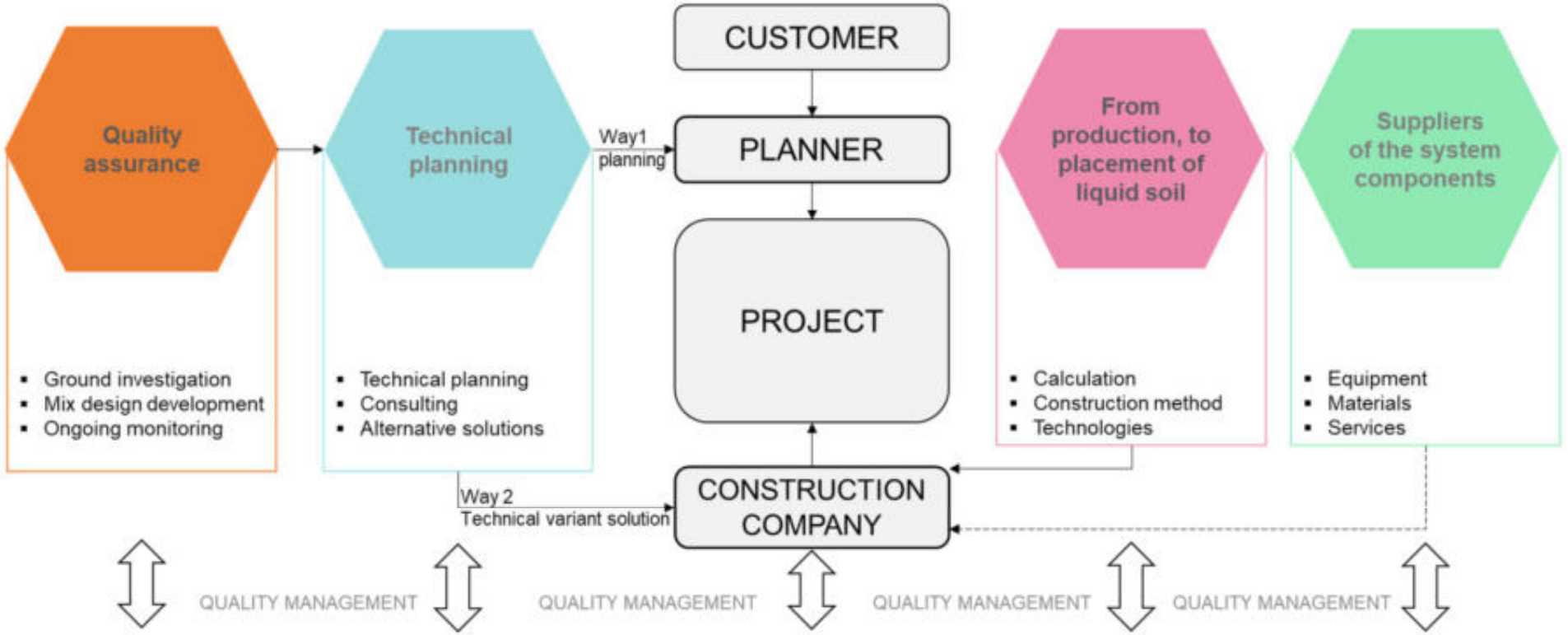



**Technical planning of liquid soil:**

Services which are designed to make the variety of possible applications of the liquid soil method technically safe and economically advantageous, and also deal with all related questions – from quality assurance to cost calculation, verification, environmental law, soil mechanics, hydrology, material suitability, technology, technical equipment, etc. – and serve as input for the project planner.

# RSS® Flüssigboden and business processes

## Business processes in underground engineering affected by the liquid soil innovation




- RAL GZ-507: is a quality mark and quality standard, similar to a German DIN standard, but with stricter requirements. Testing institutes accredited by RAL supervise and verify the application of the liquid soil method according to RAL-GZ 507, and enforce required standards.
- The required training for users in terms of quality assurance is offered by the RAL Gütegemeinschaft Flüssigboden e. V. (RAL Quality Association for Liquid Soil), in collaboration with the developers of the method and practitioners.
- The research institute for liquid soil FiFB offers educational programmes for the many newly developed technologies and solutions for users.
- Also see www.fi-fb.de; www.logic-engineering.de

# Quality assurance of RSS® Flüssigboden according to RAL-GZ 507
# Basis of safe use of the benefits

Objective 1: Prevention of construction and consequential damages

# Quality assurance of RSS® Flüssigboden according to RAL-GZ 507
# Basis of safe use of the benefits

Objective 2: Secure use of the possibilities of the liquid soil method, eg for the many possible applications that it offers.

**Protection against root penetration**


**Immobilisation**

**Technological suitability eg for backfilling with a concrete pump**

**Placement in winter**

# Quality assurance – Why and how was the RAL Quality Association for Liquid Soil founded?

- Initiated not by producers, but by customers and as their representatives planners and consultants.
- The following cities played a pioneering role here:

KWL KOMMUNALE WASSERWERKE LEIPZIG GMBH

Stadtentwässerungsbetrieb Landeshauptstadt Düsseldorf

STADTENTWÄSSERUNG GÖTTINGEN

# Why is there a need for a transparent quality assurance **in the hands of the builders**?

Shrinkage of hydraulically setting materials

# The central task of the work according to RAL-GZ 507 is the prevention of structural damage and defects:

- formulation of clear technical requirements based on soil-mechanical and physical scientific findings
- **elaboration of these requirements in a public procedure with the participation of all professional circles and the public in the form of Quality and Testing Specifications (QTS)**

⇒ These QTS form the basis of objective, transparent and reliably testable criteria as the basis for grids, roads, flood protection measures and other applications with a long lifetime

# Basis of quality assurance

RAL Quality and Testing Specifications for Liquid Soil according to RAL-GZ 507 and their implementation, beginning with the planning and ground investigation according to EC 7 or DIN 18300 (homogeneous areas)


RAL
GÜTEZEICHEN
FLÜSSIGBODEN

Flüssigboden

Gütesicherung
RAL-GZ 507

Ausgabe Januar 2014

RAL
DEUTSCHES INSTITUT FÜR GÜTESICHERUNG UND KENNZEICHNUNG E.V.


Güte- und Prüfbestimmungen
Herstellung, Transport und Einbau von Flüssigboden

1 Geltungsbereich

1.1 Begriffsdefinition

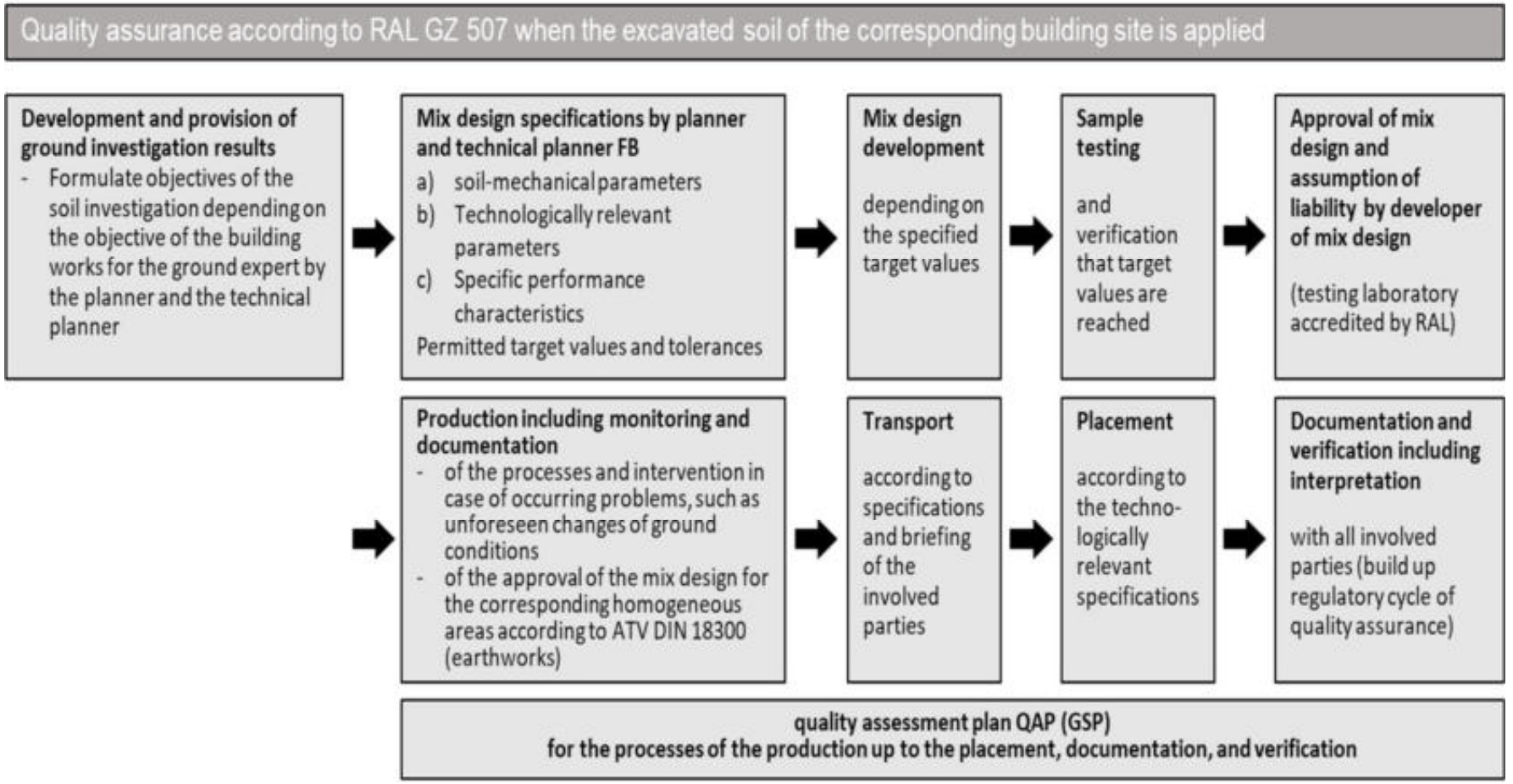
1.2 Mitgeltende Vorschriften, Richtlinien und Normen

2 Vorgehensweise bei der Anwendung des Flüssigbodenverfahrens

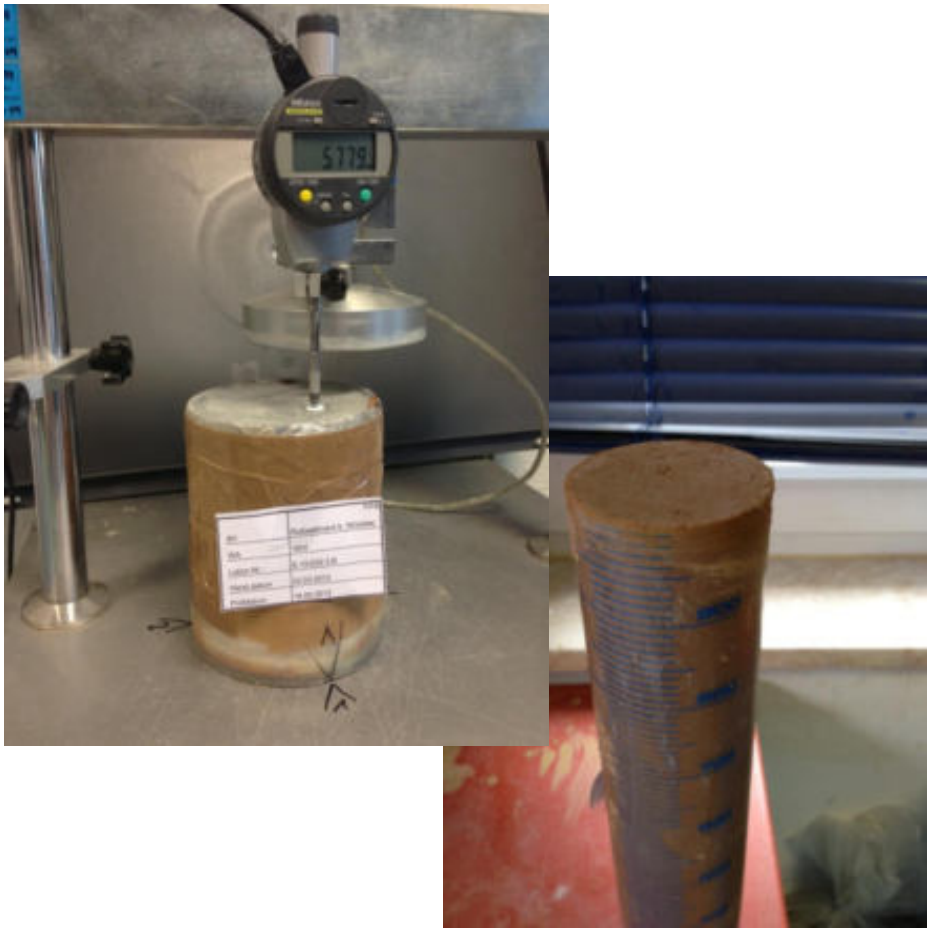
2.1 Baugrunderkundung

# Quality assurance for liquid soil – part of the technical planning and execution

## Process of quality assurance of liquid soil according to RAL-GZ 507



# Quality assurance for RSS® Flüssigboden according to RAL-GZ 507

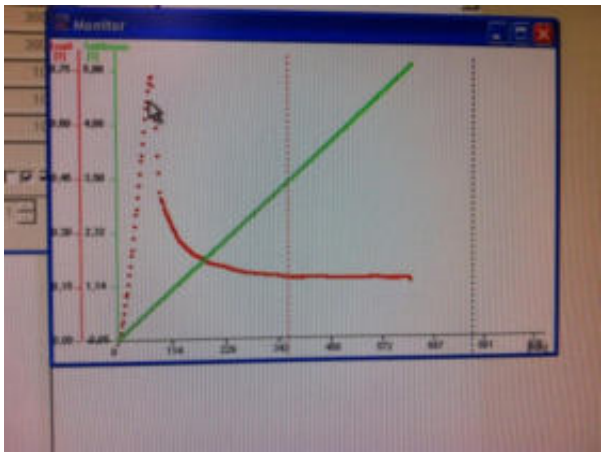


Verification of the **soil typical properties** in contrast to the properties of hydraulically setting materials by:

- Testing the material behaviour under changed placement conditions, such as load, humidity, temperature, etc.
- Example of the measurement of volume constancy or shrinkage

**Source:** FiFB, Research Institute for Liquid Soil, RAL trainings

# Quality assurance for RSS® Flüssigboden according to RAL-GZ 507



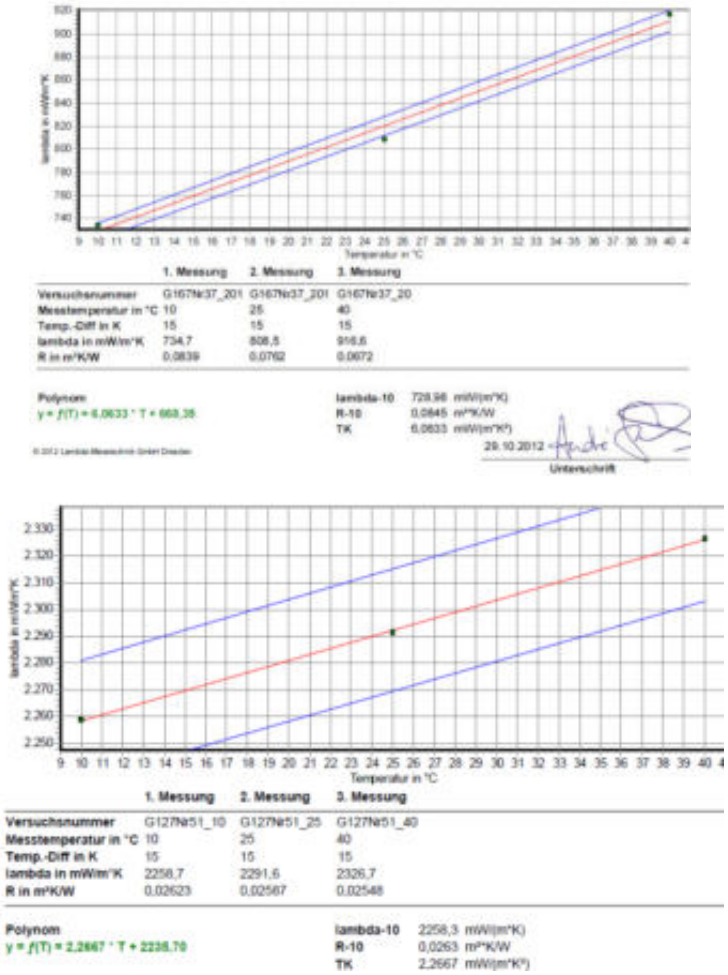
## Verification of Usability

– Verification that no shrinkage will occur by testing the friction force development over time, and thus it is secured that the complete surfaces are involved in the heat transfer between the conductor and the liquid soil TS.

– Verification of a high, transferable heat flux (see Fourier's law), since this, in analogy to the thermal conductivity and to the existing temperature differences, is proportional to the transmitting surface of the conductor. However, this surface is only completely available if there is no annular gap between the bedding material and the conductor.

**Source: FiFB**, Forschungsinstitut für Flüssigboden, Research Institute for Liquid Soil

# Quality assurance for RSS® Flüssigboden according to RAL-GZ 507



| | 1. Messung | 2. Messung | 3. Messung |
|---|---|---|---|
| Versuchsnummer | G167Nr37_201 | G167Nr37_201 | G167Nr37_20 |
| Messtemperatur in °C | 10 | 25 | 40 |
| Temp.-Diff in K | 15 | 15 | 15 |
| lambda in mW/m*K | 734,7 | 808,5 | 916,6 |
| R in m²K/W | 0,0839 | 0,0762 | 0,0672 |

Polynom: y = f(T) = 6,0633 * T + 668,35

lambda-10 728,96 mW/(m*K)
R-10 0,0845 m²*K/W
TK 6,0633 mW/(m²K²)

28.10.2012 Unterschrift



| | 1. Messung | 2. Messung | 3. Messung |
|---|---|---|---|
| Versuchsnummer | G127Nr51_10 | G127Nr51_25 | G127Nr51_40 |
| Messtemperatur in °C | 10 | 25 | 40 |
| Temp.-Diff in K | 15 | 15 | 15 |
| lambda in mW/m*K | 2258,7 | 2291,6 | 2326,7 |
| R in m²K/W | 0,02623 | 0,02567 | 0,02548 |

Polynom: y = f(T) = 2,2667 * T + 2238,70

lambda-10 2258,3 mW/(m*K)
R-10 0,0263 m²*K/W
TK 2,2667 mW/(m²K²)

## Verification of Usability

- Improved thermal conductivity of the bedding material by thermally stabilizing effect of a special liquid soil, and measurement of the lambda value with increasing temperature
- Verification of the adjustability of this parameter for liquid soil TS by means of mix design variations, since lambda also enters proportionally into the calculation of the maximum heat transfer capacity according to Fourier

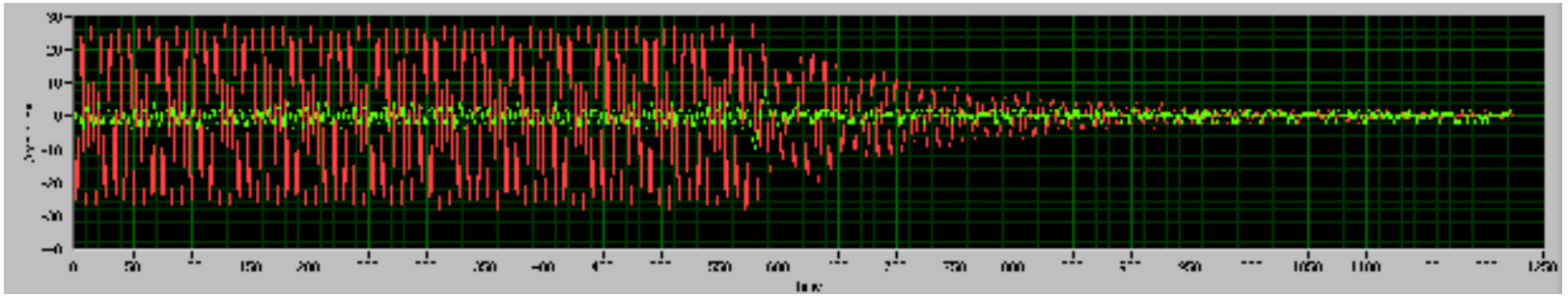
**Source: FiFB**, Forschungsinstitut für Flüssigboden, Research Institute for Liquid Soil

# Quality assurance for RSS® Flüssigboden according to RAL-GZ 507

## Verification of Usability

Verification of project and application specific performance properties, eg the damping and absorption behaviour of the respective liquid soil

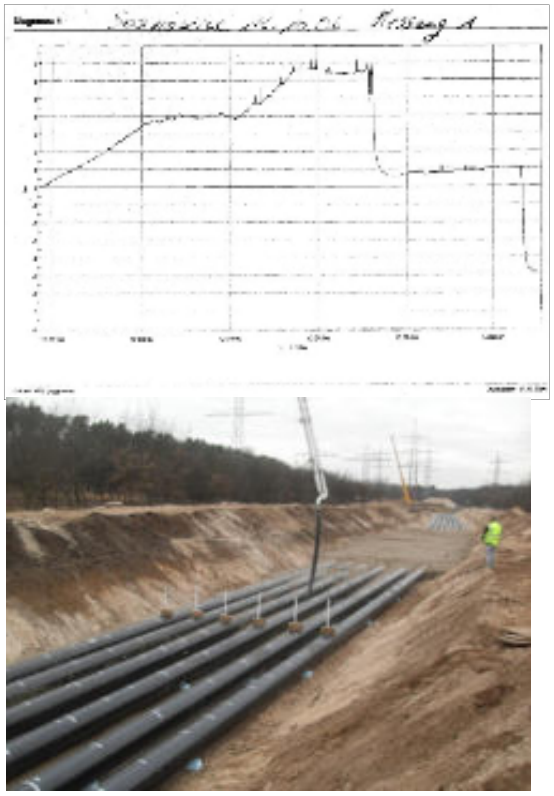
Soil sample [B]



**Source: FiFB**, Forschungsinstitut für Flüssigboden, Research Institute for Liquid Soil

# Quality assurance for RSS® Flüssigboden according to RAL-GZ 507

Measurement and verification of **technologically important properties** in the case of a buoyancy measurement as a verification installed pipes without externally stress and thus with a long lifetime, and for the determination of time sequences



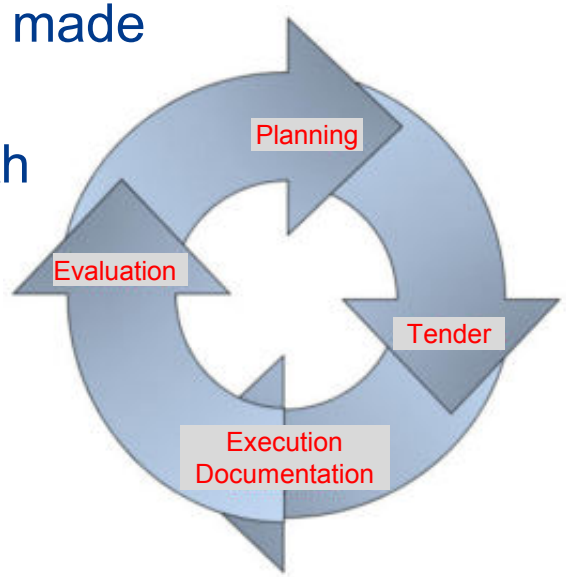
**Source:** Archive RSS® Flüssigboden building sites

# Quality assurance for RSS® Flüssigboden according to RAL-GZ 507

## Summary quality assurance

Quality assurance should be a fixed regulatory cycle from planning to execution. That means:

- Planning, implementation, documentation, consulting and monitoring as part of quality assurance should be made use of for the application of liquid soil, and
- a the results should be evaluated conclusively with all involved parties for the purpose of utilizing the experience of the construction sites




Creation of a regulatory cycle of quality assurance

## V: Planners and technical planners

# Summary

## 1. Environmental benefits

- removal of excavated materials from the construction site is not necessary
- utilisation of the in-situ excavated soils
- short transport distances
- no additional filling material
- reduction of $CO_2$ emissions
- contribution to the prevention of climate and environmental problems
- use of mineral additives only

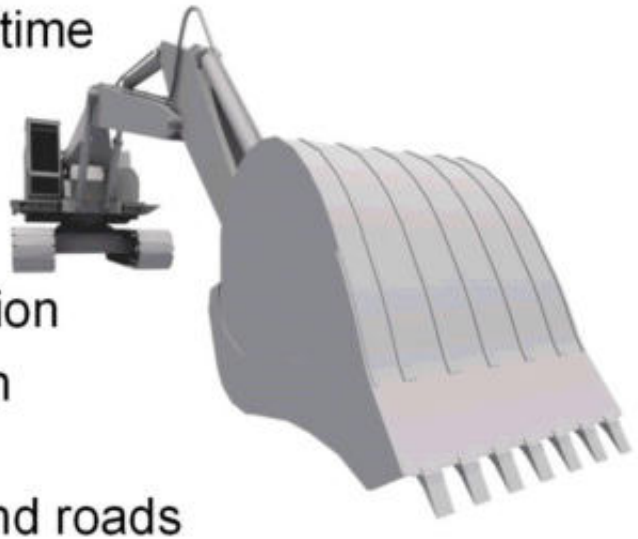
# Summary

## 2. Material behaviour

- optimum bedding
- no compaction required
- no settlements
- simple placement, pumpable if desired
- controlled solidification
- no damages to the installed components (like pipes and cables)
- improved corrosion protection
- no exposure to vibration, noise and dust
- properties similar or equal to natural soil
- single properties can be modified in a targeted way

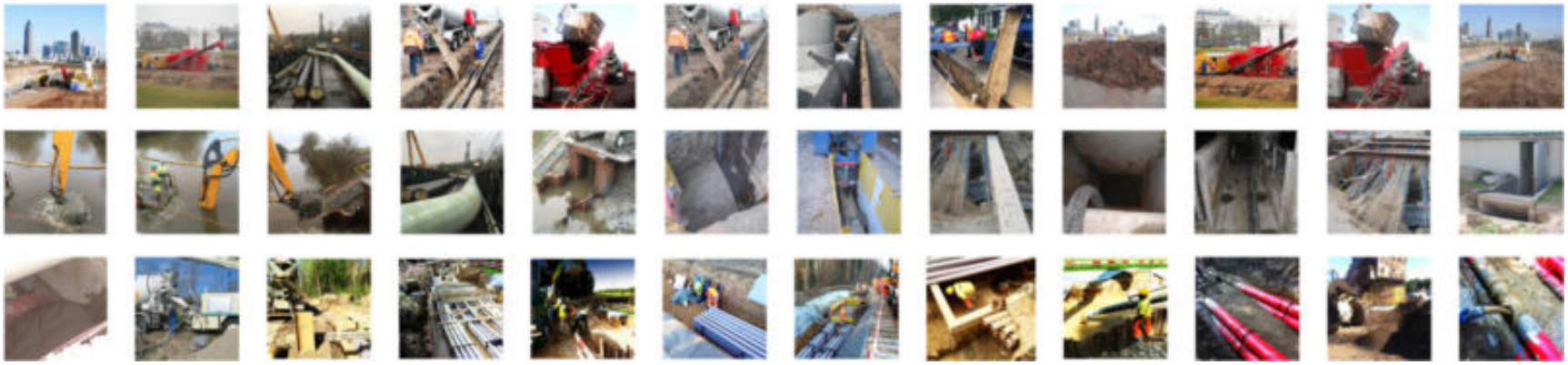
# Summary

## 3. Costs in planning, execution and quality assurance according to RAL-GZ 507



- reduction of excavation volumes, construction time and space requirements with new solutions
- high quality possible
- completely new technologies can be applied
- new cost structures in construction and operation
- often already profitable for smaller construction projects, if well planned and prepared
- significantly longer lifetimes of cables, pipes and roads are possible, depreciation!
- new urban planning possibilities through "compacted" construction
- neighbouring residents are disturbed as little as possible
- compliance with all legal environmental requirements
- technical planning services make sense and help to reduce construction and follow-up costs

# Thank you very much for your attention!



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