Liquid soil according to RAL quality mark 507

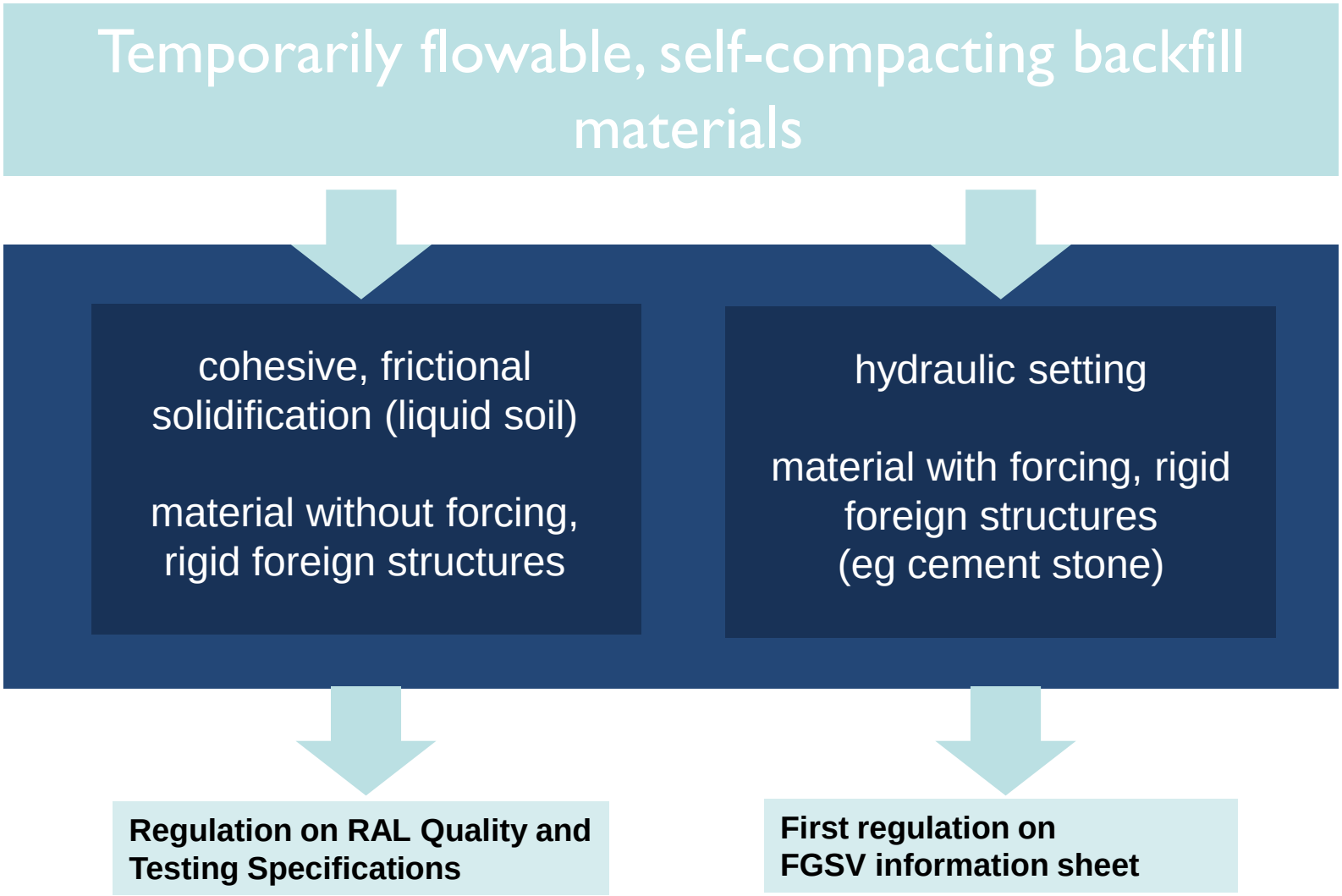
and economic benefits
of its applications

What is liquid soil (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 18 years.

Liquid soil according to RAL-GZ 507, a group of the TFSB (ZFSV)



System of the temporarily flowable self-compacting backfill materials

Source: Wikipedia - Flüssigboden (German)

Differences between the two groups of TFSB

Differences between liquid soil 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 Waste Management and Product Recycling Act (Kreislaufwirtschaftsgesetz, KrWiG)

Gütesicherung nach RAL 507 bei Einsatz des Aushubbodens der jeweiligen Baustelle

Erarbeitung und Bereitstellung der Baugrundergebnisse
- Ziele der Baugrunduntersuchung in Abhängigkeit von der Zielstellung der baulichen Aufgabe für den Baugrundgutachter durch Planer und Fachplaner festlegen

→

Rezepturvorgaben durch Planer und Fachplaner FB
a) bodenmechanische Parameter
b) technologisch relevante Parameter
c) spezifische Gebrauchs-eigenschaften
zulässige Zielwerte und Toleranzen

→

Rezeptur-erstellung
entsprech-end Ziel-werten der Vorgabe

→

Prüfung von Probekörpern
und Nachweis des Erreichens der Zielwerte

→

Freigabe Rezeptur und Haftungs-übernahme durch Rezepturentwickler
(RAL akkreditierte Prüfstelle)

→

Herstellung mit Kontrolle und Dokumentation
- der Prozesse und Eingriff bei Problemfällen wie z.B. ungeplantem Wechsel der Baugrundverhältnisse usw.
- der Freigabe der Rezeptur für die entsprechenden Homogenbereiche nach ATV DIN 18300 (Erdbau)

→

Transport
entspre-chend Vorgabe u. Einweisung der Beteiligten

→

Einbau
entsprechend der technologisch relevanten Vorgaben

→

Dokumentation und Nachweisführung samt Auswertung
mit allen Beteiligten (Regelkreislauf der Gütesicherung aufbauen)

Gütesicherung hydraulisch abbindender ZFSV – nach BQF und BÜV

Liquid soil according to RAL-GZ 507 is suitable for two main fields of applications

It is possible 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

The targeted alteration of properties is also possible

- elasticity behaviour
- flexural and longitudinal tensile strength
- shear strength
- cohesion
- vibration damping
- density
- water permeability
- good relaxation properties as basis of permanent frictional forces
- heat storage, dissipation or insulation
- improved protection against corrosion etc.

What is Flüssigboden?

Development

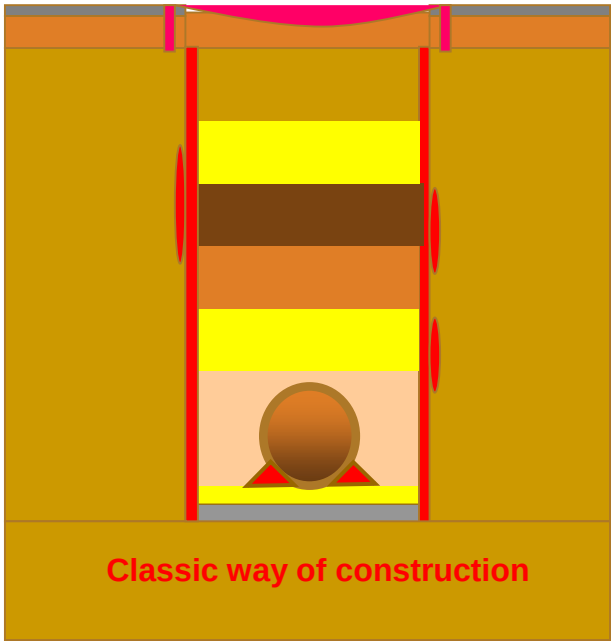
- developed by the Forschungsinstitut für Flüssigboden GmbH – more than 18 years ago in the context of research and development projects with national and international partners, eg:

- 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 LS 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 – **permissible since 2013**

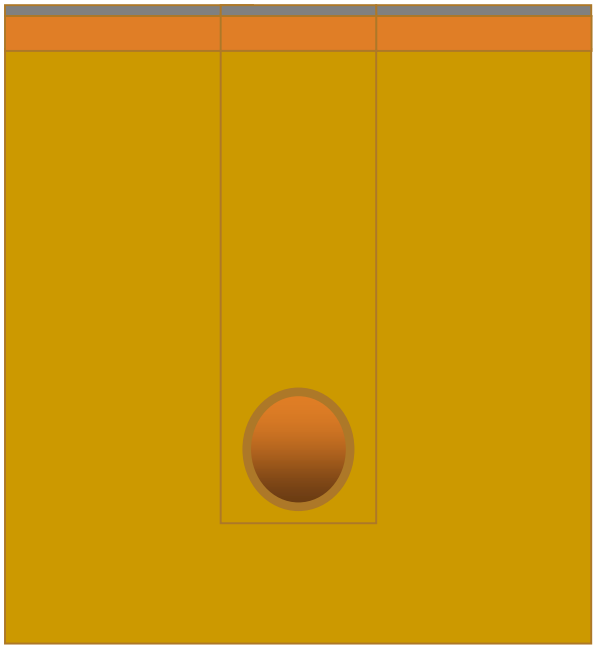
and may other partners **and subjects**

Why was liquid soil developed?

What is new is the preservation of the soil-typical properties for the prevention of settlements, pipe and road damage



backfill area with:
non-soil behaviour

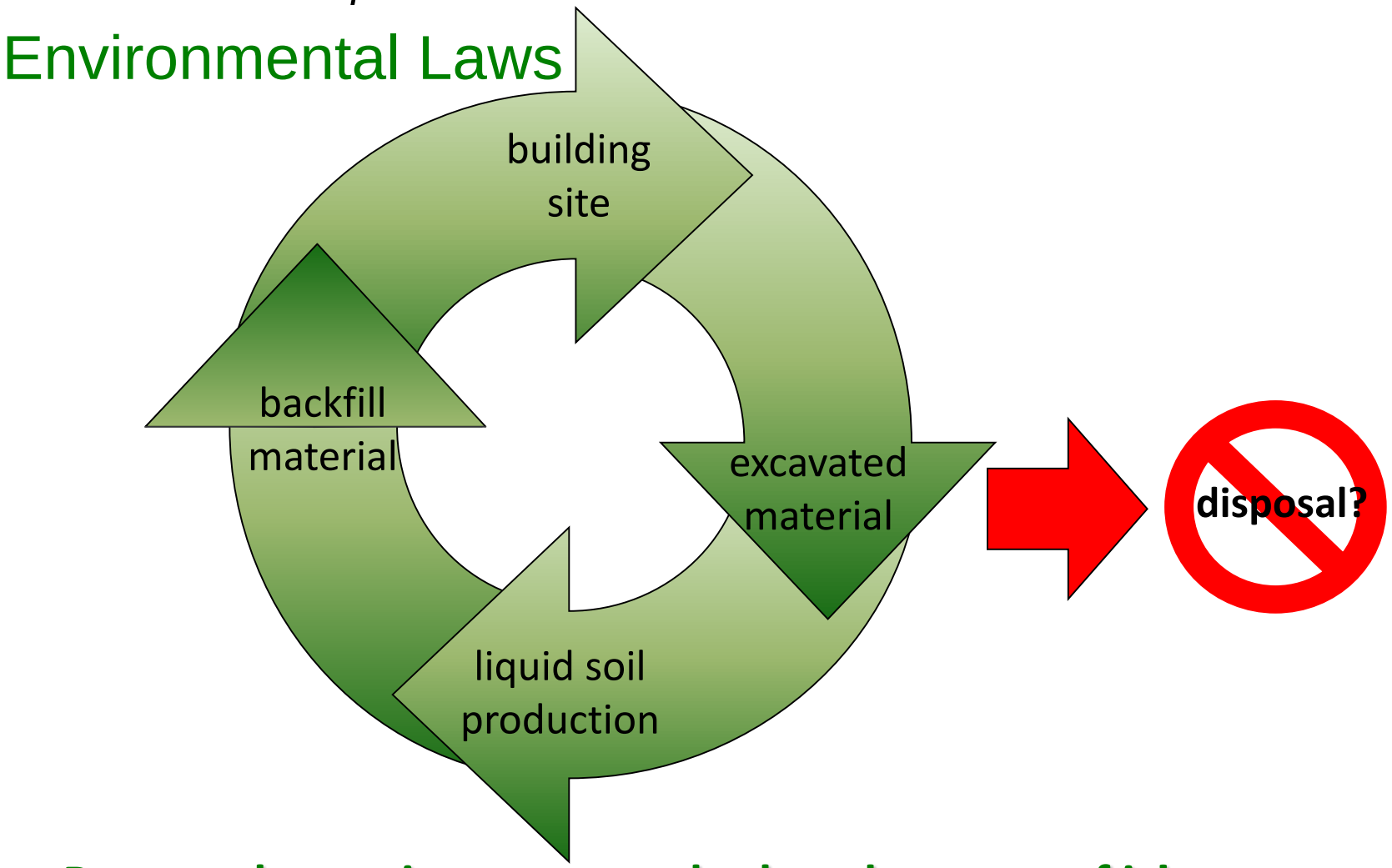


backfill area with:
soil-like behaviour

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

Why was liquid soil developed?

Liquid Soil and Environmental Laws



Protect the environment and take advantage of it!

Environmental relevance

The new German Waste Management and Product Recycling Act (KrWG) has been in force since 01 June 2012

Teil 2

Grundsätze und Pflichten der Erzeuger und Besitzer von Abfällen sowie der öffentlich-rechtlichen Entsorgungsträger

Abschnitt 1

Grundsätze der Abfallvermeidung und Abfallbewirtschaftung

§ 6 Abfallhierarchie

Abschnitt 2

Kreislaufwirtschaft

§ 7 Grundpflichten der Kreislaufwirtschaft

§ 8 Rangfolge und Hochwertigkeit der Verwertungsmaßnahmen

Abschnitt 2

Kreislaufwirtschaft

§ 7

Grundpflichten der Kreislaufwirtschaft

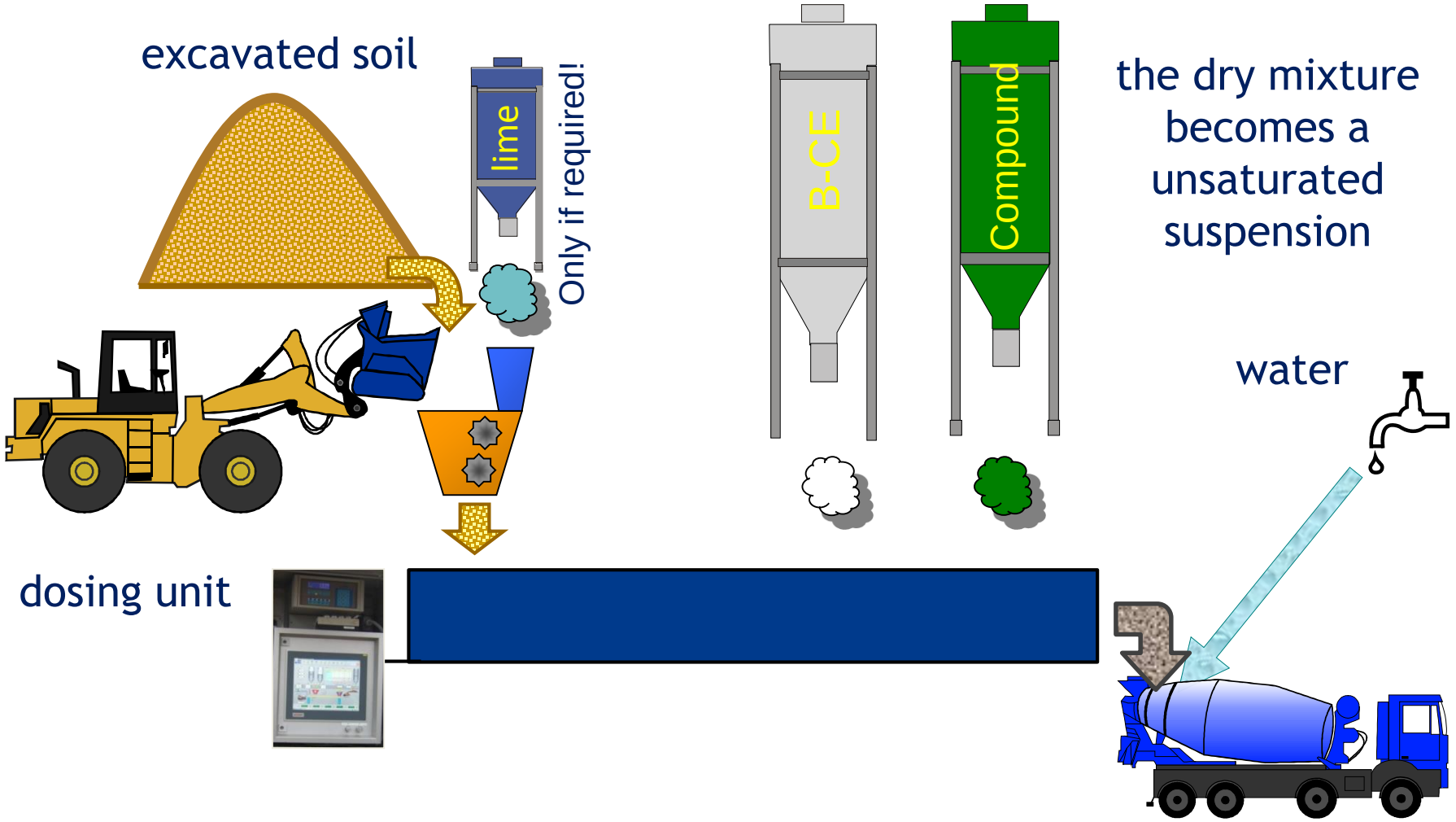
(1) Die Pflichten zur Abfallvermeidung richten sich nach § 13 sowie den Rechtsverordnungen, die auf Grund der §§ 24 und 25 erlassen worden sind.

Producers or owners of waste are obliged to recycle their waste. Recycling of waste takes precedence over disposal.

und 3 am besten gewährleistet. Der Vorrang gilt nicht für Abfälle, die unmittelbar und üblicherweise durch Maßnahmen der Forschung und Entwicklung anfallen.

Liquid soil according to RAL-GZ 507

Liquid soil production



Implementation of the specifics of the production process with the required technology

Forms of production

Stationary production in a central plant eg of a concrete plant or recycler or as a combined stationary and mobile plant

mobile construction site production in a compact unit for small-capacity building sites (eg 30–60 m³/h)

(depending on the soil type)

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

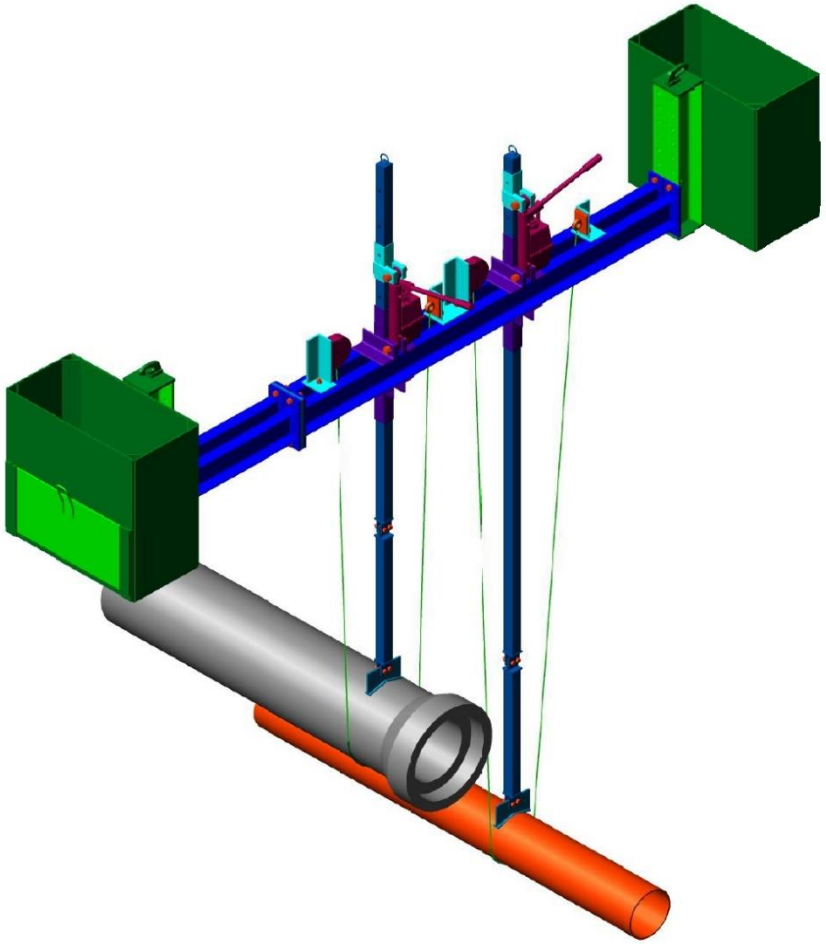
Production equipment – compact unit

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



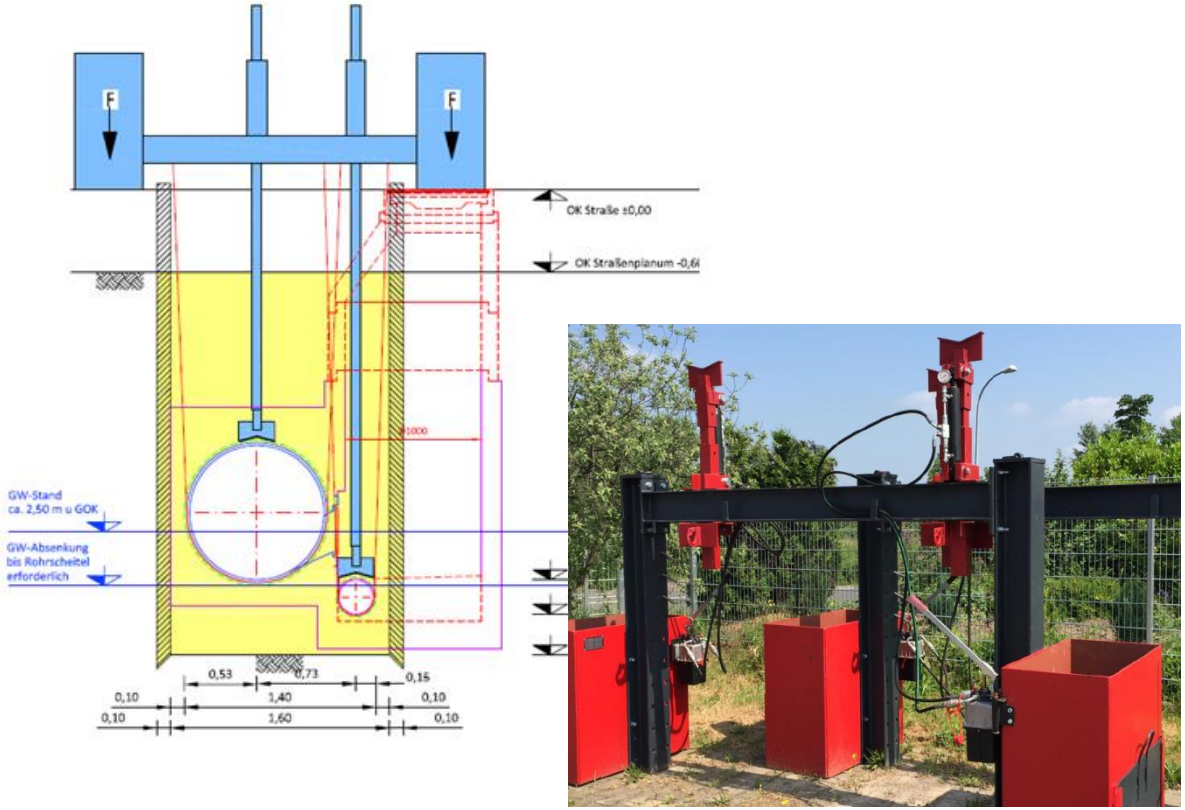
Source: -PROV- Produktions- und Vertriebsgesellschaft mbH – RSS Maschinentechnik

Placement equipment – Pipe laying aids as part of the system technology for constructions with LS

- a modern aid for economic working with liquid soil -

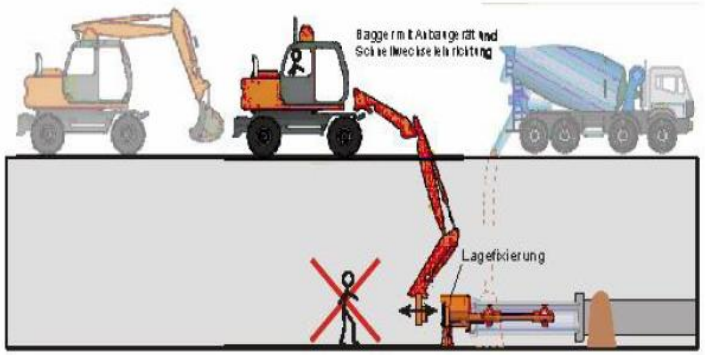
Pipe laying with higher groundwater levels

using the **RSS Pipe Laying Aid**



… and even more 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

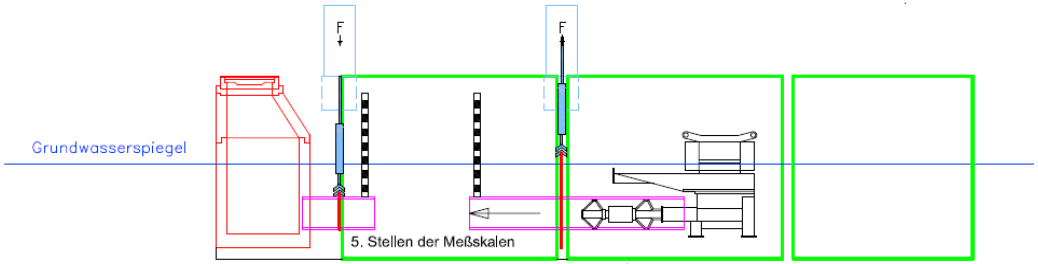
Source: -PROV- Produktions- und Vertriebsgesellschaft mbH – RSS Maschinentechnik

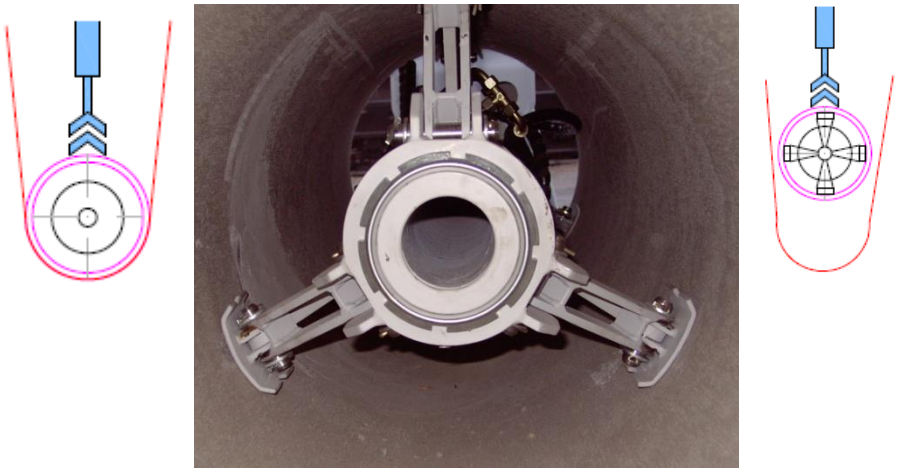
Placement equipment – Pipe laying aids as part of the system technology for constructions with LS

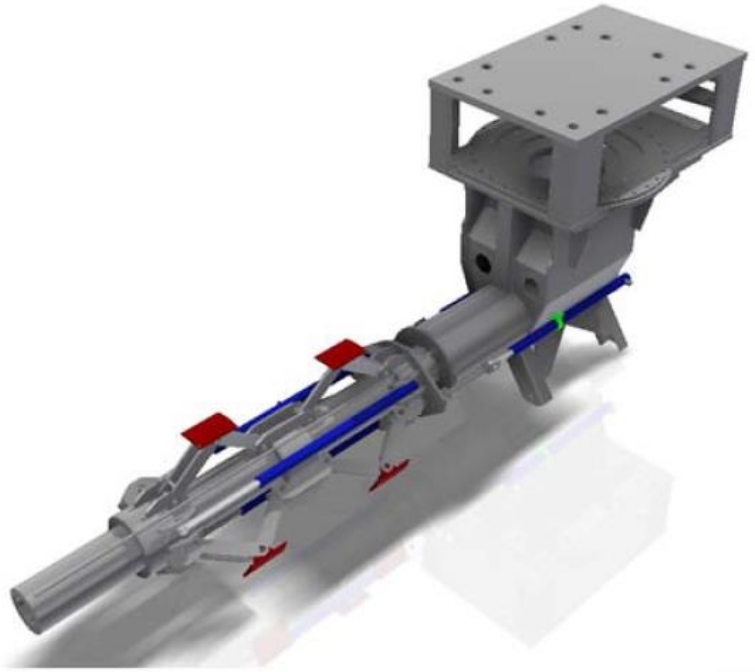
- a modern aid for economic working with liquid soil -

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)**



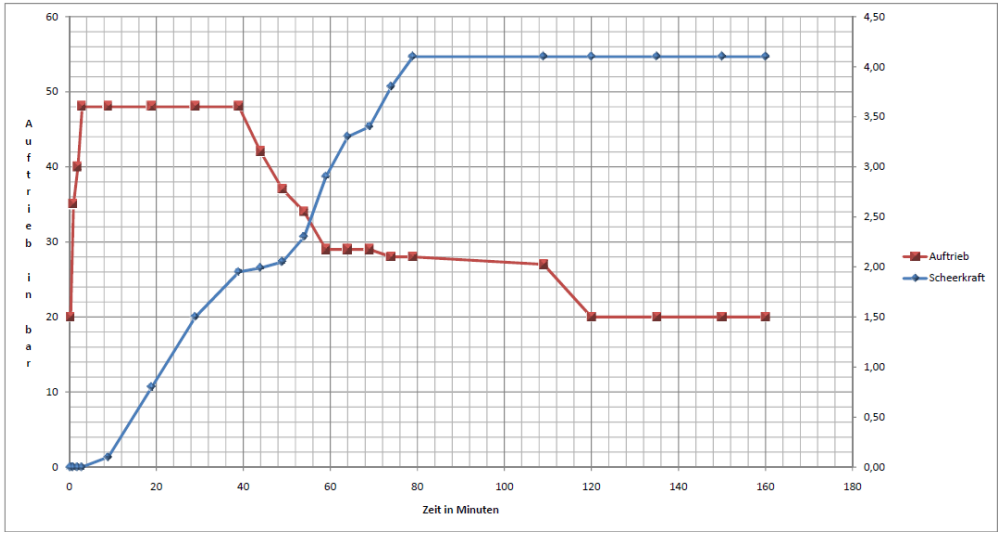




Alternative solutions with verification – here of the lining – task of the technical planner for LS applications

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 liquid soil

Possible applications of liquid soil 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 liquid soil

Possible applications of liquid soil 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

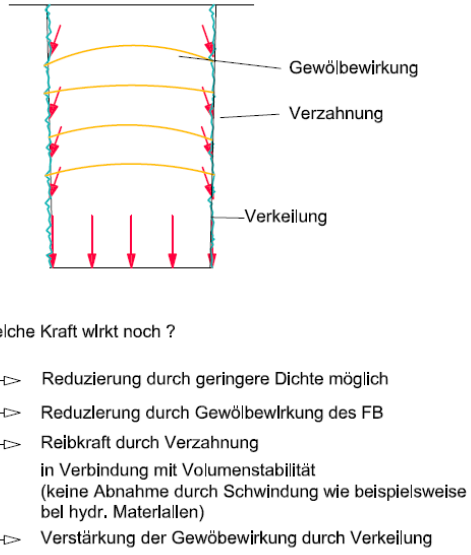
Blue clay as source material for liquid soil

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 liquid soil

Possible applications of liquid soil 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

Use: Lining, water retention, subsoil improvement, reduction of masses .....
TECHNOLOGY

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 liquid soil

Possible applications of liquid soil according to RAL-GZ 507

Use: Number of lining elements, water retention, subsoil improvement, reduction of masses .....
TIMED TECHNOLOGY and consequences

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!)

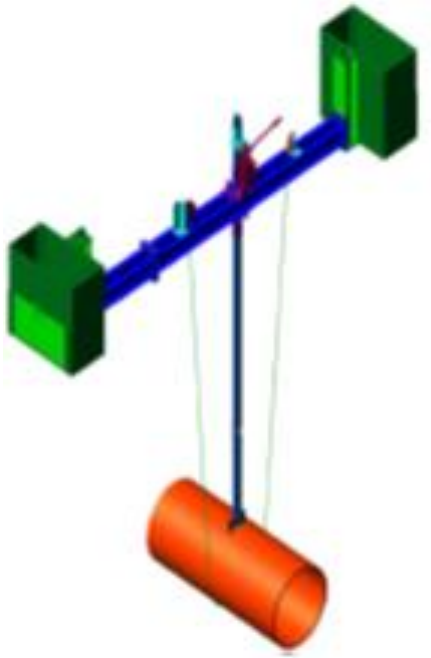
Source: Archive RSS Flüssigboden® building sites

Experiences with liquid soil

Possible applications of liquid soil according to RAL-GZ 507

Use: fast excavation, fast backfilling, minimized downtimes of the gang and technology, ...
TECHNOLOGY and consequences

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

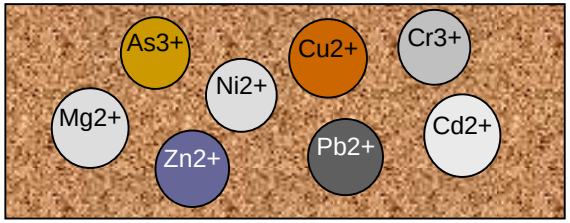
Experiences with liquid soil

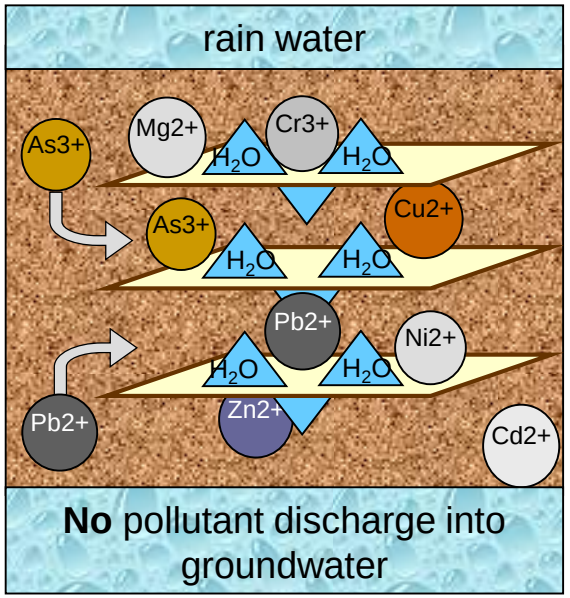
Possible applications of liquid soil according to RAL-GZ 507

Use: Disposal costs, subsoil improvement as flat foundation, ... TECHNOLOGY and consequences

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 liquid soil

Possible applications of liquid soil according to RAL-GZ 507

Use: Flat foundation instead of deep foundation, transport, disposal, ... TECHNOLOGY and consequences

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 liquid soil

Possible applications of liquid soil according to RAL-GZ 507

Use: **Construction period, personnel, technology, ...**
TECHNOLOGY and consequences

Control of technologically relevant properties:

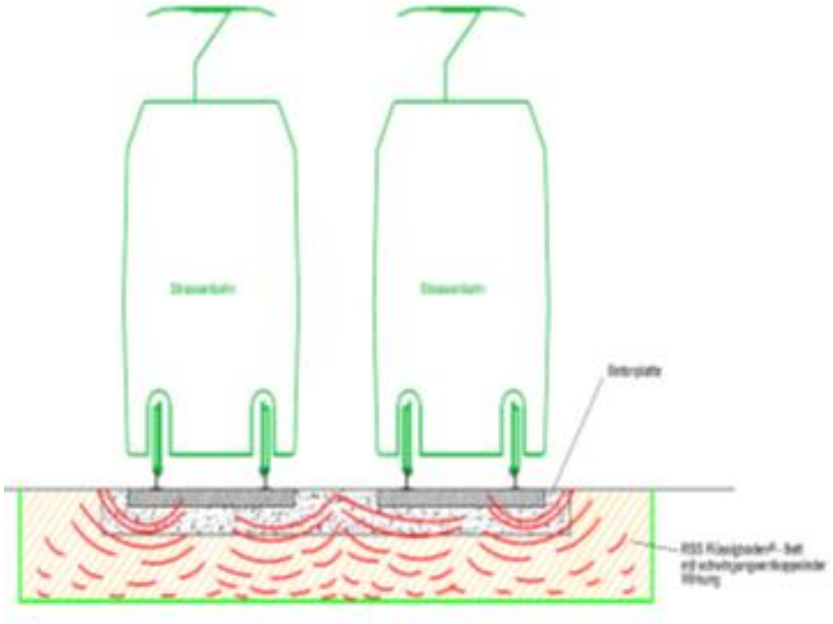
- Backfilling of a high-pressure gas pipeline on a slope with liquid soil according to RAL-GZ 507
- Working at a slope of 40–45 degrees with pump – the material does not flow off
- Securing the abutment function
- Significant reduction of construction time

Source: Archive RSS Flüssigboden® building sites

Experiences with liquid soil

Possible applications of liquid soil according to RAL-GZ 507

Use: Disposal, transport, exchange material, permanent solution instead of mechanical solution,
PLACEMENT TECHNOLOGY and consequences



Vibration isolation and damping:

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

Experiences with liquid soil

Possible applications of liquid soil according to RAL-GZ 507

Use: Masses, no slow and vulnerable technology and construction performance .....
TECHNOLOGY and consequences

Applications in monument conservation:

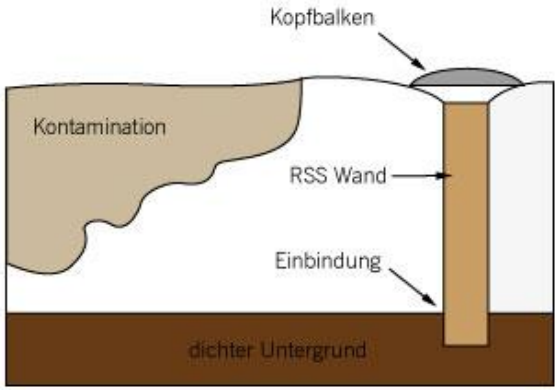
eg protection of old, listed buildings against vibrations and water by the use of liquid soil

Source: Archive RSS Flüssigboden® building sites

Experiences with liquid soil

Possible applications of liquid soil according to RAL-GZ 507

Use: Exchange material, transport and disposal, simpler technology and execution .....
TECHNOLOGY and consequences



- 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 liquid soil

Possible applications of liquid soil according to RAL-GZ 507

Use: **Exchange material, transport and disposal, masses as consequence of optimised coefficient of permeability (kf), simpler technology and execution .....**

TECHNOLOGY and consequences

- Sealing wall

- Core seal

Experiences with liquid soil

Possible applications of liquid soil according to RAL-GZ 507

Use: Exchange material, transport and disposal, substitution of concrete, recovery of the reinforcement .....
TECHNOLOGY and consequences

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

Experiences with liquid soil

Possible applications of liquid soil according to RAL-GZ 507

Use: Substitution of a deep-anchored, sealing sheet pile wall by a support–LS wall with recoverable reinforcement, later removal not necessary, foundation slab and anchoring versus granular subbase, etc. .....
TECHNOLOGY and consequences

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

Experiences with liquid soil

Possible applications of liquid soil according to RAL-GZ 507

Eisenbahn-Bundesamt

Use: **Exchange material, transport and disposal, substitution of concrete, effective solution .....**
TECHNOLOGY and consequences

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 liquid soil

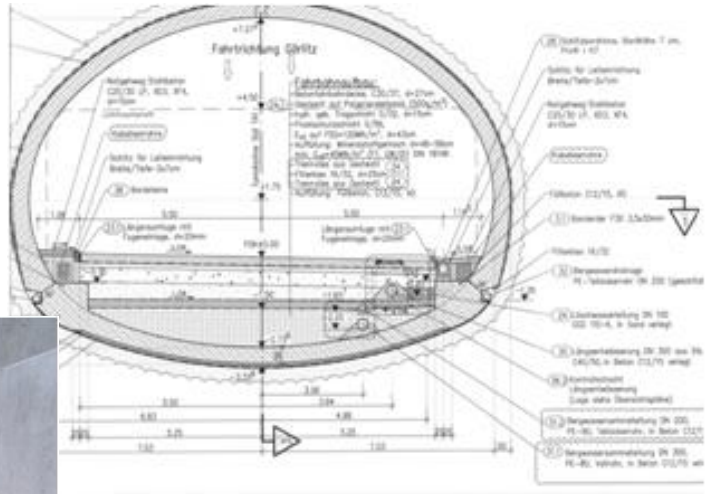
Possible applications of liquid soil according to RAL-GZ 507 in tunnels

Use: Exchange material, transport and disposal, material flow optimisation, space, simple technical solutions ..... TECHNOLOGY and consequences

Applications in tunnelling:

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

etc



Source: Archive RSS Flüssigboden® building sites

Experiences with liquid soil

Road construction with liquid soil according to RAL-GZ 507

Use: Flat foundation instead of deep foundation, exchange material, transport and disposal, simpler technology and execution ..... TECHNOLOGY and consequences

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

Experiences with liquid soil

Road construction with liquid soil according to RAL-GZ 507

Use: Minimized settlement despite difficult subsoils, flat foundation instead of deep foundation, exchange material, transport and disposal, simpler technology and execution ..... TECHNOLOGY and consequences

- Road construction on soft plastic subsoils or mud

Experiences with liquid soil

Road construction with liquid soil 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

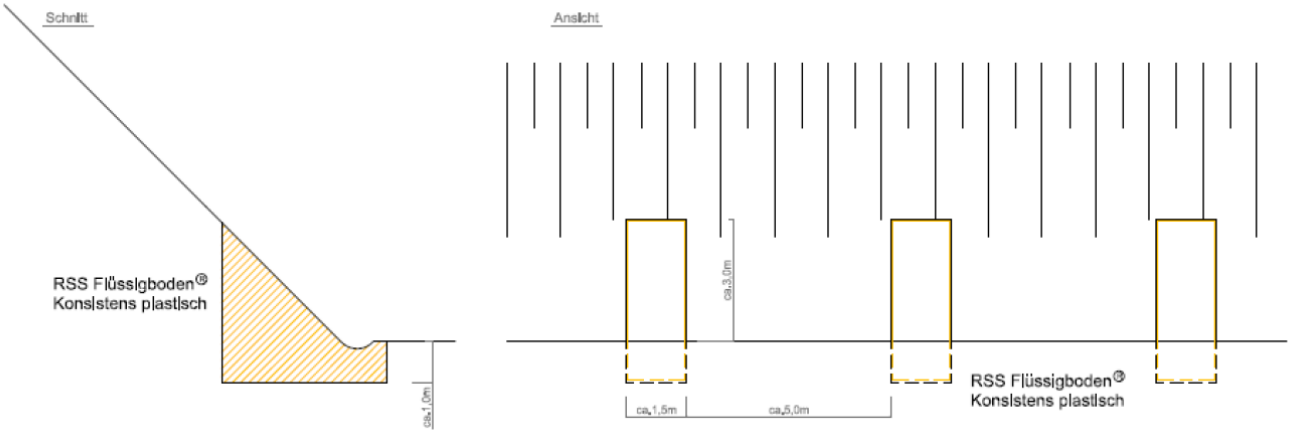
Use: **Simple solution instead of expensive mechanical solution, no aging .....**
TECHNOLOGY and consequences

Source: Archive RSS Flüssigboden® building sites

Experiences with liquid soil

Road construction with liquid soil according to RAL-GZ 507

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



Use: **Costs of an alternative solution ..... TECHNOLOGY and consequences**

Source: Archive RSS Flüssigboden® building sites

Experiences with liquid soil

Road construction with liquid soil according to RAL-GZ 507

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

Source: Archive RSS Flüssigboden® building sites

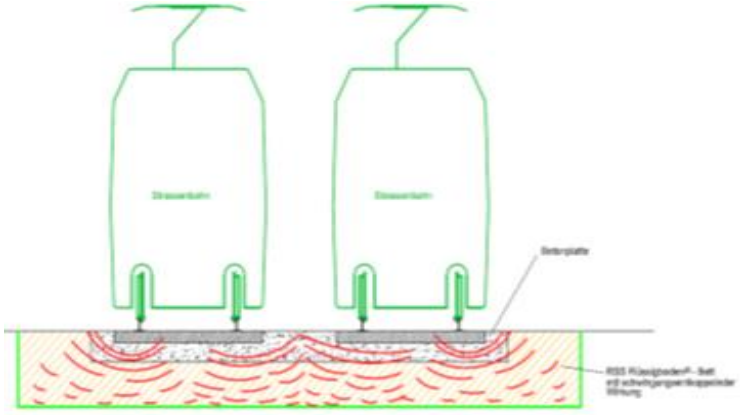
Use: Flat foundation instead of deep foundation, exchange material, transport and disposal, simpler technology and execution, immobilisation..... TECHNOLOGY and consequences

Motorway construction Luxembourg – France

Experiences with liquid soil

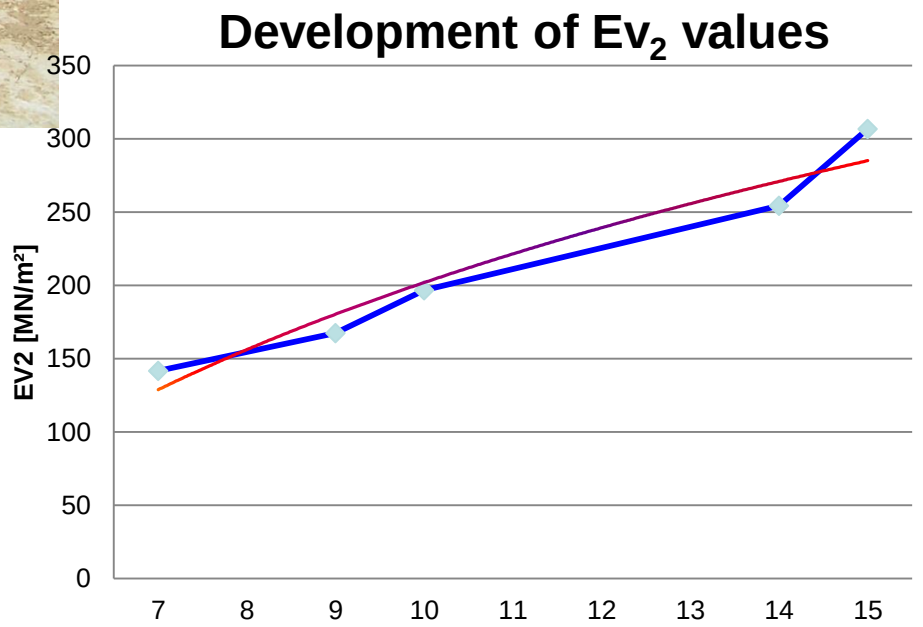
Road construction with liquid soil according to RAL-GZ 507

Source: Archive RSS Flüssigboden® building



Use: Durable, cost-effective solution instead of expensive mechanical solution with material fatigue, exchange material, transportation and disposal, construction speed .....
TECHNOLOGY and consequences

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



Experiences with liquid soil

Dyke construction with liquid soil according to RAL-GZ 507

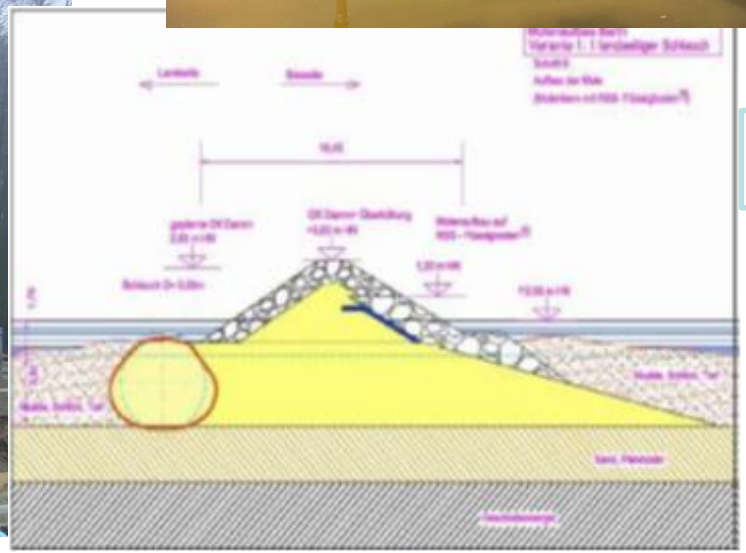
Use: Exchange material, transport and disposal, substitution of seals, one backfill body instead of several layers
TECHNOLOGY and consequences

Source: Archive RSS Flüssigboden® building sites

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



Experiences with liquid soil

Avoiding base failure/ground heave with liquid soil according to RAL-GZ 507

Use: Exchange material, transport and disposal, substitution of concrete, damping helps avoid consequential damages .....TECHNOLOGY and consequences

Water engineering / harbour facilities

Source: Archive RSS Flüssigboden ®

building sites

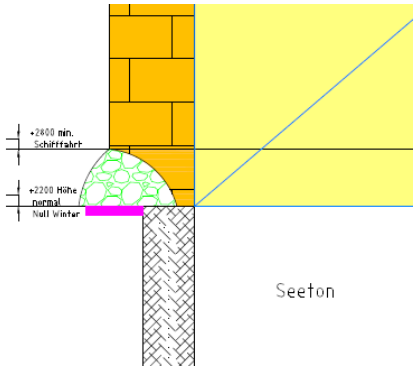
- Backfilling of scourings behind sheet piling
- Vibration damping and thus the prevention of base failure as a result of dynamic loads eg through propellers or traction pull
- Backfilling in and under water independently whether fresh or salt water
- Prevention of damage in the subsoil as a result of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

Experiences with liquid soil

Solving static problems with liquid soil according to RAL-GZ 507

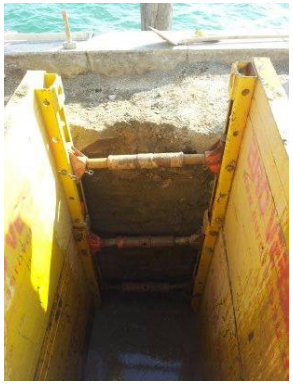
Use: Exchange material, transport and disposal, substitution of expensive foundation solutions, prevention of adverse flows caused by foreign bodies .....TECHNOLOGY and consequences

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 liquid soil

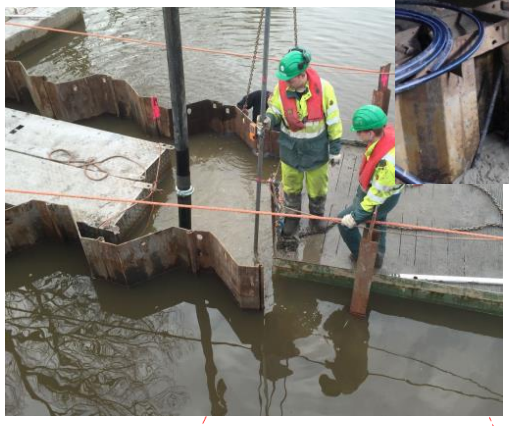
Culvert construction in running water with liquid soil according to RAL-GZ 507

Use: Placement in running water, no momentum effect due to controlled buoyancy with consequences for cranes etc., no load-bearing bodies, construction time .....
TECHNOLOGY and consequences

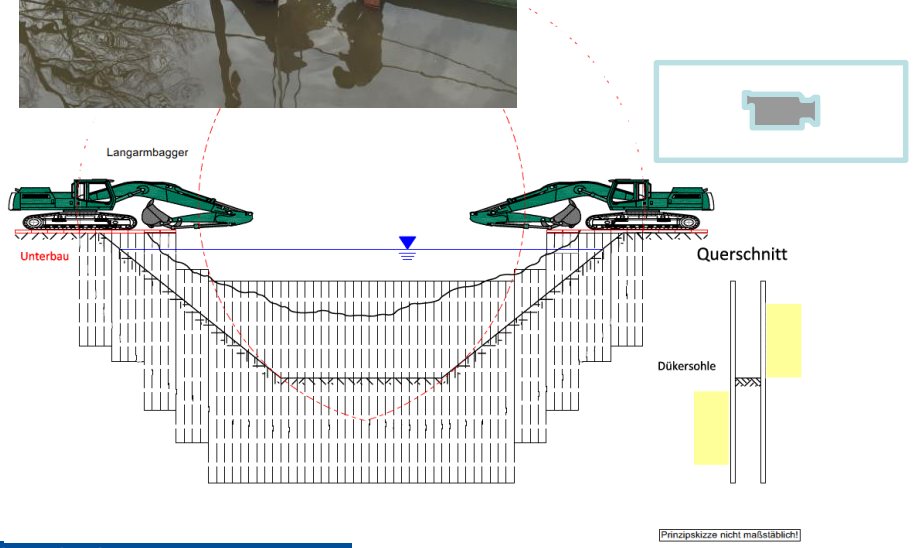
Culvert construction in running waters

- 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 liquid soil

Possible applications of liquid soil according to RAL-GZ 507 for supply lines

Use: ?????????????????????????? – what do sensitized calculators now see themselves?
TECHNOLOGY and consequences as the focus of the search for savings – need for technology knowledge!

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:

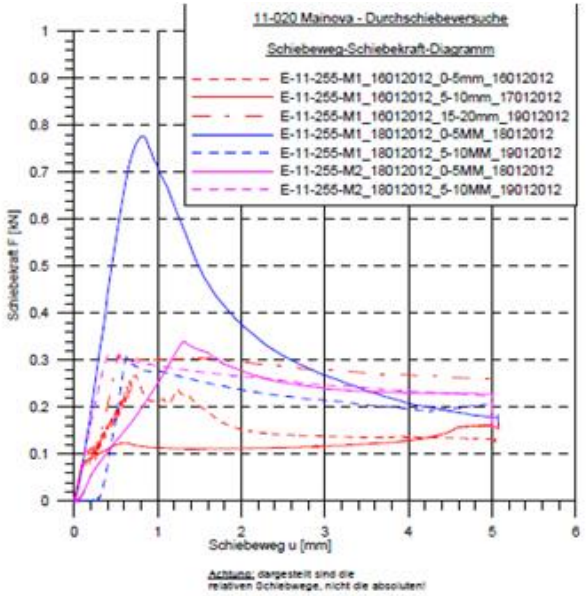
Advantages for municipalities or waste water companies: Applications for municipal supply and disposal companies in the fields of all supply lines like gas, drinking water, to high voltage lines, FOC or district heating, but also rain and waste water

Experiences with liquid soil

district heating

Quality assurance and verification

Source: Archive RSS Flüssigboden® building sites

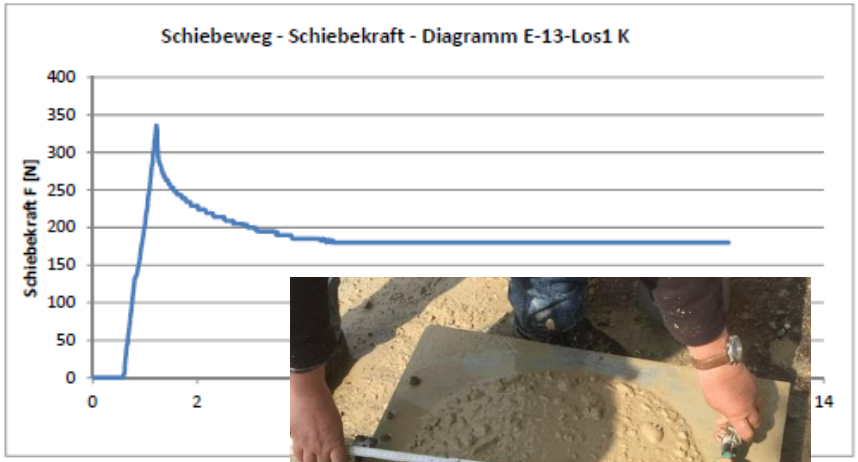


Durable friction forces with a defined upper and lower limit on the district heating pipe – basis for a long lifetime of the pipe without any damages – Berlin, Unter den Linden, plastic sheath pipe DN 400

Experiences with liquid soil

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 liquid soil

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 liquid soil according to RAL-GZ 507

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

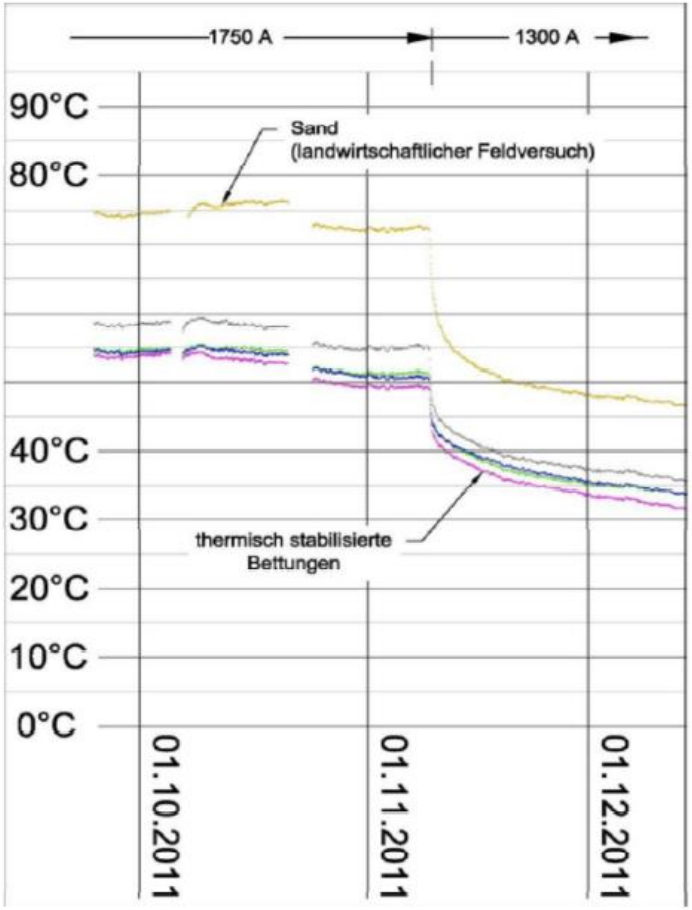
Source: Archive RSS Flüssigboden® building sites

Experiences with liquid soil according to RAL-GZ 507

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.



Experiences with liquid soil according to RAL-GZ 507

Construction of high and ultra-high voltage lines

- **Raesfeld – first 380 kV project of the energy revolution**
- Construction of new high-voltage lines with the need for good heat dissipation with thermally stabilizing Flüssigboden TS in the sense of the demands of agriculture for preserving the properties of their resource "soil"

Source: Archive RSS Flüssigboden® building sites

Experiences with liquid soil according to RAL-GZ 507

Construction of solar heat storage tanks

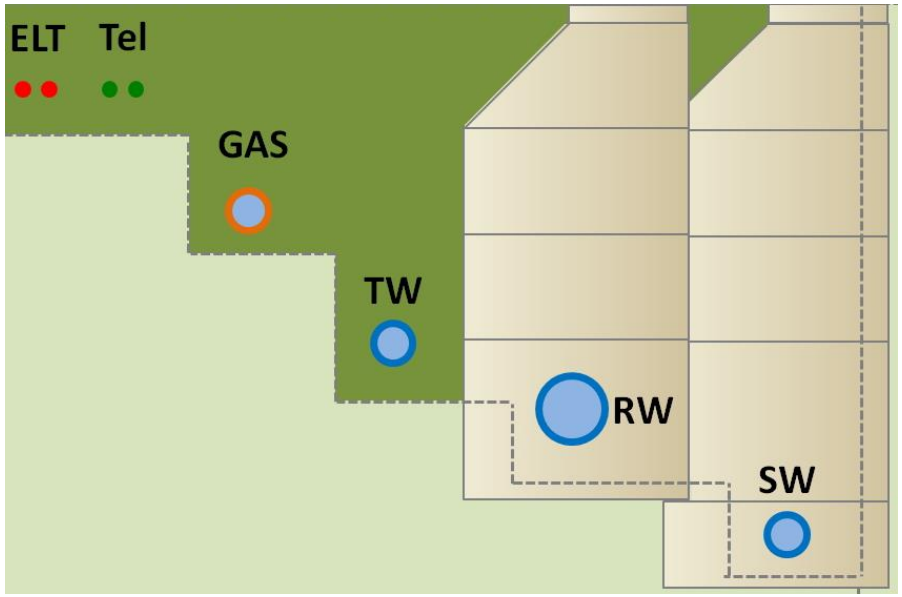
with a 0.8m thick, surrounding slotted wall made of heat-insulating RSS Flüssigboden®, with high waterproofness and a core of heat-storing and also waterproof RSS Flüssigboden®

- **Insulation and storage**
- Construction of solar heat storage tanks with thermally insulating liquid soil in the outer ring and thermally stabilizing liquid soil for storage while simultaneously cooling photovoltaic plants to increase the efficiency of the plants

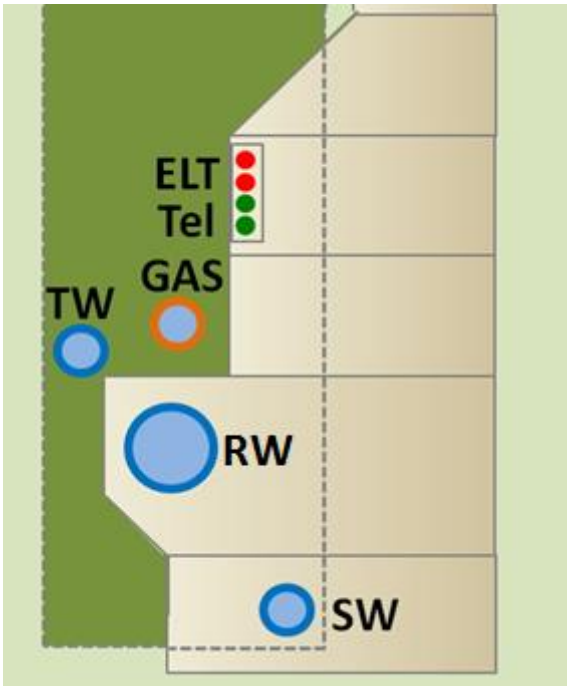
Source: Archive RSS Flüssigboden® building sites

Energy revolution – a new reason for liquid soil

Combined conduits – chance to solve urban problems



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



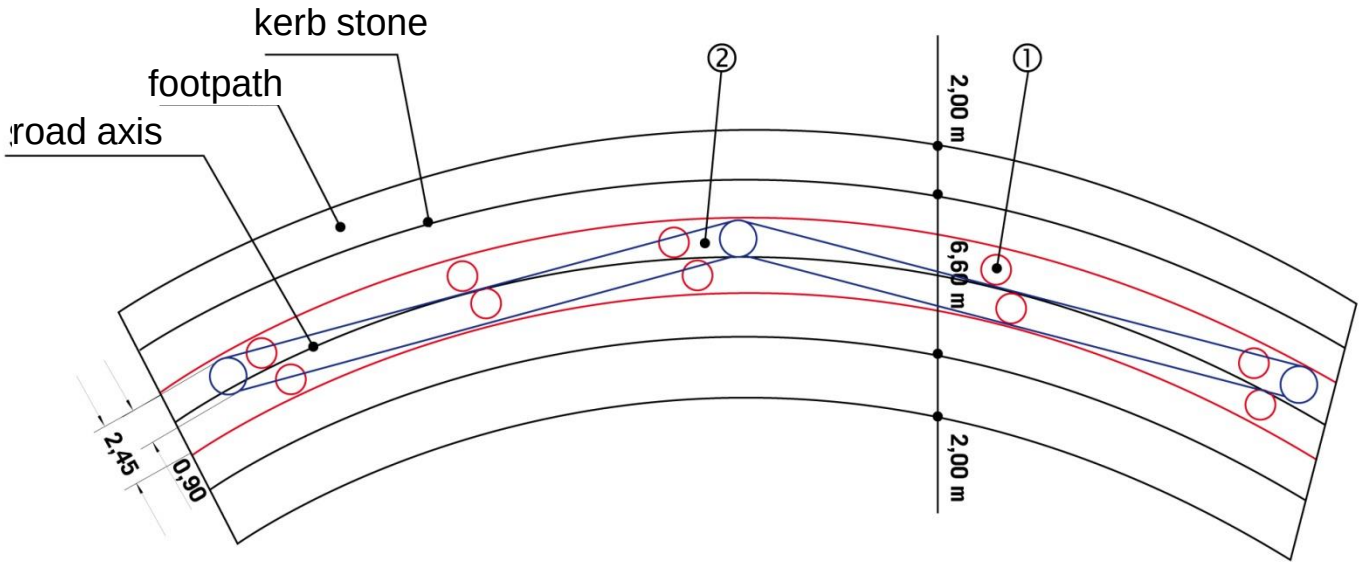
Increasing effort in the maintenance of the grids required new solutions

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



Legend

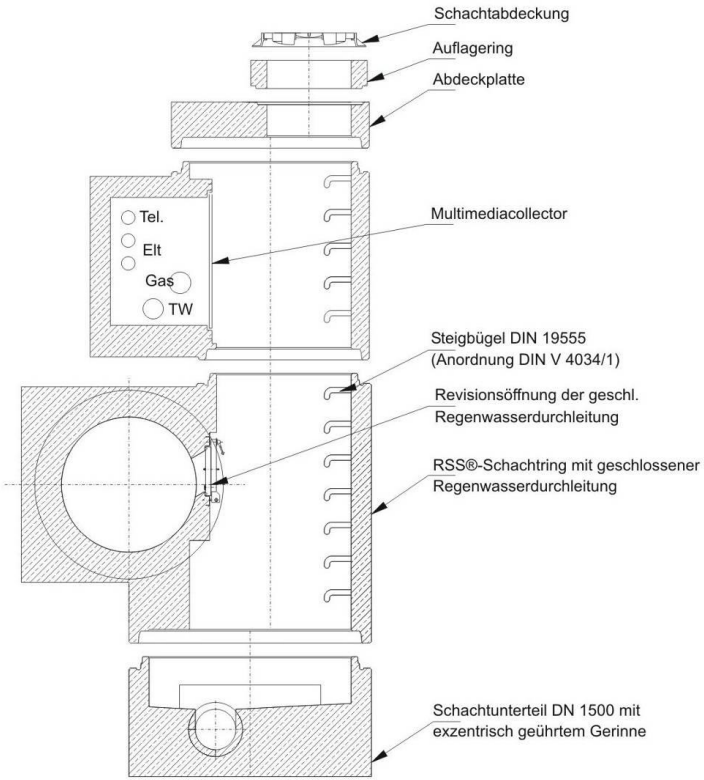
① classical with 2xDN1000 shafts, pairwise

② use of RSS shafts with RSS Flüssigboden® and optimised trench width

Experiences with combined conduits and liquid soil according to RAL-GZ 507

Source: Archive RSS Flüssigboden® building

Source: engineering office LOGIC, project Stuttgart, Katharinen hospital



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

Experiences with combined conduits and liquid soil 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 liquid soil

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, Mittlerer Schlossgarten

Quality assurance of liquid soil according to RAL-GZ 507 – Basis of safe use of the benefits

Use: The material has to work because the benefit of technology is much higher than a benefit that can be drawn from cheap material!!! Ie not the material price but the function is decisive!

Objective 1: Prevention of construction and consequential damages

Quality assurance of liquid soil 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

etc.

STADTENTWÄSSERUNG GÖTTINGEN

But where does the need for a transparent quality assurance **in the hands of the builders** come from?

Shrinkage of hydraulically setting materials

The central task of the work according to RAL-GZ 507 for the prevention of structural damage and defects consists in:

- 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

Diese Güte- und Prüfbestimmungen definieren die Güteanforderungen an Herstellung, Transport und Einbau von Flüssigboden.

Flüssigboden ist ein zeitweise fließfähiges und volumenkonstant verfestigendes Verfüllmaterial für bautechnische Zwecke, das sowohl aus Bodenmaterial, als auch aus natürlichen und aufbereiteten Böden und Gesteinen hergestellt werden kann.

Diese Güte- und Prüfbestimmungen gelten nicht für die Herstellung von zeitweise fließfähigen Baustoffen aus den o.g. Materialien deren Festigkeitsbildung vorwiegend auf dem Einsatz hydraulischer Bindemittel beruht und/oder deren Festigkeitsbildung durch latent- oder resthydraulische Bestandteile beeinflusst werden.

1.1 Begriffsdefinition

Flüssigboden im Sinne dieser Güte- und Prüfbestimmungen ist das Ergebnis eines Verfahrens und wird wie folgt charakterisiert:

- alle Bestandteile sind umweltökologisch unbedenklich,
- durch eine Lösbarkeit in Anlehnung an die Bodenklassen 3-5 nach DIN 18300,
- ist aus allen Arten von gesetzlich zulässig verwertbaren mineralischen Stoffen und Bodenmaterialien, z. B. aus natürlichen und aufbereiteten Gesteinskörnungen (wie Kies-Sand-Gemisch) sowie aus güteüberwachten Recyclingmaterialien ohne treibende, latent- oder resthydraulische und den Wasser- Bindemittelwert verändernde Eigenschaften herstellbar,
- ist zeitweise fließfähig und in verschiedene Konsistenzen (fließfähig bis plastisch) mit gleichbleibenden bautechnisch relevanten und chemisch stabilen Endeigenschaften herstellbar,
- ist selbst verdichtend und durch Kohäsion und Reibung (friktional) rückverfestigend ohne die Bildung fremder, physikalisch starrer Bindemittelstrukturen,
- weist hohe Volumenkonstanz im Ausgangs- und Endzustand unter gleichbleibenden, äußeren Bedingungen auf,
- kann in Bezug auf seine Eigenschaften anwendungsspezifisch gezielt verändert werden.

1.2 Mitgeltende Vorschriften, Richtlinien und Normen

- alle zutreffenden Normen und Vorschriften einschließlich den allgemein anerkannten Regeln der Technik,
- alle umweltrechtlichen und arbeitsschutzrechtlichen Anforderungen und Gesetzlichkeiten.

2 Vorgehensweise bei der Anwendung des Flüssigbodenverfahrens

Um Flüssigboden im Sinne dieser Güte- und Prüfbestimmungen herstellen, transportieren und einbauen zu können, müssen nachfolgende Verfahrensschritte eingehalten werden.

2.1 Baugrunderkundung

Der Umfang der Baugrunderkundung ist in Normen geregelt und erfolgt im Sinne des Normenhandbuches EC 7-2 in der Regel zweistufig als Vor- und Hauptuntersuchung. Wird davon abgewichen muss zumindest eine Hauptuntersuchung durchgeführt werden.

Bereits im Rahmen der Voruntersuchungen sind direkte Aufschlüsse erforderlich.

Die direkten Aufschlüsse sind in der Hauptuntersuchung bevorzugt als Schürfe auszuführen, um die erforderlichen Mengen an Probenmaterial zur Verfügung stellen zu können.

Geltende Normen und Regelwerke

Die Anforderungen an Baugrunduntersuchung, Laborversuche und dem geotechnischen Bericht

sind in

- *DIN EN 1997-2 Eurocode 7: Entwurf, Berechnung und Bemessung in der Geotechnik, Teil 1: Allgemeine Regeln,*
- *DIN EN 1997-2 Eurocode 7: Entwurf, Berechnung und Bemessung in der Geotechnik, Teil 2: Erkundung und Untersuchung des Baugrunds,*
- *Für Projekte in Deutschland einschließlich DIN EN 1997-2/NA: Nationaler Anhang und DIN 4020:,*
- *Geotechnische Untersuchungen für bautechnische Zwecke – Ergänzende Regelungen zu DIN EN 1997-2*

bzw. jeweiliger nationaler Anwendungsdokumente und Anhänge in den jeweils gültigen Ausgaben verbindlich geregelt.

Geotechnische Kategorie bei Anwendung von Flüssigboden

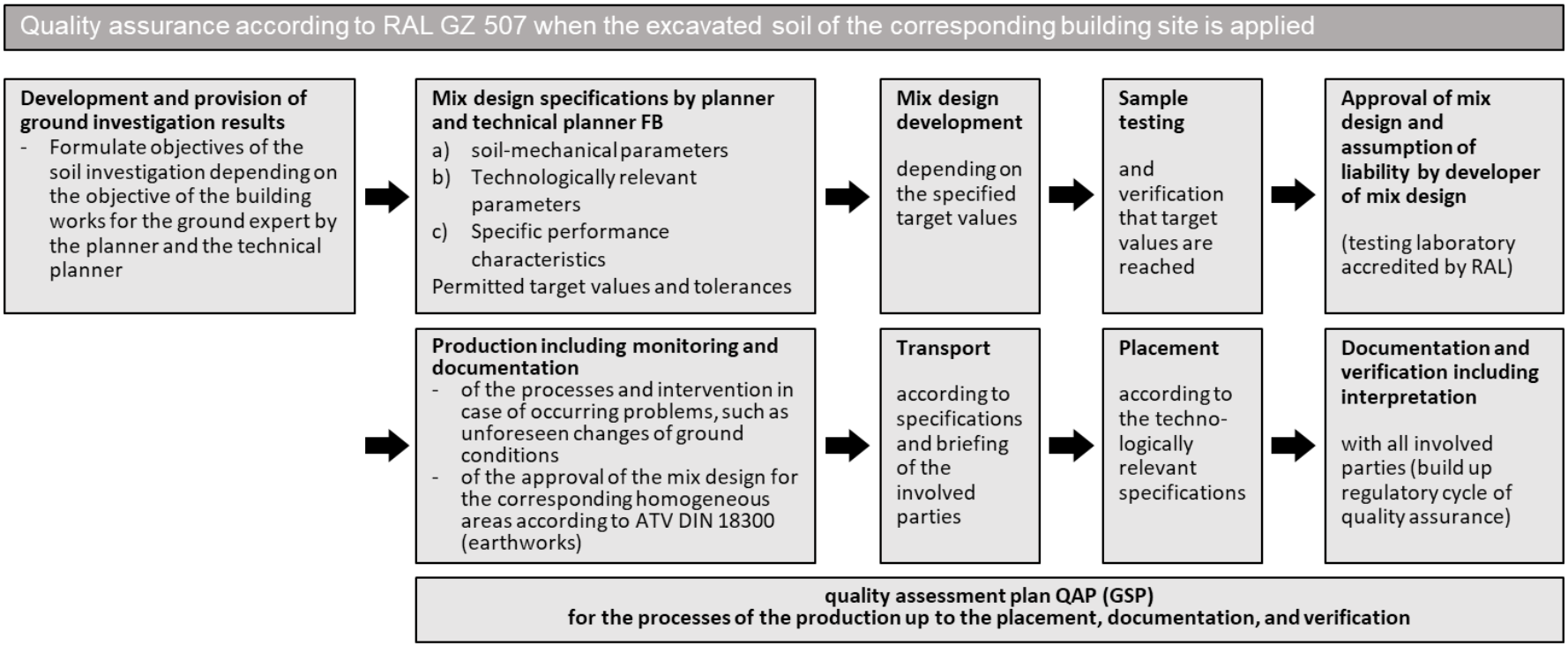
- Nach EC 7 ist vor Beginn der Baugrunduntersuchungen die Baumaßnahme in eine der drei Geotechnischen Kategorien GK1, GK2 oder GK3 einzustufen. Umfang und Art der Baugrunduntersuchungen sowie der Laborversuche orientieren sich u.a. an der Geotechnischen Kategorie, siehe Abschnitt 2.2, EC 7.
- Baumaßnahmen, bei denen Flüssigboden zur Anwendung kommt, sind unter Ausschluss nachfolgender Ausnahmen in die geotechnische Kategorie GK 2 einzustufen.

Wird Flüssigboden vorwiegend für die folgenden Aufgaben eingesetzt, ist die Baumaßnahme der geotechnischen Kategorie GK 3 zuzuordnen:

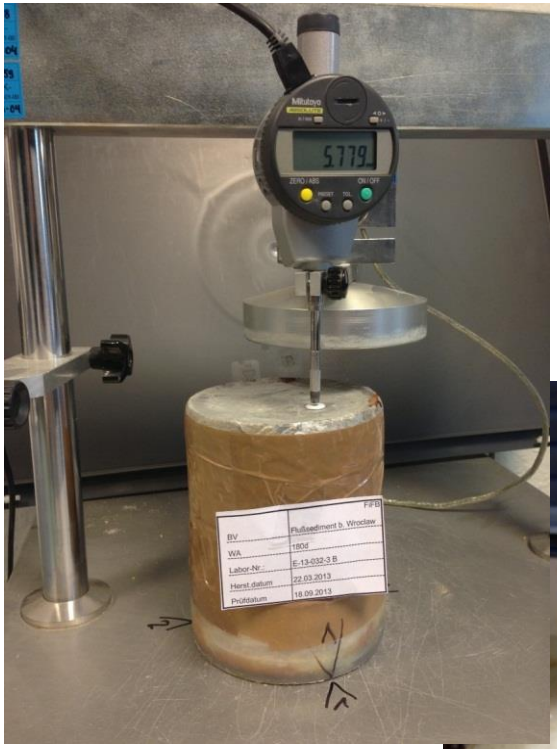
- Schwingungsisolierung,
- Wärmeisolierung oder Wärmeableitung,

Activities and offers of the RAL Quality Association for Liquid Soil for interested parties

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



Quality assurance for liquid soil according to RAL-GZ 507

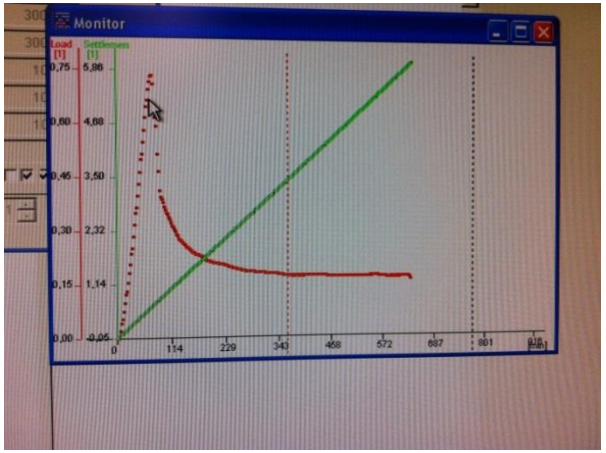


Verification of the **soil typical properties** in contrast to the properties of hydraulically setting materials by:

- 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 liquid soil according to RAL-GZ 507



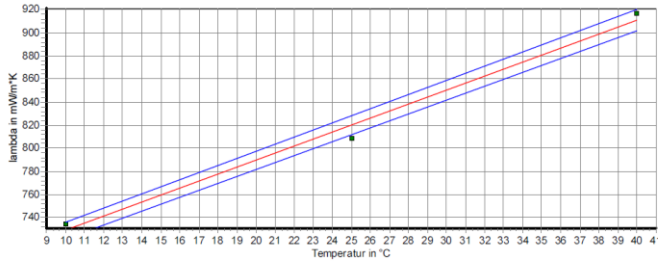
Verification of Usability

– 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 liquid soil according to RAL-GZ 507



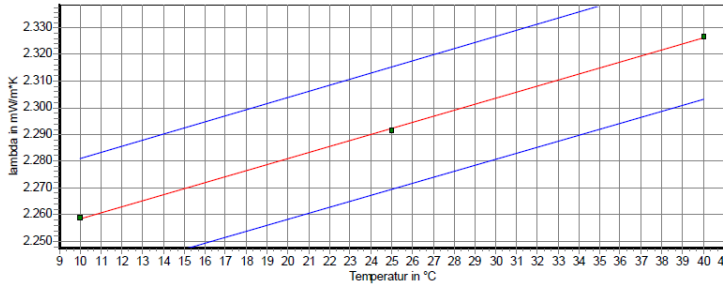
	1. Messung	2. Messung	3. Messung
Versuchsnummer	G167Nr37_201	G167Nr37_201	G167Nr37_20
Messtemperatur in °C	10	25	40
Temp.-Diff in K	15	15	15
lambda in mW/m*K	734,7	808,5	916,6
R in m²K/W	0,0839	0,0762	0,0672

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

lambda-10	728,98	mW/(m*K)
R-10	0,0845	m²*K/W
TK	6,0633	mW/(m*K²)

29.10.2012 André

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	0,02587	0,02548

Polynom
y = f(T) = 2,2667 * T + 2235,70

lambda-10	2258,3	mW/(m*K)
R-10	0,0263	m²*K/W
TK	2,2667	mW/(m*K²)

Verification of Usability

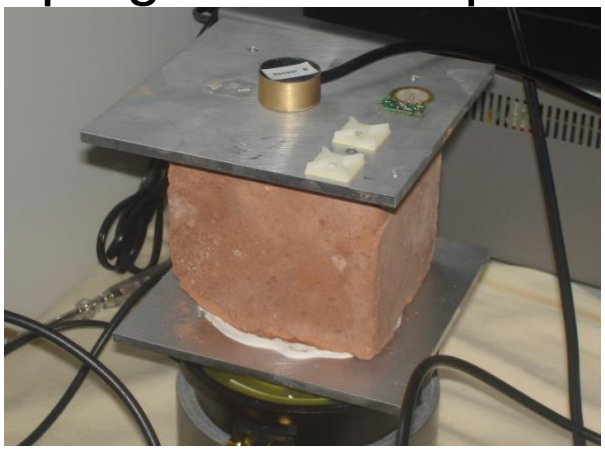
- Improved thermal conductivity of the bedding material by thermally stabilizing effect of a special liquid soil, and measurement of the lambda value with increasing temperature
- Verification of the adjustability of this parameter for liquid soil TS by means of mix design variations, since lambda also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

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

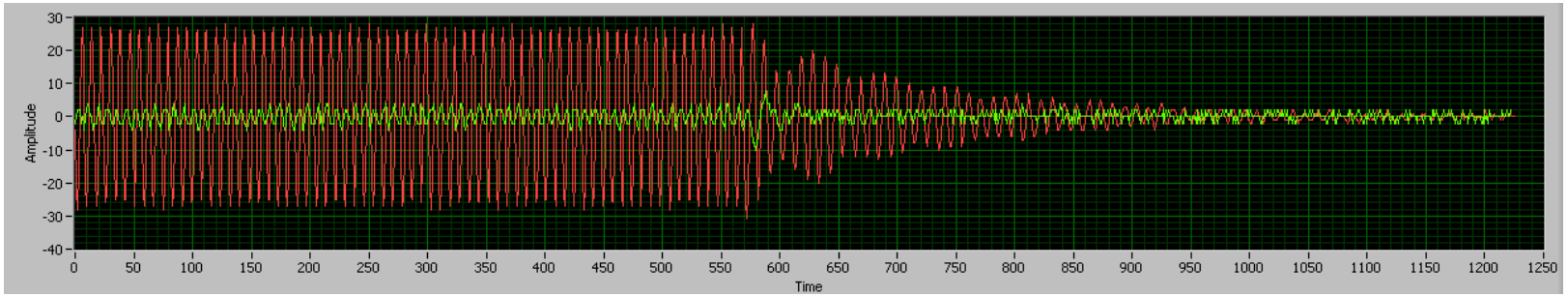
Quality assurance for liquid soil according to RAL-GZ 507

Verification of Usability

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



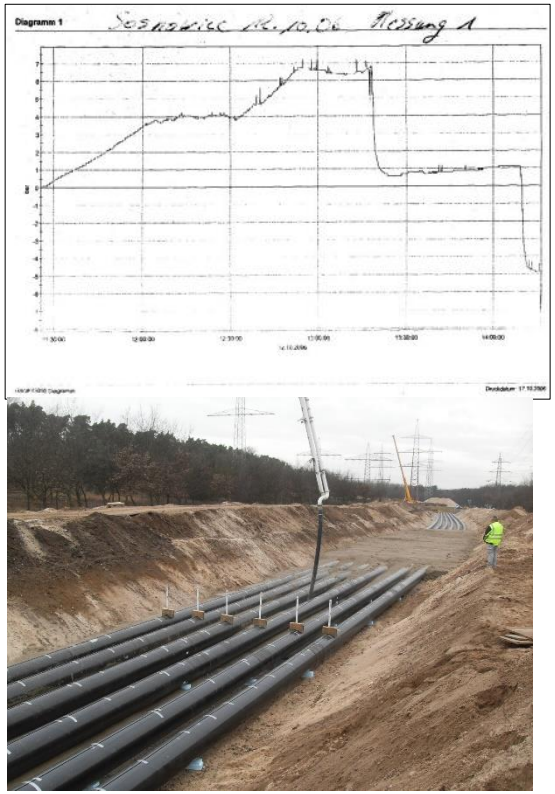
Soil sample [B]



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

Quality assurance for liquid soil 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



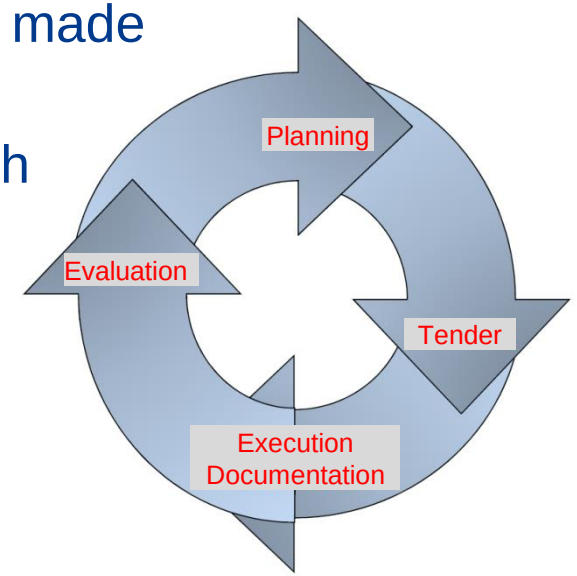
Source: Archive RSS Flüssigboden® building sites

Quality assurance for liquid soil 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

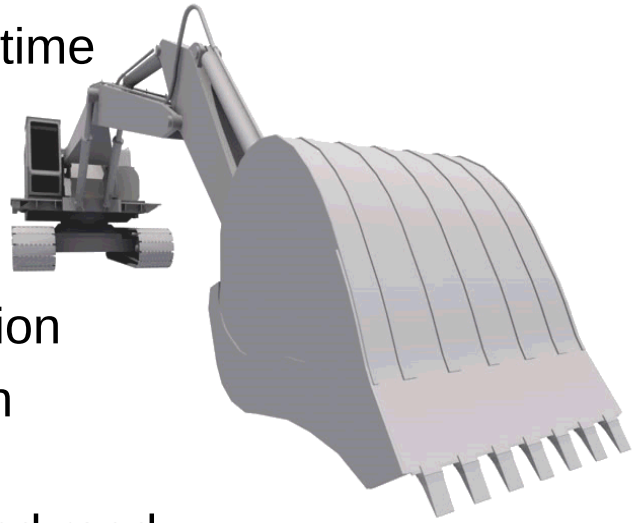
Summary

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 for your attention!

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