Soil Improvement Systems

Traditional replacement by crushed material (2-3 m deep) with lean concrete layer (10-15 cm), mechanical & chemical stabilization either with lime or cement, geotextile grids for pavement, stone and sand columns encased by geotextile, other methods to avoid Liquefactions, subsurface drainage, …

A _ Structured Questionnaire to Soil Improvement / Soil stabilization

Nr.	Employer's Documents / **Design = paramount (Scope of Works)**	Observation by „Builders" Inconsistence to Specification, Method of Measurement and BoQ	Builder's Proposal to overcome „impracticable constructability".	General remarks
100	**SOIL Conditions encountered / geotechnical exploration results**			
	▪ cohesive soil silt – clay – loam – sand agglomerates			
	▪ grain size distribution graph)			
	▪ organic layers between the different soil strata (clay, silt, peat, sludge)			
	▪ actual Shear strength of the surrounding soil			
	▪ Actual Load Bearing Capacity of the soil / CBR greater than seven (7).			
	▪ Natural Water Content of the different soil properties			
	▪ Ground water stream, ground water level, permeability coefficient of the soil strata / layers			
	▪ Level of the hard firm strata (depth from the undisturbed surface to the hard firm "foundation")			
	▪ Geotechnical report with the borehole results available: varied soil characteristics, moisture / water content, ground water flow, permeability coefficients, aso.			
200	**DESIGN Parameter**			
	▪ Identify level of improvement in surrounding soil stability, replaced soil by sand / stone columns (with encased geotextile?), release of water pore pressure by suitable drainage system and the load bearing capacity of the column with less bulging deformations.			

		▪ Unit cell concept with triangle or square pattern arrangement			
		▪ Computation of the spacing of the diameter of the piles, spacing, allowable soil and ultimate load carry capacity			
		▪ Diameter of the stone / sand columns (0,5 m – 1,2 m for soft weak tributary soil)			
		▪ Encased gravel or sand columns with geotextile (confinement effect), suitable for surrounding soft / weak soil			
		▪ Grain size distribution of the crushed aggregate			
		▪ Embedded depth of the stone column into the hard firm strata			
		▪ Geogrids in different intervals to retain the column form and behave as stable			
300	**DRAINAGE System**				
		▪ Drainage paths, e.g. Gravel blanket on top of the stone columns			
		▪ Drainage path properly designed to control the pore water pressure and settlement / consolidation			
		▪ **Subsurface Drainage** on each side, and in the middle, if a dual carriage way is designed			
		▪ Water must be rapidly dissipated to reduce the **pore water pressure** / preventing liquefaction through vibration of the installation and traffic loads later on and damages by settlements due to high water ground water as well.			
400	**Design Drawings with Notes**				
		▪ Drawings showing the Layout, Elevation, … levels, positions, dimensions, quality of the works			
		▪ Drawings showing the details of the Columns with Depths to embed in the stiff strata (dimensions, levels, .			
		▪ Does the Drawings refer to Quality Assurance System (tech Specification)?			
400	**Field Tests carried out?**				
		▪ Ahead of any construction execution it is desired to carry out field tests / samplings as a prerequisite of any			

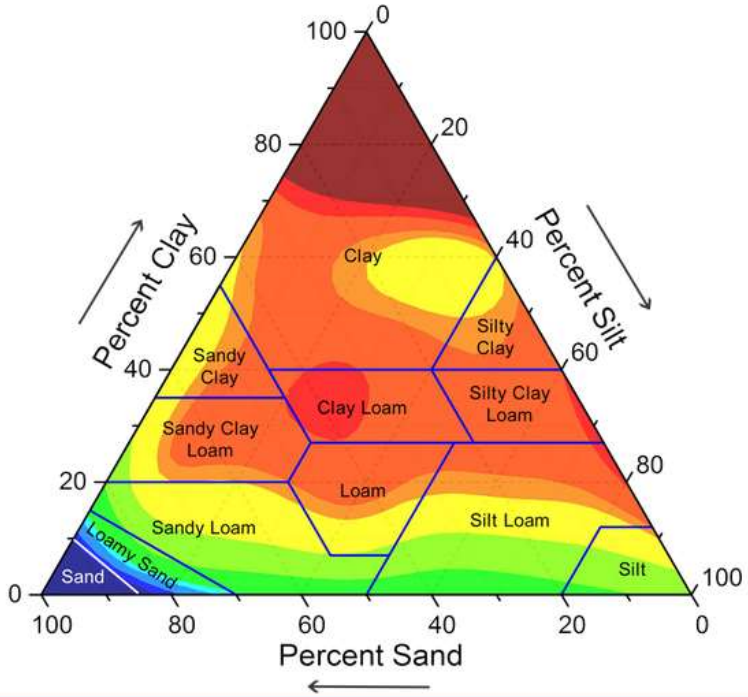
	commencement of permanent works. e.g. load bearing test, crash test, functional tests to secure FFP / Fit for Purpose. ▪ FIELD tests carried out - according to Specification – or by Engineer's instruction? Failures like bulging through lateral earth pressure in the critical pile length / shearing failures, punching failure in the "firm, stiff" ground strata due to insufficient capability (floating support) to build up an appropriate reaction force > load bearing capacity will not meet the requirements ▪ Requirements of the Stone and Sand columns properly defined? ▪ Quality Assurance System = Tech Specification Criteria?			
500	**Method of Construction / Installation pattern with the rigs**			
	▪ By ramming or vibration (hazardous procedure to liquefy the wet silt-clay-sand mixture)			
	▪ By boreholes with damping			
	▪ Wet top feed method or bottom feed compaction system			
	▪ Inspection and Testing procedure … What does the Specification about the (i) "input of classified material, Contractor's responsibility to process the "ingredients" and to inspect & test the output in compliance with the Quality Assurance System (SC4.9) in principle defined in the Tec . Specification.			
600	**Contract Administration**			
	▪ **Claim Notices SC20.1** for Disruption and Delay due to "impracticable constructability" : defective design not Fit for Purpose due to insufficient Site Data (SC04.10) and UPC (SC04.12) at Base Date. ▪ **Continuing Effect**, submission of **Interim Claims** at monthly intervals with **accumulated** delay and amount claimed …			

		further Particulars may reasonable required by the Engineer pursuant to SC20.1 (b)			
		▪ **Variation Proposals** requested by the Engineer SC13.1			
		▪ Value Engineering SC 13.2! WHY? Acceleration may not be the case and why shall the Contractor take over all design costs and disruption / delay periods on his own account?			
		▪ **Claim Requests** substantiated and in Principle decide (approve, disapprove **with detailed comments**) subject to [SC20.1], evaluated Quantum (time, cost plus profit) [SC12.3] and formal Notice of Ascertainment by the Engineer [SC03.5]			
		▪ Termination procedure followed according to FIDIC Clause15 ; (i) Termination by Employer during the period of completion or (ii) Termination by Employer after expiry of Time for Completion (initial or substantiated EoTfC)			
		▪ SC15.1 **Notice to Correct** to make good the failure and to remedy it within a specified reasonable time			
		▪ SC15.2 Termination by Employer: entitled, if the reasons for a substantial breach of Contract are met > 14 days' **NOTICE to terminate** the Contract without wrong-doings and expels the Contractor from the Site (e) bankrupt liquidation+ (f) bribe			
		▪ SC15.3 **Valuation at Date of Termination**: value of works, goods, Contractor's Documents, and any other sums due to the Contractor in accordance with the Contract ▪ SC15.4 **Payment** after Termination (a) Employer's claims (b) withhold further payments to EMP all costs (c) recover loss and damage (completing the works) > pay any balance to the Contractor			
		▪ SC15.5 Employer's Entitlement to Termination for **Convenience,** (28 days grace period) but not execute himself or to arrange another contractor to execute			
		▪ SC15.6 Corrupt or Fraudulent Practices			
		▪ Potential of **Wrong-doing** Termination identified? Which actions have been induced / arranged / disposed?			

B _ Identification of Soil Conditions : Clay 2my, Silt, Sand max. DE 2,0 mm / BE 4,75mm

Note: Consider the natural moisture content, the pore water pressure and the ground water level

In the image below (from Natural Resources Conservation Service) there is a representation of the soil textural separation percent of clay, silt, and sand. Based on this separation the Intake Rate and Field Capacity differ from a soil type to another.

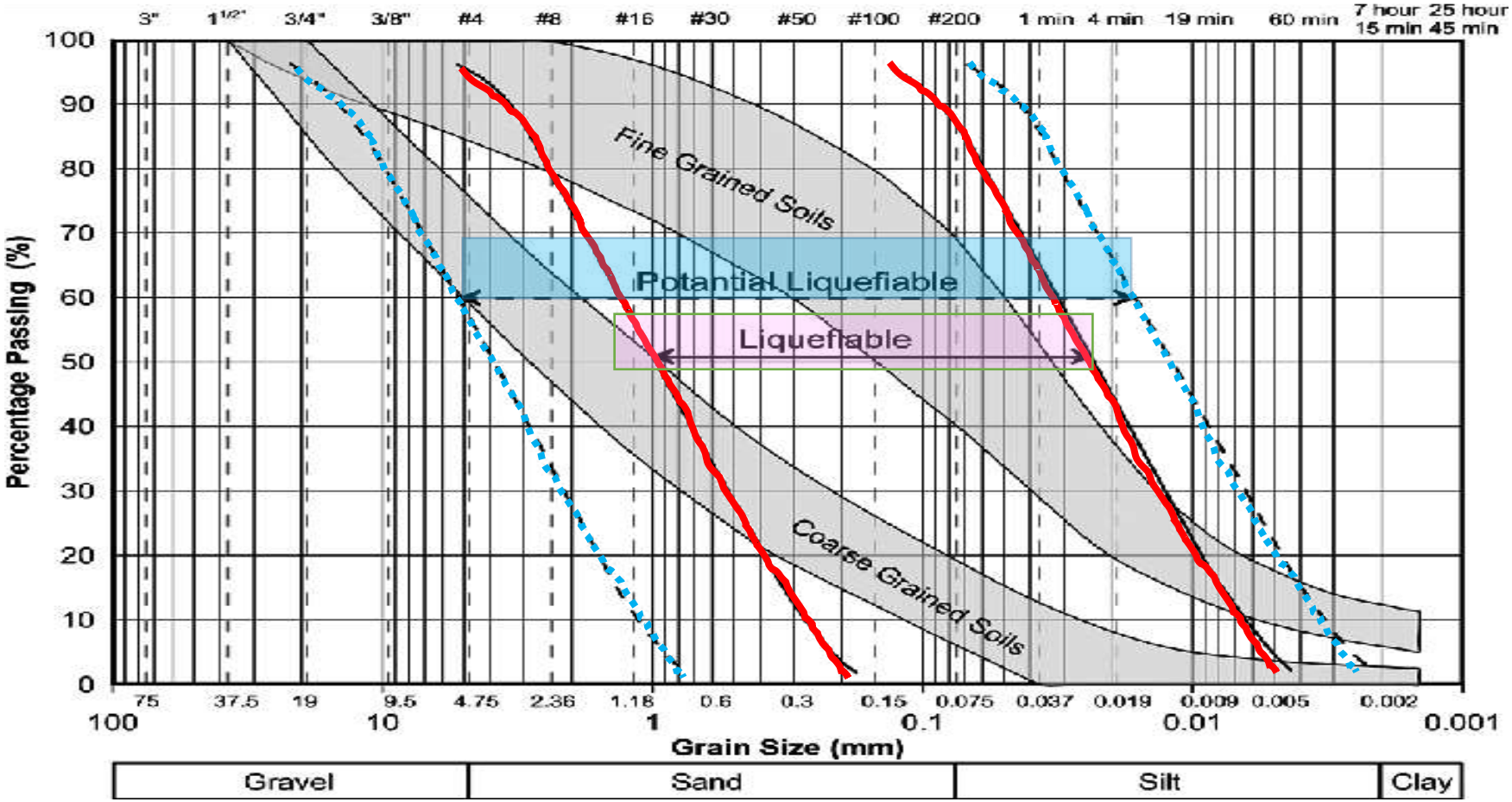


Source : https://www.google.com/url?sa=i&url=https%3A%2F%2Fsupport.rainmachine.com%2Fhc%2Fen-us%2Farticles%2F228001248-soil-types&psig=AOvVaw35YS2eaz8CbLdtT1vh57hd&ust=1629105585792000&source=images&cd=vfe&ved=2ahUKEwiRiZuv2bLyAhWgxrsIHf3rAmAQjRx6BAgAEA

Source : https://www.google.com/url?sa=i&url=https%3A%2F%2Fsupport.rainmachine.com%2Fhc%2Fen-us%2Farticles%2F228001248-soil-types&psig=AOvVaw35YS2eaz8CbLdtT1vh57hd&ust=1629105585792000&source=images&cd=vfe&ved=2ahUKEwiRiZuv2bLyAhWgxrsIHf3rAmAQjRx6BAgAEAo

C _ Potential of Liquefiable Soil

Obeserve the Partical / grain size distribution for the hazard for liquefaction: lower curve (Silt): 0,005-0,010 mm upper curve(Sand): 0,150 – 4,75 mm
The Employer's designer shall definitely explore the soil conditions (Site Data SC04.10 Red Book 1999-2017/ Pink Book MDB2010) by geotechnical profiles and laboratory tests extensively in order to avoid erroneous design parameters / stability failures (not Fit for the Purpose) at Base Date and to obviate Unforeseen Physical Condition / UPC-claims (SC04.12) from the Contractor / Builder in the course of implementation.



Source: https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.researchgate.net%2Ffigure%2FGrain-size-distribution-interval-for-liquefaction-susceptibility-of-the-soil-samples_fig14_258806465&psig=AOvVaw2j2byQXYVrLeR-t2LBWTuY&ust=1629105001108000&source=images&cd=vfe&ved=0CAcQjRxqFwoTCPCfxJzXsvICFQAAAAAdAAAAABBI

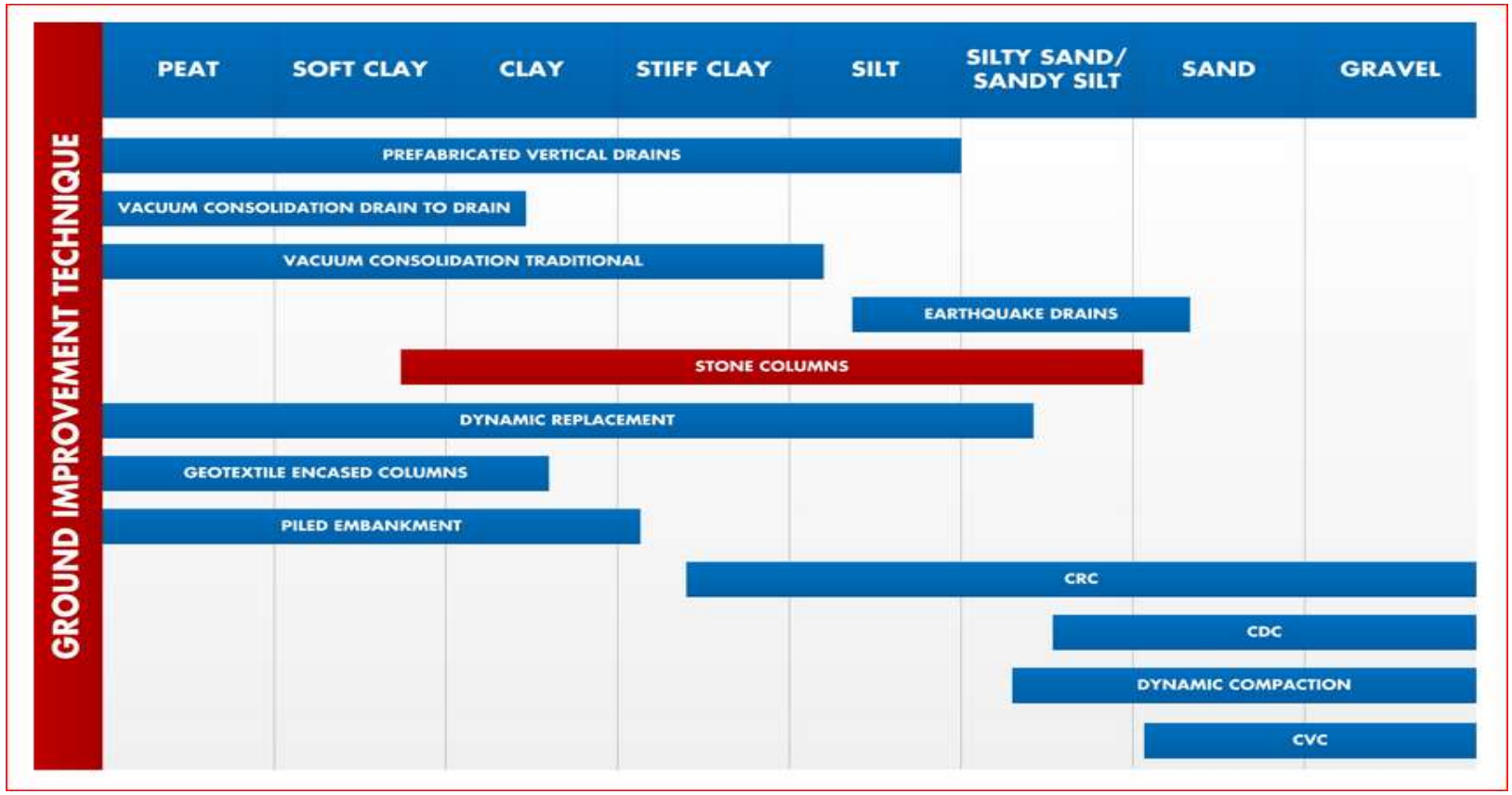
D _ Result of Soil “Liquefaction”

due to dynamic stress (e.g. traffic flow, earthquakes), ground water level, increased water pore pressure
Buyoance lifts the empty pipes and manholes.

Source : https://upload.wikimedia.org/wikipedia/commons/1/1e/Chuetsu_earthquake-earthquake_liquefaction1.jpg

E _ Proposed “company” Application of the difference Soil Improvement Methods

Proposed application dependend of the Soil properties; not linked to ground water level, grain size distribution of silt and sand, natural moisture content, pore water presure.



Alternative Design Charactersitics with Installation procedure

German Method: CSV Bodenstabilisierung Laumer … soil stabilization by sand-cement-bound columns, installation vibraton-free, 28 days` strength = 500 kN.