



INTRODUCTION OF TOTAL COMPACTION SYSTEM

SEPTEMBER, 2018



DENVER KOREA ENGINEERING & CONSTRUCTION INCORPORATION

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- 2 OVERVIEW & CHARACTERISTICS OF T.C.S. TECHNOLOGY
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- 7 CERTIFICATION OF PUBLIC INSTITUTION & ACADEMIC SOCIETY

COMPANY INTRODUCTION



- Company Profiles
 - Patents Holding
-

1. Company Introduction

Company Profile

○ General Status

Company name	DENVER KOREA E&C INC
C.E.O	JUNG. EUI YOUP.
Founded	JUNE 23, 1993
Business Field	BORING GROUTING, REINFORCE STRUCTURE, CIVIL ENGINEERING. EARTHWORK
Main Office Address	#325, Hwangsaeul-ro, Bundang-gu, Seongnam-si, Gyeonggi-do, Korea
Web Page	www.denverkorea.co.kr

○ MAIN OFFICE AND WAREHOUSE

▼ DENVER MAIN OFFICE (SEOHYUN-DONG, BUNDANG)



▼ DENVER P&P (GYEONGGI-DO GIMPO)



1. Company Introduction

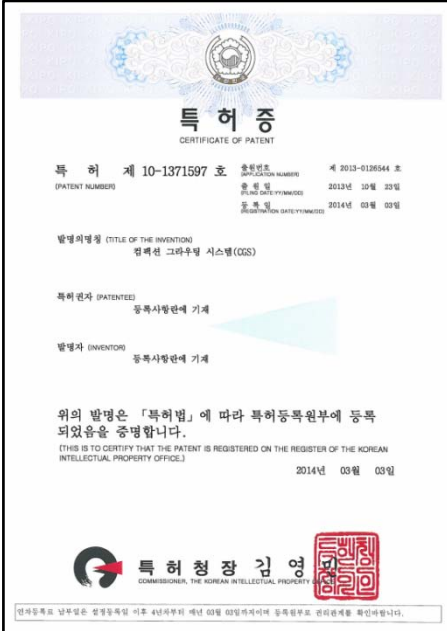
Company Profile

COMPANY HISTORY

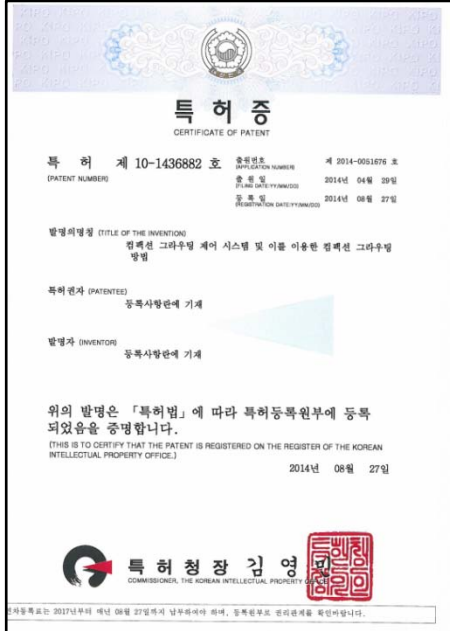
A First Stage	Aug, 1993	<ul style="list-style-type: none"> Induce Compaction Grouting (CGS Technology / LMG Technology) from Denver Grouting, U.S.A
Design & Execution Stage	January, 1994~	<ul style="list-style-type: none"> Over 1,000 cases of execution & Design
Technical Development Stage	July, 1994	<ul style="list-style-type: none"> Intellectual Property Rights: 18 cases Patent, 1 Disaster Prevention technology Acquisition
	June, 2012	<ul style="list-style-type: none"> R & D Started Low mobility high pressure injection pump, Quality control Management system
	April, 2014	<ul style="list-style-type: none"> Development real time monitoring system for grouting injection Low mobility high pressure injection pump completed (SI-P): Multi-injection pump and Quality control system completed
	October, 2014	<ul style="list-style-type: none"> Disaster Prevention technology acquisition (#77)
	January, 2015	<ul style="list-style-type: none"> Quality control management system (QCM) completed
	March, 2015	<ul style="list-style-type: none"> Pump, Injection units, Material mixture system upgrade
	2016. 09	<ul style="list-style-type: none"> Construction license
Supplementation of Technology Development Stage	~ Present	<ul style="list-style-type: none"> R&D Continuing

1. Company Introduction

Patents Holding



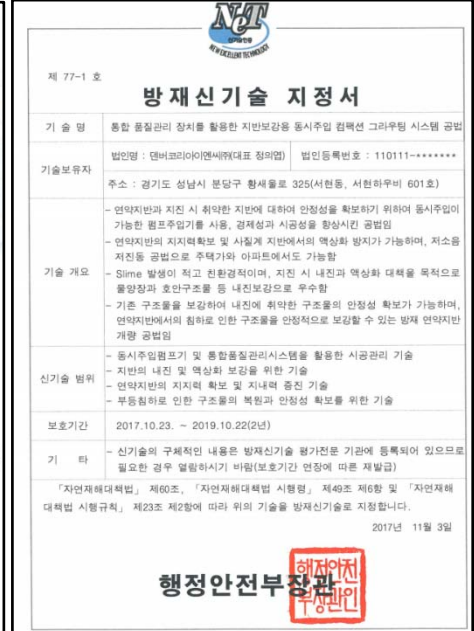
Compaction Grouting System
(10-1371597)



Compaction Grouting Method
Using Compaction Grouting
Control System
(10-1436882)



Quality Control Metering for
Mortar Manufacturing with
Soil and Crushed Stone
(10-1630350)



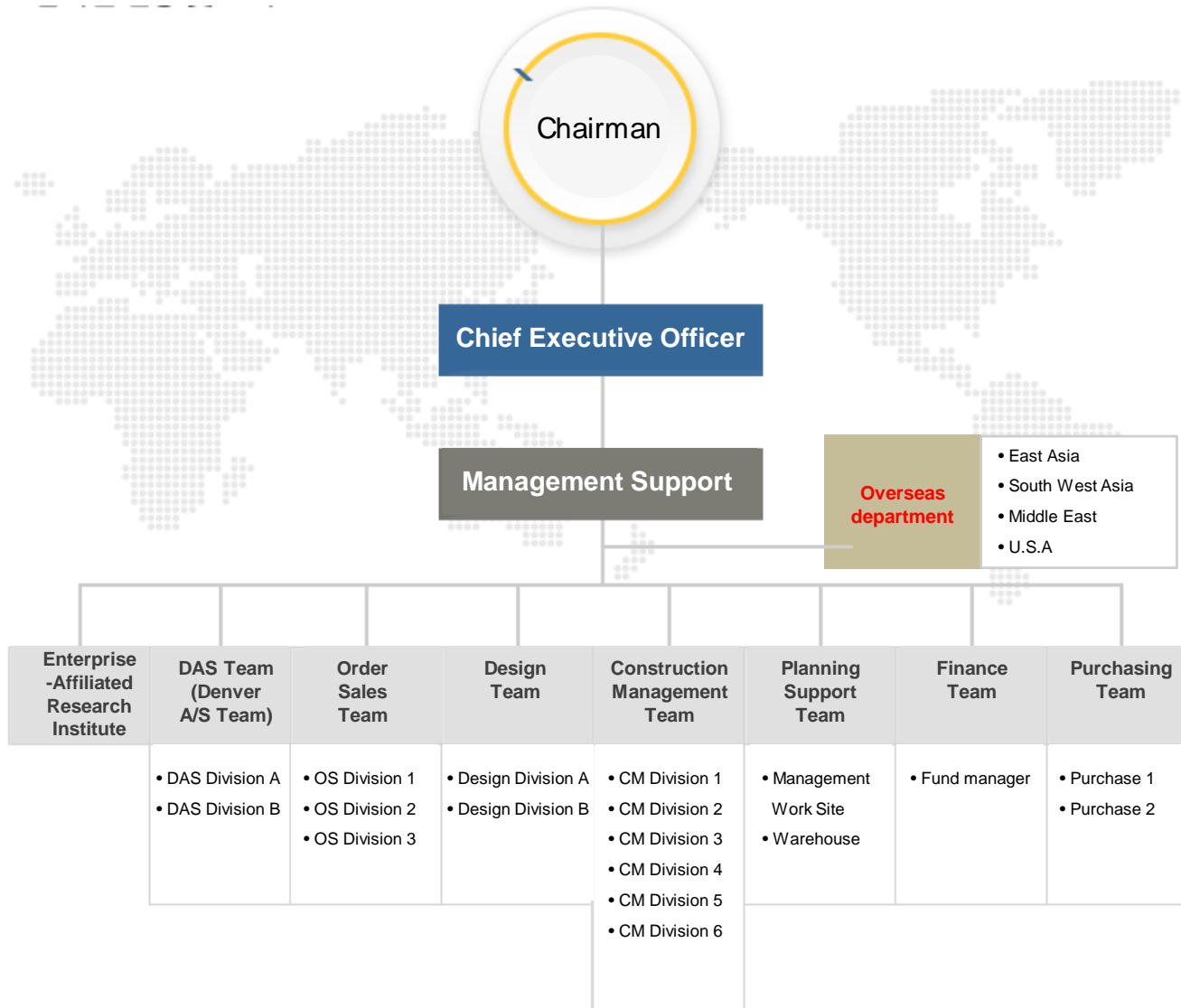
Construction Method of
Simultaneous Injection Compaction
Grouting System for Ground
Reinforcement Using Integrated
Quality Control System
(Modern technology of disaster
prevention. Registered No 77-1)

* Patents Holding (19 Patents)

- Integrated Construction Management Monitoring System for Compaction Grouting (10-1829425)
- Precision measuring supply, quality control metering plant for mortar and how to manufacture mortar (10-1715233)
- Ocean Pollution Prevention System (10-1698960)
- Injection Pressure Variable Grout Materials Injection System using Rotating Units (10-1695912)
- Grouting Method for Ground Restoration by Multi-Point Injection (10-1143538)
- Etc.

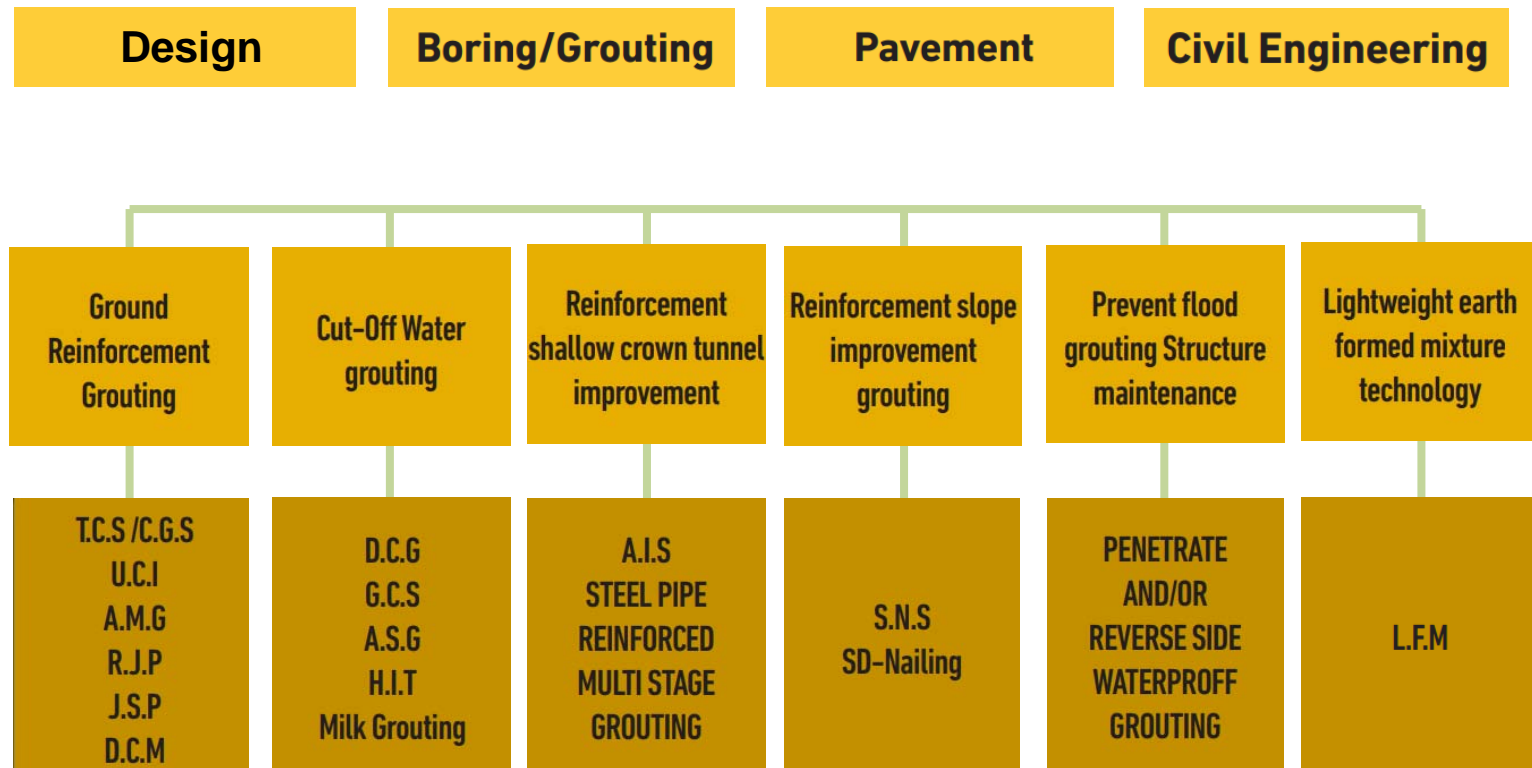
1. Company Introduction

Company Organizational Chart



1. Company Introduction

Major Business

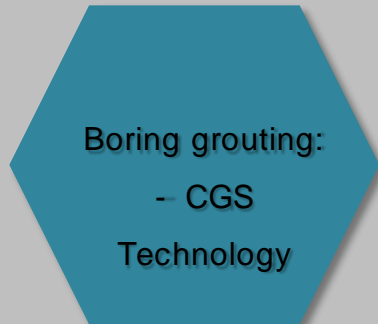


1. Company Introduction

» Domestic Business

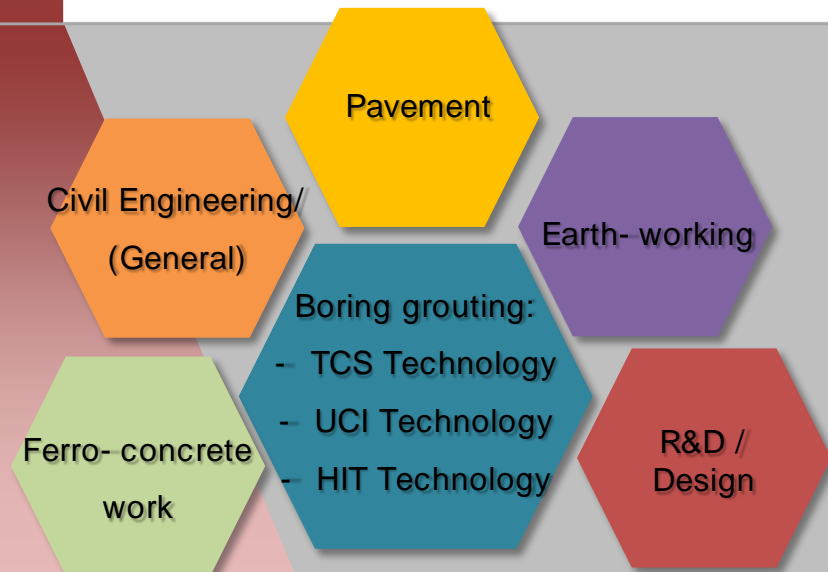
PAST

- Primary Induce T.C.S. Technology into Korea
- Seismic performance reinforcement and Fundamental soft ground rehabilitation
- Domestic Promotion and Sales
- Based on technology, subcontracting works from major domestic companies. And also power plants or owner contractors.
- Boring-Grouting Works



PRESENT

- Steady Publicity and Promotion T.C.S. Technology
- Market Dominance Increase
- Improving the Sales and Financial Structure
- Credit rating rises due to R&D investment
- Possession of the performance & new technology as a General contractors position. it is possible to participate in the bidding and succeeded in diversifying the business as Boring-Grouting works, Civil Engineering, Earth-working, Pavement working, Ferro-concrete works

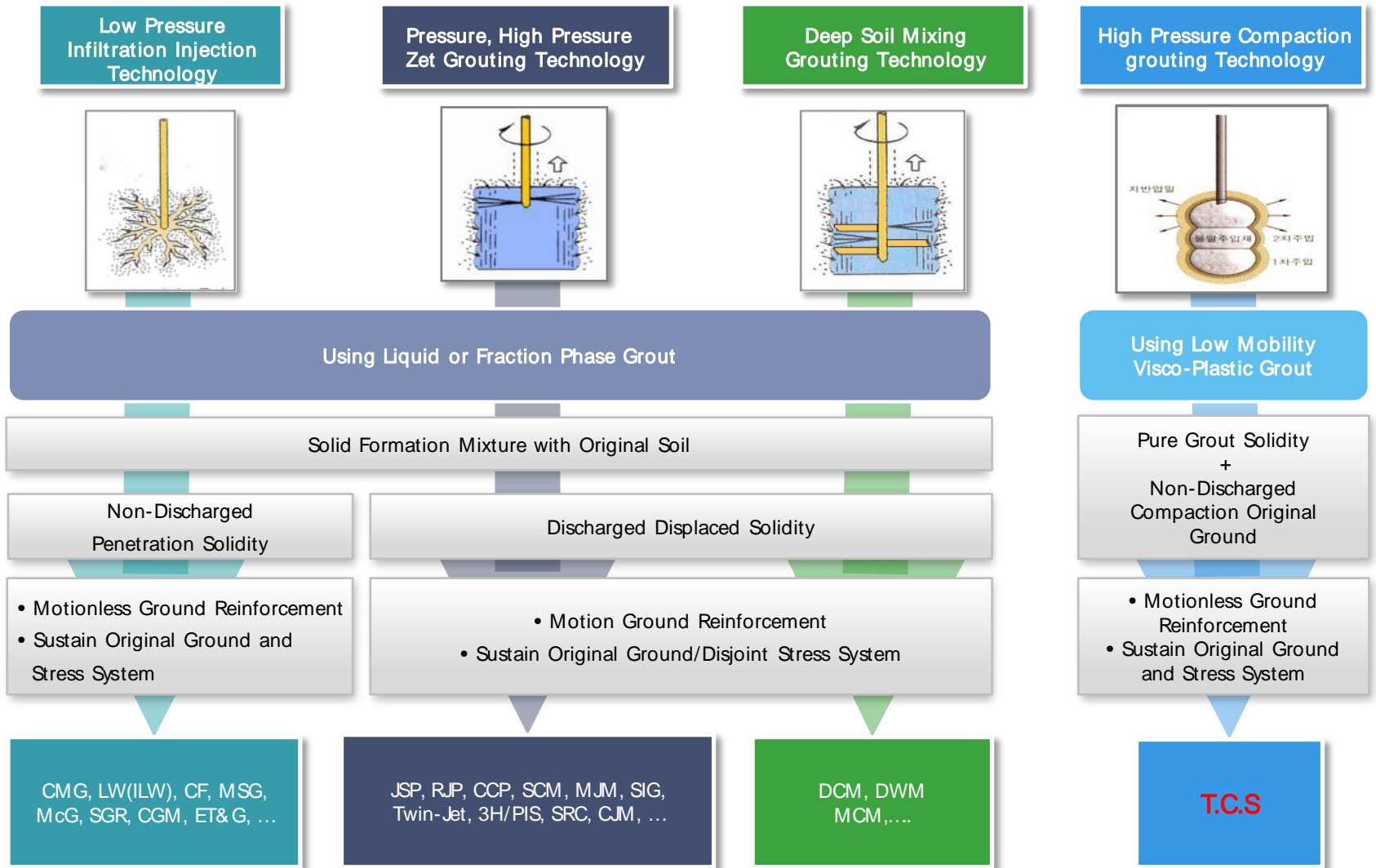


OUTLINE AND CHARACTERISTICS OF T.C.S. TECHNOLOGY

- Classification of Grouting Technology
 - Overseas: Low Mobility High pressure Mortar Injection Technology (Domestic: TCS Technology)
 - Classification of Low Mobility High Pressure Mortar Injection Technology
 - Overview of T.C.S. Technology
 - Characteristics of T.C.S. Technology
 - Application Range of T.C.S. Technology
 - Equipment Arrangement and Execution Order of T.C.S. Technology
 - Injection Material of T.C.S. Technology
-

2. Outline and Characteristics of T.C.S. Technology

Classification of Grouting Technology



2. Outline and Characteristics of T.C.S. Technology

Overseas: Low Mobility High Pressure Mortar Injection Technology (Domestic: TCS Technology)

LMG Technology
Denver Korea E&C (Korea)

HAYWARD BAKER INC.
COMPACTION GROUTING

Compaction grouting improves a wide range of ground conditions by displacement, for a variety of site improvement and remedial applications.

Compaction grouting was used to seal this 160-foot diameter sinkhole that extended down to the Florida aquifer.

When a research-designed compaction grout is injected into that displacing soil, remedial almost at twen-solved to remedial loosened

side the advan-cesses elect- in re-

REED
B20HP

Sanshin-Corp (Japan)
CPG Technology

三信建設工業の地盤の液化化対策工法
コンパクショングラウチング工法 (CPG®工法)

コンパクショングラウチング工法とは

注入材料

設備構成

施工手順

特長

● 単動式複筒ピストンポンプ

● 常用最大圧力: 8MPa

● 吐出量: 1.8m³/hr

CPG Pump

2014/9/17
Compaction Grouting
22

2. Outline and Characteristics of T.C.S. Technology

Classification of Low Mobility High Pressure Mortar Technology

Low Mobility Mortar Injection Technology

LMG | Low Mobility Grouting(ASCE, Sam Bandimere)

- A technology to increase the ground density by compressing and strengthening the surrounding ground by forming a homogeneous solid volume in the form of a cylindrical shape by injecting low mobility mortar material into the ground (Structure basic design criteria description,2009)

High Pressure Mortar Injection Technology (injection rates < 2ft³/min)

I Total Comapction System

- Compaction Grouting
"injection rates < 2ft³/min(0.06m³/min, 0.006m³/strokes)" [Sam Bandimere, 1997]
- If the injection rate is too high compared to the condition of the target ground, the water pressure fracture occurs at the beginning of the injection and the injection effect is greatly reduced.

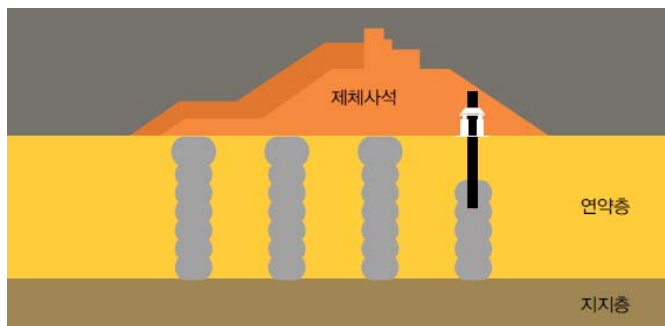
Non-compression Mortar Injection Technology (injection rates > 2ft³/min)

- Void Fill, Large Water cut-off projects "injection rates > 2ft³/min" [Sam. Bandimere, 1997]
- Large void charging with injection rate exceeding 2ft³/min, large cut-off water charging, etc are injected irrespective of pore pressure dissipation. Even injection rate is greatly than condition of ground, the injection effectiveness won't be down. (This is because in the effect of the pore is greater than the dissipation due to the ground stability in the place where the pore is large)

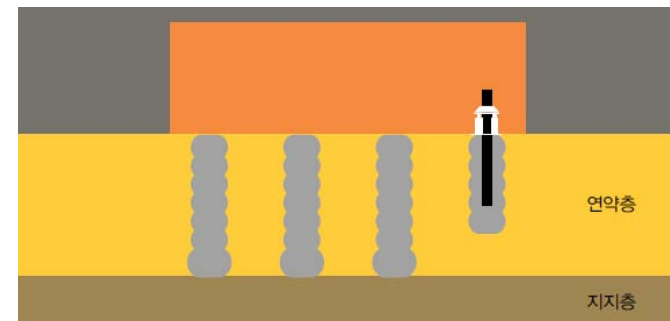
2. Outline and Characteristics of T.C.S. Technology

Classification of T.C.S. Technology

- The T.C.S. Technology is an injection method using the non-discharged substitution principle using the mortar injector, which artificially compresses and densify soft and/or loosen soil composition named ground modification technology.
- A low-mobility infusion material of 5~7 cm or less slump is injected into the ground to form a solid volume in the form of a cylindrical column, Technology is hardened and densely applied to the surrounding ground to be composite ground with mortar column.
- A technology of increasing the density of the surrounding ground by injecting the mortar at a constant pressure on the weak ground.
- Simultaneous injection pump to facilitate quality control and execution management through real-time monitoring through execution, economical improvement and control system and to secure the uniform quality of injection materials through weighing system.
- Classification of Technology
 - Bottom up Method: Apply on Land, Seashore soft ground, Seismic, Liquefaction potential area, etc, reinforcement
 - Top down Method: Apply on Unequal settlement areas, Structure rehabilitation, etc, reinforcement



Bottom up Injection



Top down Injection

2. Outline and Characteristics of T.C.S. Technology

Characteristic of T.C.S. Technology

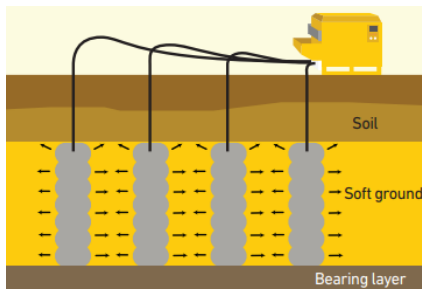
1. Improving execution and economic efficiency by injecting simultaneously to the multiple drilled holes using SI-PUMP/Tyranno-PUMPS.
2. QCS-F system monitors the situation injected into the ground in real time monitoring, so that quality control and execution management are convenience.
3. Providing the homogeneous quality of the injection material by enabling the measurement of the fixed quantity measurement of the material through the QCM-PM system.
4. Using the CRT service, it's easy to manage execution by securing real-time execution transparency, quality, and safety management.
5. Enhanced compression of surrounding grounds to secure support for land and marine soft grounds and enhancement of stability.
6. Excellent Seismic reinforcement and liquefaction on sandy soil ground for countermeasure of seismic and liquefaction purpose and also on lighters wharf, quay and revetment structure.
7. Minimize the dropout of the injection material at the planned location by slump under the 5~7 cm.
8. By injecting the low mobility mortar, there is no slime generation and it is environmentally friendly.
9. The effect of void charging of the fast in flow on boulder bed layer and the ground reinforcement effect is excellent.
10. Equipment is adjustable to compact, so small scale construction and limited spaces execution facilities are adaptable.



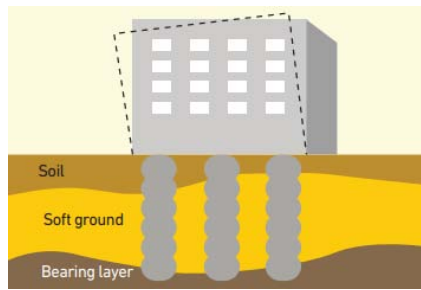
2. Outline and Characteristics of T.C.S. Technology

Application range of T.C.S. Technology

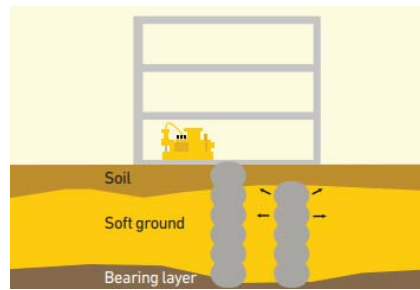
- Ground Modification: Improvement of fundamental ground bearing capacity. Prevention of liquefaction, Reinforcement of seismic on existing structure (lighters wharf/ revetment, etc).
- Support Structure: Under pining on new/existing structure, drainage gate foundation ground reinforcement.
- Restore and Prevention of structure settlement: Horizontal restoration and prevention of additional settlement in the structure of differential settlement on the structure.
- Fill: Collective filling in abandoned mines or ground, void fill on lower of sand gravel layer of structure at seashore, and revetment structure.



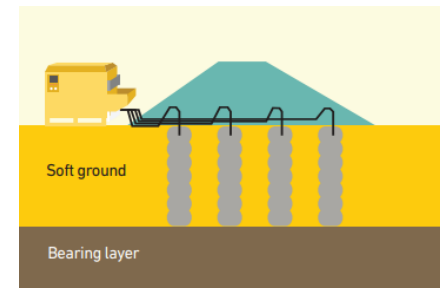
Ground modification



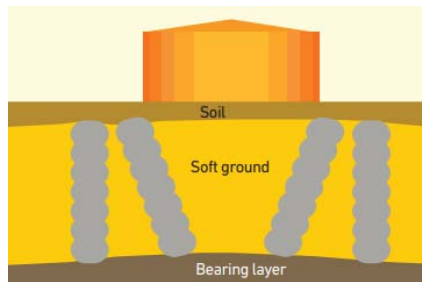
Restore settlement



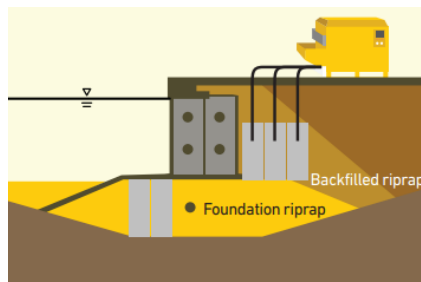
Narrow work space



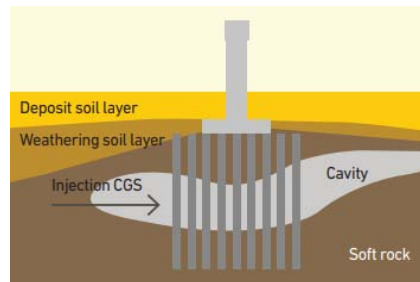
Reinforcement on wick foundation at harbor structure



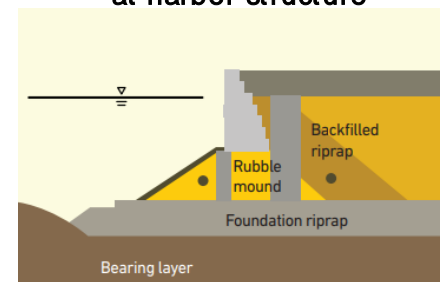
Prevention of liquefaction



Reinforcement of seismic



Cavity filling



Void fill and Cut-off water

2. Outline and Characteristics of T.C.S. Technology

Applicability of T.C.S. Technology over on Organic/ Peat Layer

Characteristic of Organic, Peat Layer and Point

- Settlement arouse is large because water content ratio and compressibility is too big.
- Permeability is minimal, big settlement arouse in timely.
- 2nd pressure settlement arouse in big even 1st pressure settlement occur.
- Settlement should be greater if road, bridge and structure constructed over on organic/peat layer. Lack of bearing capacity creating Geotechnical problems.

Reason of ground improvement technology over on organic/ peat layer

- A typical weak ground improvement technology is a free loading or free loading + drainage promotion method, which is a method is releasing the gap water or the amount of settlement is excessive, so it takes a long time and the exact amount of settlement is not predictable. Geotechnical problem occurring even after execution.
- Needed technology which it could prevent settlement but increase bearing capacity to develop over on organic/peat layer.
- Technology necessity to control of excessive settlement and save expenses as free loading and also save execution time.

T.C.S. Technology will solve the problem of structure deformation due to sedimentation on organic and peat layer. T.C.S Technology's advantage is ground improvement strength and excellent settlement reduction effect.

2. Outline and Characteristics of T.C.S. Technology

Equipment Arrangement and Execution Order of T.C.S. Technology

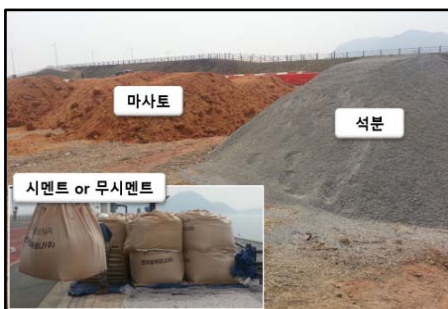


1. Main Equipment Set up

2. Material in

3. Drilling

4. Material input



Mixer plant, Injection pump set up

Bring in to work site, cement replace-able to cement-less solidification agent

Drill on targeted point with drilling equipment

Inputting material on auto mixture plant and set auto mixture ratio (cement/ cement-less/ soil/ crushed aggregate)

2. Outline and Characteristics of T.C.S. Technology

Injection material of T.C.S. Technology



Mixing cement with crushed aggregate less than 10mm, viscous soil together and maintain slump less than 5 to 7 cm. This mortar directly mixed in the field to produce and inject at the same time.



EXECUTION OF T.C.S. TECHNOLOGY

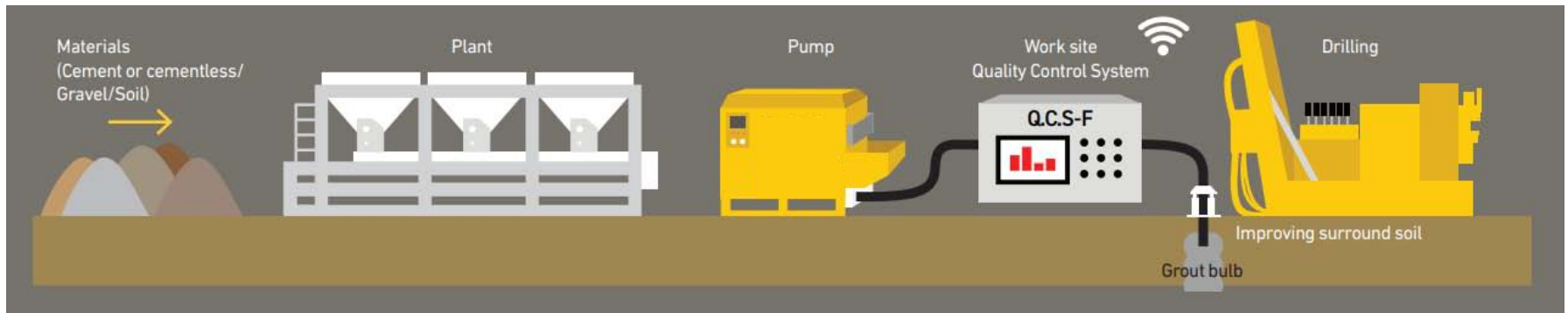
- INJECTION EQUIPMENT
 - EXECUTION ON LAND/SEASHORE
 - SYSTEM OF T.C.S EXECUTION
-



3. Execution of T.C.S. Technology

SYSTEM OF INJECTION

- Set up plant: Center of work site for efficiency of work perform
- Drilling process: Drill unto targeted area using bit and casing
- Drilling process: Non-discharge type without ground cutting and injection gradually of planned injection



Mini Drill
(Compact area)



Flush Rotary Drill



Injection pump
(Material delivery)



QCM-PM



QCS

3. Execution of T.C.S. Technology

Land Execution



Injection equipment setting on land



Drilling on land



Injection on land

Seashore Execution



Injection equipment setting on barge



Drilling on seashore

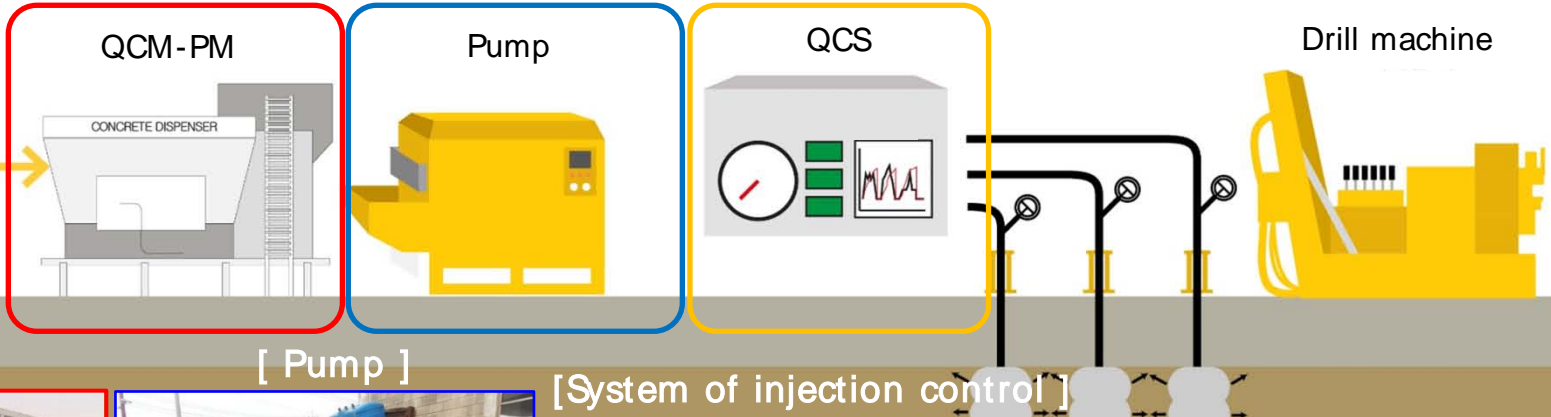


Injection on seashore

The land and the marine drilling and injection execution are performed after the location survey

3. Execution of T.C.S. Technology

EXECUTION OF T.C.S. TECHNOLOGY



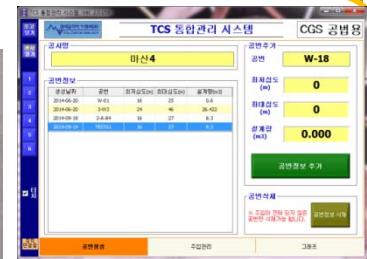
[Plant]

[Pump]

[System of injection control]

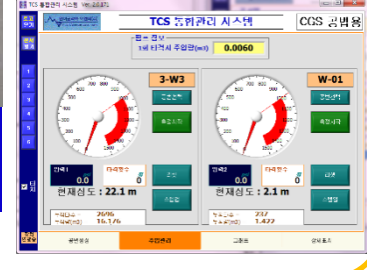
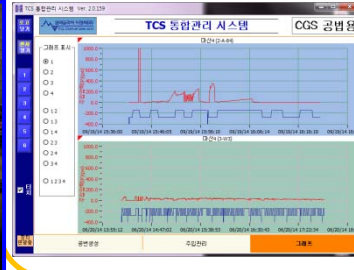


QCS
실시간 주입타수, 주입량
주입압, 주입시간 측정



QCM-P 작업 보고서

일시	시멘트 (kg)	사질토 (kg)	마사토 (kg)	석분 (kg)	총합 (kg)
2015-12-12 10:40 - 11:30	0.140	0.140	0.000	0.000	0.280
2015-12-12 11:40 - 13:05	0.820	0.820	198.000	0.150	1.810
2015-12-12 13:10 - 14:05	0.300	0.300	2130.000	1.500	2630.800
2015-12-12 14:10 - 15:05	12.760	12.760	3366.000	2.307	4817.520
2015-12-12 15:10 - 16:05	10.300	10.300	2745.000	1.500	3790.800
2015-12-12 16:10 - 17:05	0.250	0.250	2409.000	1.953	2909.453
2015-12-12 17:10 - 18:05	0.820	0.820	1797.000	1.221	3646.841
2015-12-12 18:10 - 19:05	2.820	2.820	750.000	0.825	6344.866
2015-12-12 19:10 - 19:15	0.000	0.000	0.000	0.000	0.000



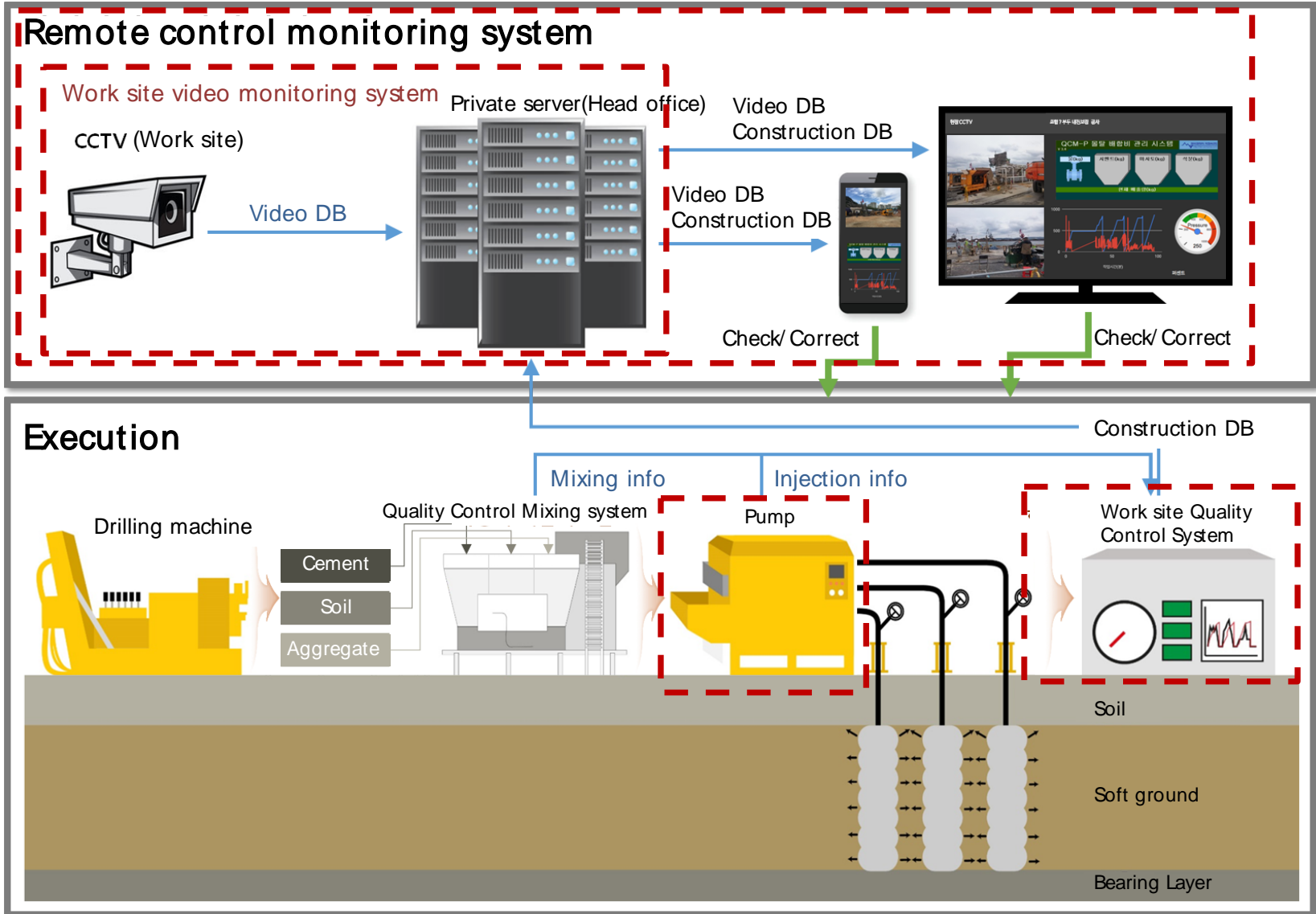
Measurement of injection material in plant

Injection speed less than 0.06m³/min

Analyze result of real time injection counter, Injection quantity, Injection pressure, Injection time

3. Execution of T.C.S. Technology

Real time remote control system (Quality control)



EXECUTION MANAGEMENT EQUIPMENT AND QUALITY OF T.C.S.

- Low Mobility High Pressure Mortar Pump
 - Low Mobility Mortar material Mixture Equipment
 - Real time Quality Control Monitoring System
-



4. EXECUTION MANAGEMENT EQUIPMENT AND QUALITY OF T.C.S.

Low Mobility High Pressure Mortar Injection Pump

- Injection Quantity of Low Mobility High Pressure Mortar Pump is $0.006\text{m}^3/\text{stroke}$
- Injection Speed Control of Low Mobility High Pressure Mortar Pump is Less Than $0.06\text{m}^3/\text{min}$
- Perforated Holes Are Injected With Mortar In Simultaneously Reduce Execution Times.

SI-P20



1 Hopper 2 Line
Simultaneously Injection
(Disaster Prevention Technology)

SI-PUMP



2 Hopper 2 Lines
Simultaneously Injection

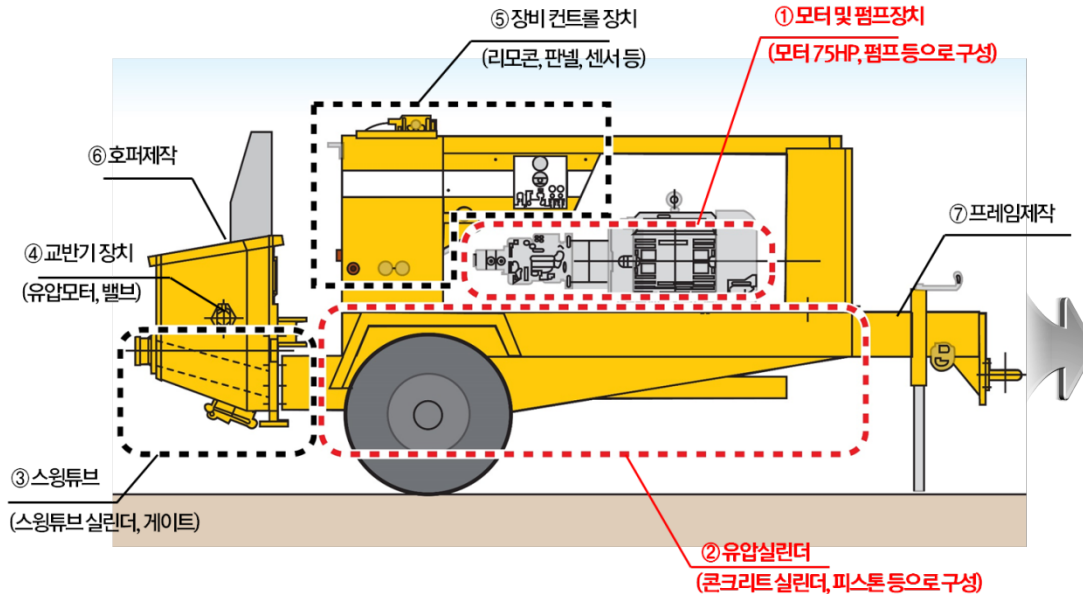
Tyranno-PUMP



3 Hopper 3 Lines and more
Simultaneously Injection

4. EXECUTION MANAGEMENT EQUIPMENT AND QUALITY OF T.C.S.

MULTIPLE SIMULTANEOUS PUMPS



➤ Pump Specification

- SIZE : 3.4 X 2.1 X 1.7 m
- Cylinder width: 4 inch (6Cylinders)
- Maximum outlet: 210 kg/cm²
- Outlet quantity : 0.006 less than stroke
- Injection: Simultaneously Injection
More Than 3 Lines
- Less than 50% noise



4. EXECUTION MANAGEMENT EQUIPMENT AND QUALITY OF T.C.S.

Material Mixture Equipment of Low Mobility High Pressure Mortar Pump

Existing Material Mixture



[Soil/ Crushed Aggregate]



[Sieving]



[Material Input]

- Existing Material Input was using Backhoe and Measure with Sight
- Quality of materials was jagged by Site Engineer's Judgments.

Quality Control and Measurements System (QCM-PM)



[Automatic Mixture Unit for Mortar Injection]

- QCM-PM measure Material as Quantitative Quantity
- Accurate Measurement of Cement, Aggregate and Soil

4. EXECUTION MANAGEMENT EQUIPMENT AND QUALITY OF T.C.S.

Material Mixture Equipment of Low Mobility High Pressure Mortar Pump

- QCM-PM Quality Control Measurement
 - Accurate volume combination with equipment that can automatically adjust the weight of Input materials.
 - Increased homogeneous ground reinforcement effect and efficient execution management.

1. Set targeted weight (Ex: Aggregate 250kg)



3. Measure discharged quantity on scale



QCM-PM



Weight measurement of
Cement, Soil, Aggregate, Water



2. Receive discharged quantity



4. Compare between scale vs monitor

4. EXECUTION MANAGEMENT EQUIPMENT AND QUALITY OF T.C.S.

Real time monitoring for quality management

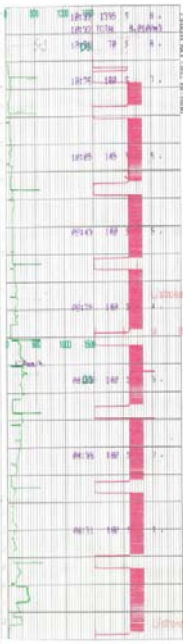
Control manually



Flow meter (Domestic)



Flow meter (Japanese)



Flow meter

G.S Print System

ject : 2012-05-23
 ime : 10:34:20
 ile No :
 ill Depth :
 ection Depth :
 it Volume : 0.0000 m3

asp 01	Shot : 48
asp 02	Volume : 0.2880 m3
asp 03	Shot : 48
asp 04	Volume : 0.2880 m3
asp 05	Shot : 48
asp 06	Volume : 0.2880 m3
asp 07	Shot : 48
asp 08	Volume : 0.2880 m3
asp 09	Shot : 48
asp 10	Volume : 0.2880 m3
asp 11	Shot : 48
asp 12	Volume : 0.2880 m3
asp 13	Shot : 48
asp 14	Volume : 0.2880 m3
asp 15	Shot : 48
asp 16	Volume : 0.2880 m3
asp 17	Shot : 48

Counter meter

- Analogue recording difficult to retrieve data of execution
- Difficult to control of quality and injection

Auto Control



Ground repulsion pressure, Injection quantity, Injection time, Injection depth recording

- Real time ground repulsion pressure, Injection quantity, Injection time, Injection depth control

Remote Control



- Easy to control of quality and injection with real time monitoring
- Quality analysis and accumulation data retrieve on diversification conditions.

Quality control available by real time remote control system

4. EXECUTION MANAGEMENT EQUIPMENT AND QUALITY OF T.C.S.

REAL TIME QUALITY CONTROL MONITORING SYSTEM

- Injection Execution Stage (Manually Control----Auto Control)
 - Automatically managed to secure certain quality Repulsive pressure, Injection time, depth of the ground during execution and also easy injection management.
 - Technical response is convenience per various type of soil/ execution analysis/ Accumulating execution data
 - Modern combined management system achieves lightweight of execution and quality control through program updated.

AUTO CONTROL

Remote administration

QCS ver.1(2014.10)



1 Channel Iron case
(Disaster Prevention
Technology)

QCS ver.2(2015. 4)



1 Channel Hard case

QCS ver.3(2016. 5)



2 Channel Hard case

QCS ver.4(2017. 1)



2 Channels Real time
execution control

Technology development improves of execution performance and also quality control

4. EXECUTION MANAGEMENT EQUIPMENT AND QUALITY OF T.C.S.

REAL TIME QUALITY CONTROL MONITORING SYSTEM (2)

- Execution management monitoring program reflecting the influence factors needed execution management
- Improving convenience of quality-enabled injection management by real time monitoring during execution
- Technical convenience/ Execution quality analyses and save data on various ground condition

System

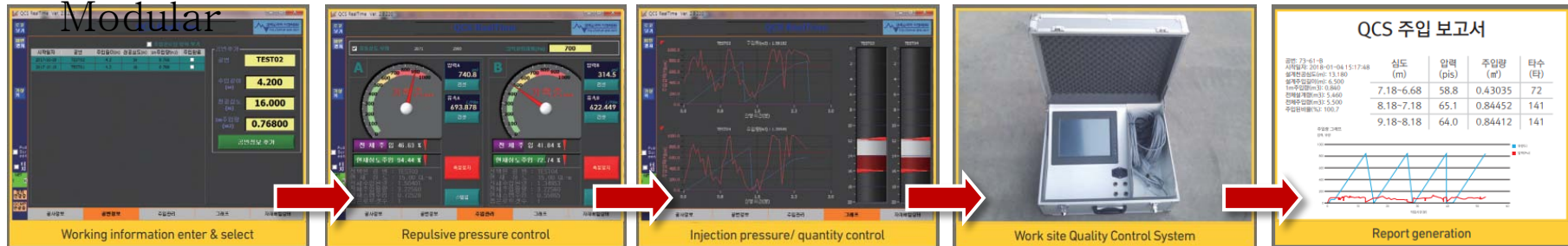
- Members
- Work site execution quality monitoring modular
- Work site visual monitoring modular
- Remote control monitoring modular

Monitoring Clause

Item	Description
Injection depth	Measure the current depth and inject it at the correct location
Injection time	Confirmation and management of changes in execution influencing factors with time
Injection material mixture	Injection material mobility confirm (sufficiently low mobility)
Injection material accurate quantity	Produce injection materials by mixing in an accurate amount through weighing
Injection material quantity	Make sure the injection quantity is appropriate for the amount Designed
Injection pressure (Repulsive pressure)	Determination of the compacted effect of grounds by ground repulsive pressure
Injection speed	Needed sufficient time to dissipate of pore pressure
Injection hole location, distance	Attain the purpose of the improvement of the designated ground through design

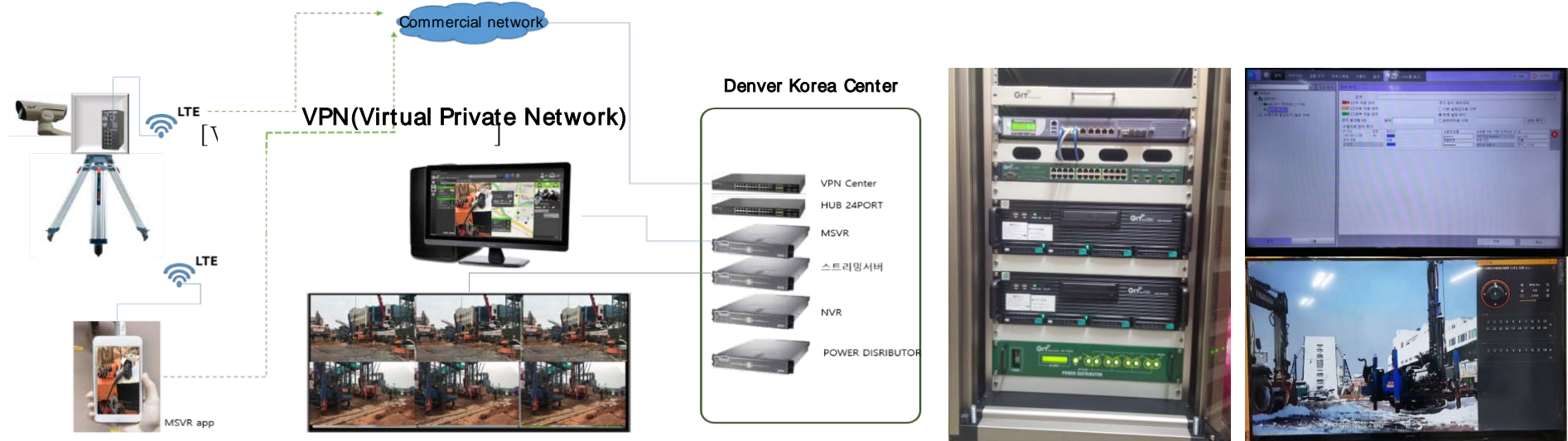
Work Site Execution Quality Monitoring

Modular



4. EXECUTION MANAGEMENT EQUIPMENT AND QUALITY OF T.C.S.

Work Site Visual Monitoring System(QUALITY CONTROL)



[Data Centralized Station] [Electric Signboard]



Ageing Test



Server Manufacture



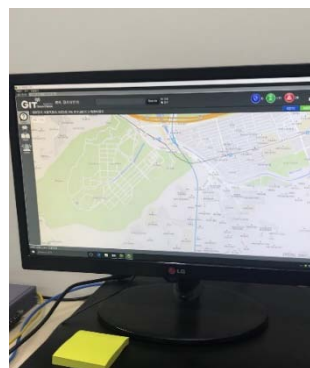
Make Camera



Visual Test



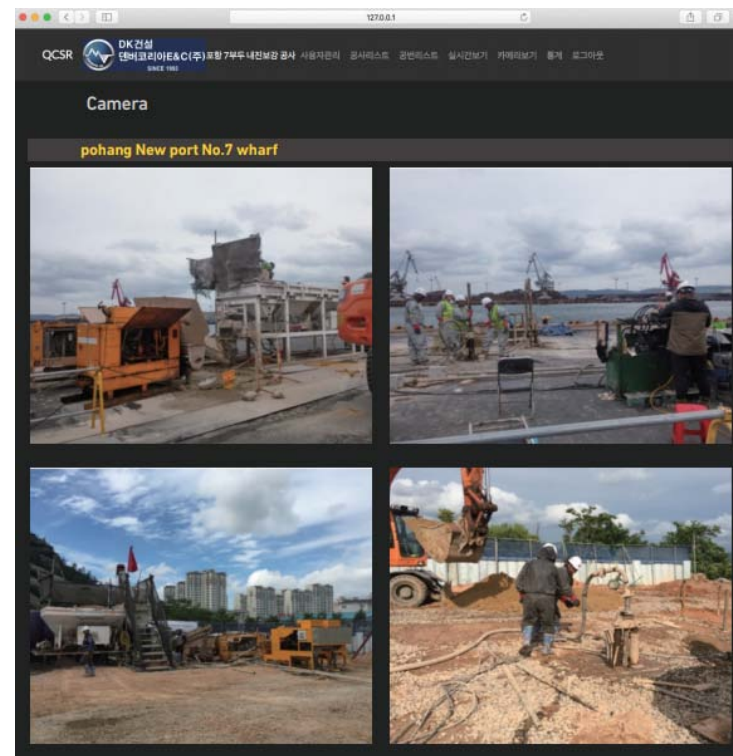
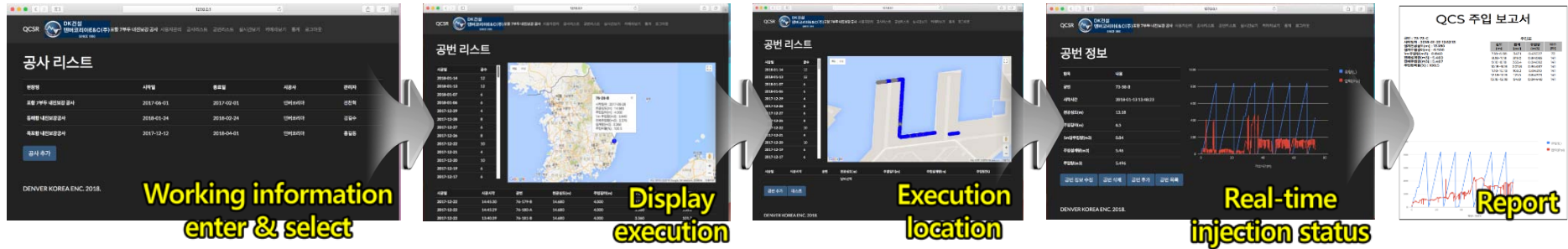
Save Visual Image S/W



MSVR Server S/W

4. EXECUTION MANAGEMENT EQUIPMENT AND QUALITY OF T.C.S.

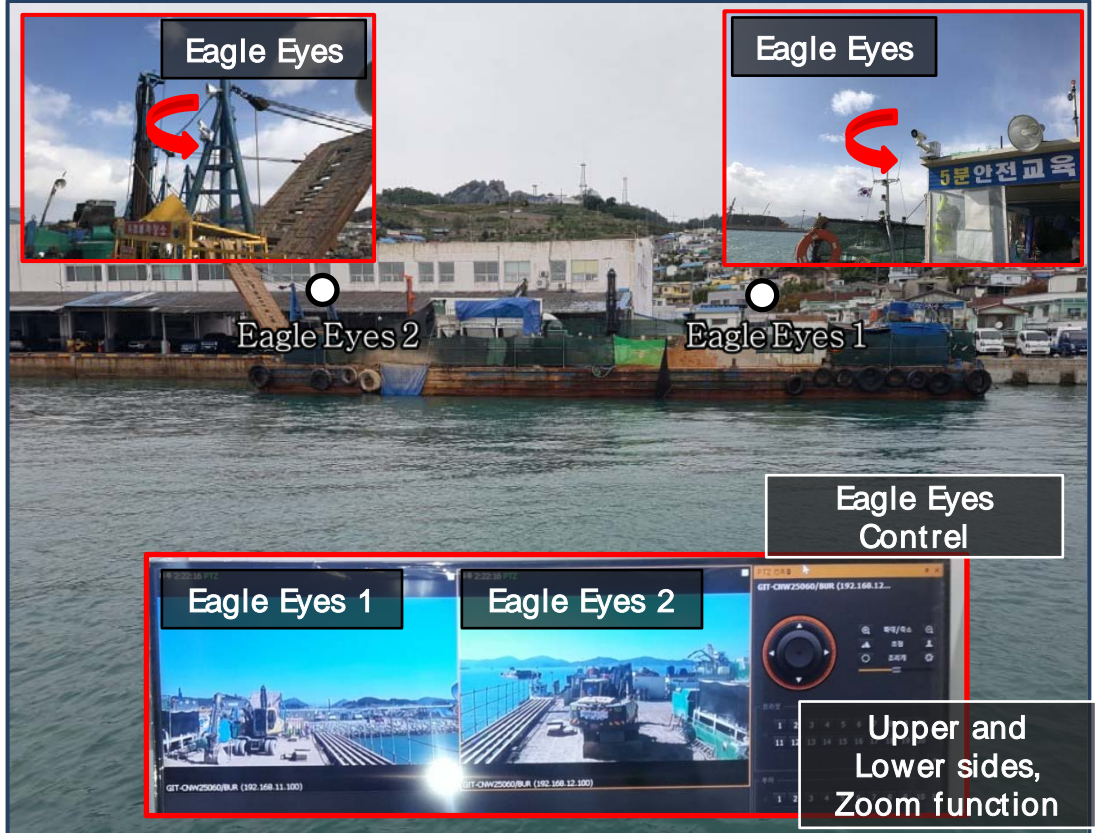
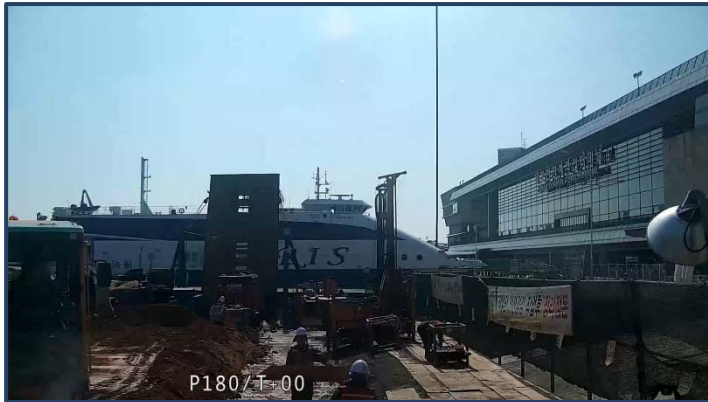
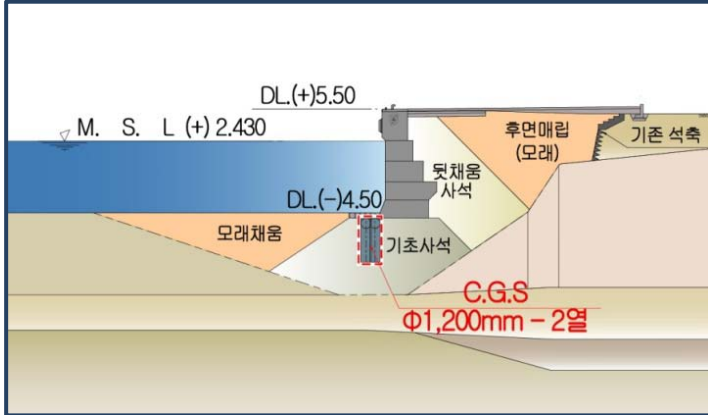
Remote Control Monitoring System



4. EXECUTION MANAGEMENT EQUIPMENT AND QUALITY OF T.C.S.

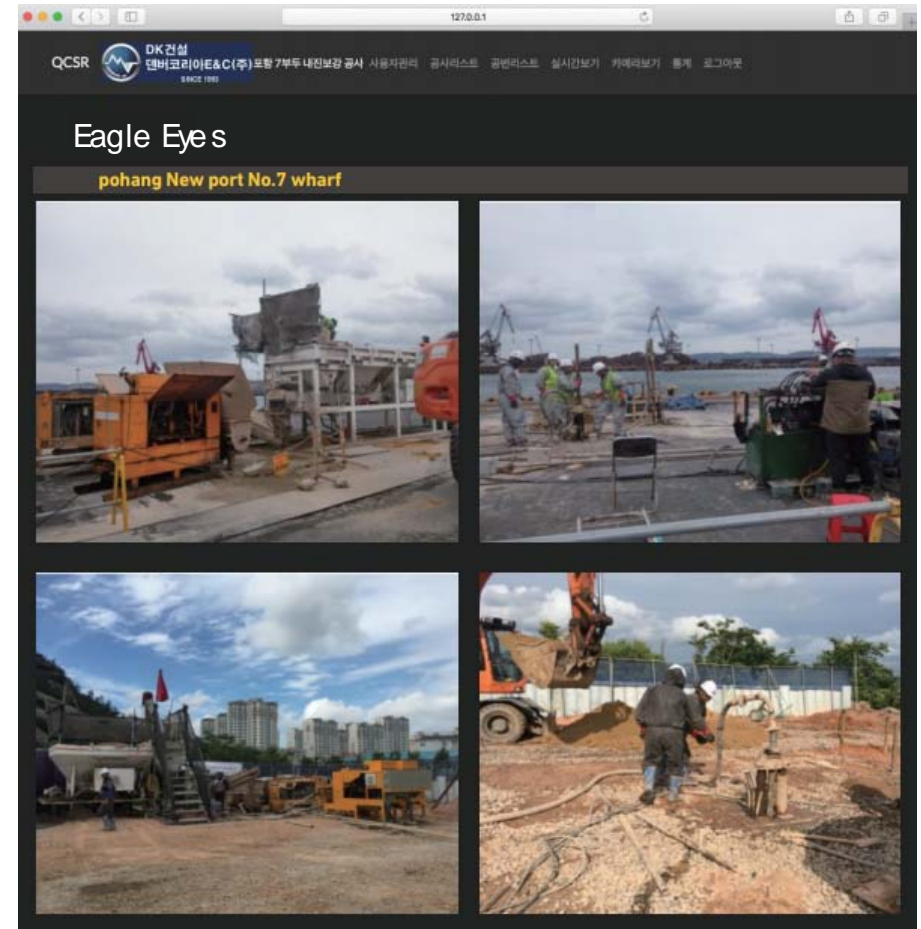
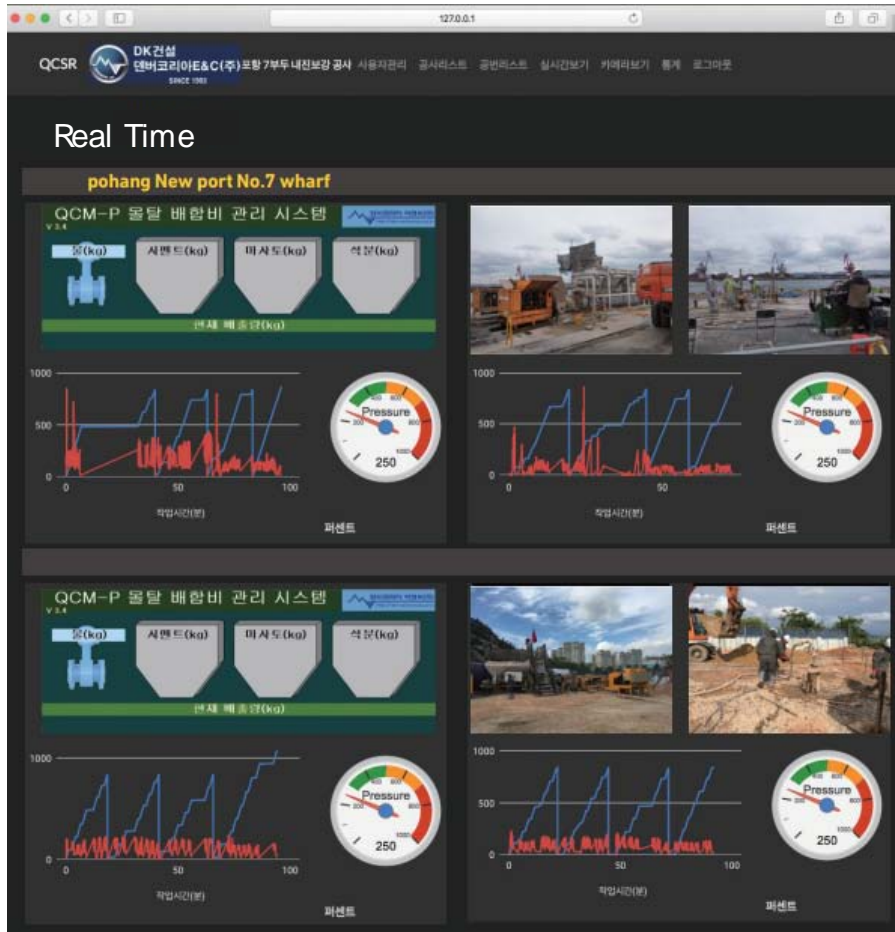
Site Evaluation

Seismic Reinforcement Work Site at Mok Po Harbor Structure



4. EXECUTION MANAGEMENT EQUIPMENT AND QUALITY OF T.C.S.

Remote Control Monitoring System



EXECUTION MANAGEMENT OF T.C.S.

- Execution anagement of T.C.S
-



5. EXECUTION MANAGEMENT OF T.C.S.

Execution management of T.C.S

Check Items		Standard of Evaluation
Injection	Adequacy of Injection Equipment	- Maximum commercial pressure 3,000psi(210kg/cm ²) pumping capacity equipment
	Adequacy of injection casing pull up	- Less than 33 cm per each 1 step
	Adequacy of pressure gauge set up	- Capacity: equipment capable of measuring pressures of over 70kg/cm ² - Set up location: Between casing and injection head connecting area
	Adequacy of injection	- Injection execution starting bottom and proceeding as pull up casing - Measurement of Concrete Compressive Strength of Modified forms - Check injection quantity by recording injection counter - Injection report per holes

Precautionary note for Execution Site

- Be sure to observing the displacement of the surrounding adjacent structure when injection is proceed.
- Recommended adjacent execution after pressure dissipation by injection.
- Establish an injection plan to minimize the impact on peripheral structures and existing completed holes of T.C.S.
- Prevent safety accidents by checking sufficient ground survey and underground buried object investigation in design

5. EXECUTION MANAGEMENT OF T.C.S.

Before construction

Sump test



- $S \leq 7$ cm

Discharge test



- Discharge rate of grout ≤ 0.06 \square /min

Uniaxial compression test



- Uniaxial compression test of laboratory mixture sample curing 28 days (curing 7 days strength is 30~40% of curing 28 days)

During construction

Check grouting status



- Automatically check grouting pressure, volume, time, and depth in real time

After construction

Field Core Sampling



- 28 days cured core to check compressive strength

Uniaxial compression test of core



- Compressive strength of core > specified design strength

**THANK YOU
VERY MUCH**