

For all soil conditions

TAC through

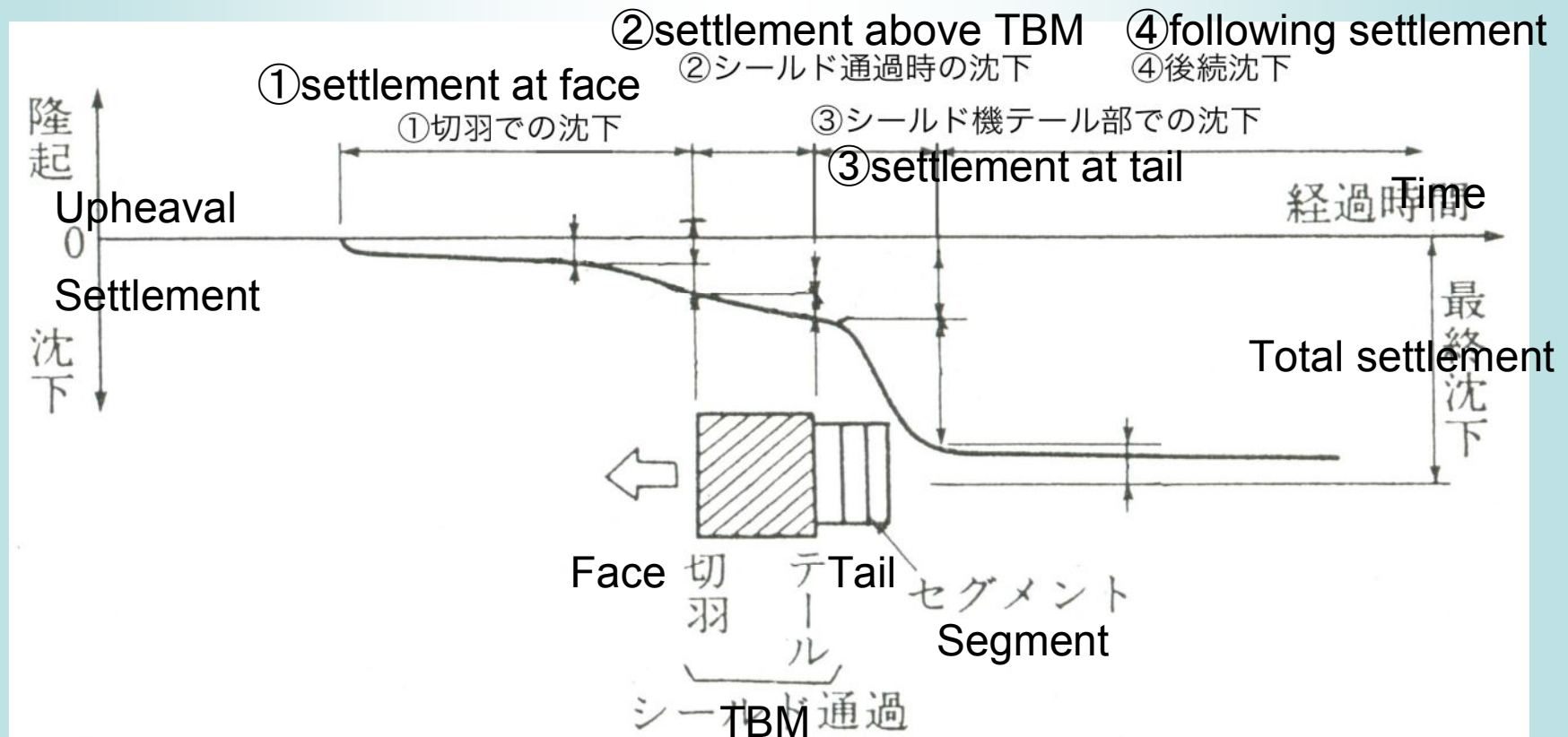
The polymer additive for EPB TBM

(株) タック

TAC Corporation

TBM excavation and settlement

Line of settlement during TBM excavation



シールド推進による地盤変位の分類
The classification of settlement

Factors and analysis in settlement

	Factors	analysis
① settlement at face	Looseness because of release of in-situ stress	Control miss of earth pressure at face
② settlement above TBM	Looseness because of overcutting	Release of in-situ stress because of overcutting Controls miss of TBM position
③ settlement at tail	Collapse of tail void	Shortage of pressure and volume in backfill grouting Delay at timing of grouting
④ following settlement	Consolidation settlement	Fade of excess pore water pressure Damage of soil structure

Earth pressure control at face

- **The main factors of settlement at face are because of control miss in pressure and excavate soil volume.**
- **Making excavate soils to plastic flow muck makes proper excavation control.**
- **Utilization of proper materials and proper injection range for excavate soils is able to be stable excavation.**

Sorts of additive material

	Target Soils	Character	problems
Bentonite	gravel sand	Easy to get it General material	Plant and storage yard are big
Form	gravel sand silt clay	Cutter torque is small Easy to make plastic muck	Difficult to control pressure balance in gravel and sand without fines
Polymer	gravel sand silt clay	Easy to make plastic muck by mixing with fines	Need fines in excavate soils
Multiple additions	gravel and sand without fines	Efficient for gravel and sand without fines to use bentonite+form+polymer	Complex to equipment

Outline of TAC Through

- **Maker** : TAC Co.
- **Name** : TAC Through
- **Look** : liquid
- **PH** : 6.8
- **Gravity** : 1.06
- **Stickiness** : 1.0~2.0dPa·s
- **Figure** : 18kg/can



TAC Through Undiluted solution and Water



**solution + water
(1:10)
(paste)**



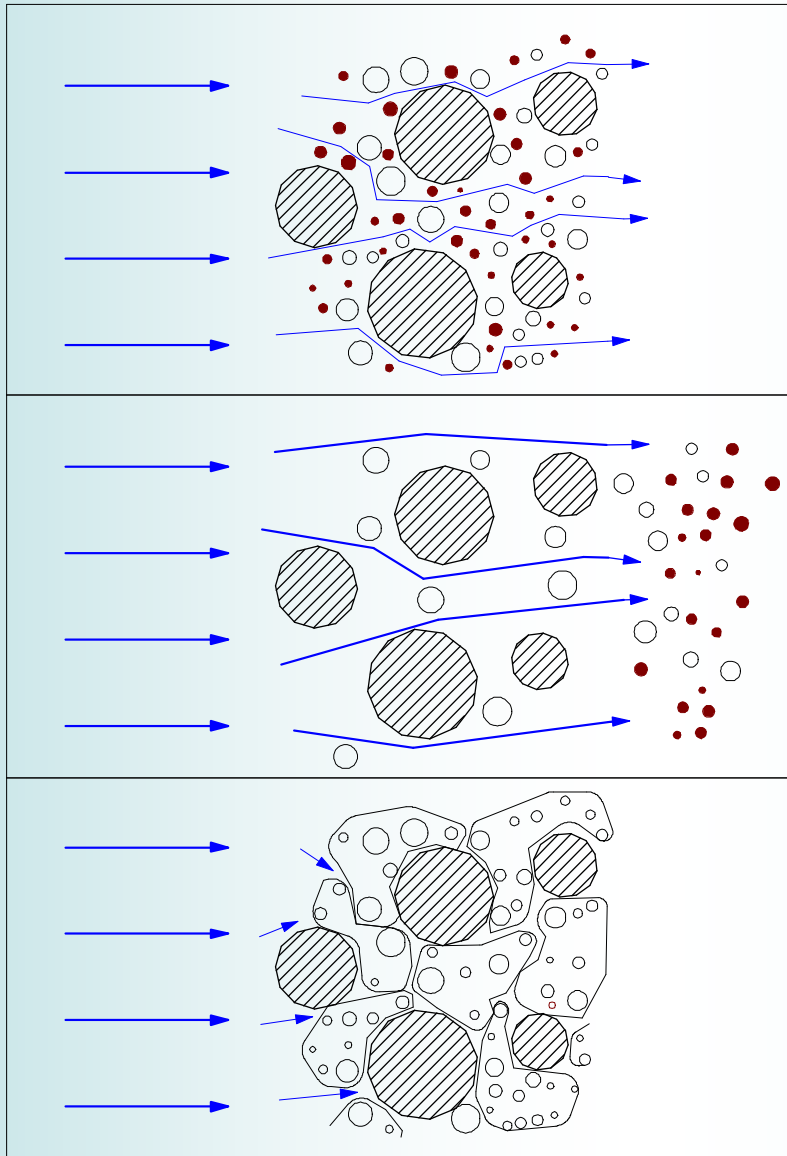
**TAC Through
Undiluted solution
(a little sticky)**



**TAC Through
dilute liquid
1kg/m³
(like water)**

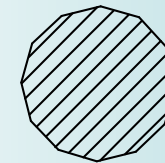
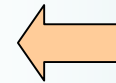
Working of TAC Through

Water pressure



bentonite

Form



Coarse-grained fraction

Fines flow out by water pressure

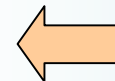


Fine-grained fraction



Additon material

polymer



Tough to water pressure by polymer

Aggregated work by polymer with fines

Diluvial clay and TAC through



add water 30% (volume range) to soil
Difficult to mix water and hard clay

add TAC through water (0.1% density)
30% (volume range) to soil

Easy to mix water and hard clay



TAC through liquid makes mass clay to soft clay and protects sticking to chamber.

Sand soil and TAC through



add water 15% (volume range) to soil

Water flows out from soil

add TAC through water (0.1% density) 15% (volume range) to soil

Soft and close-knit soil



TAC through liquid mixes with fines in sand soil, and sand soil changes to be a close-knit soil.

Gravel sand soil and TAC through



add bentonite liquid 20% (volume range) to soil

Bentonite liquid flows out from soil

add TAC through water (0.2% density) 20% (volume range) to soil

Soft and close-knit soil



TAC through liquid mixes with fines in gravel sand soil, and sand soil changes to be a close-knit soil.

Gravel sand soil and TAC through (movie)



**Gravel sand
squeal by mixing**



**Gravel sand + TAC
smooth by mixing**

Gravel sand soil without fines and bentonite solution

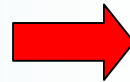
Gravel sand
soil without
fines



Soil doesn't fix

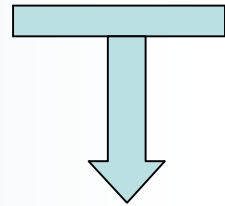


Add bentonite
solution 20%
to soil



Gravel sand soil without fines and TAC through

Gravel sand
soil without
fines



bentonite liquid 20%+TAC
through water (0.3% density)
10%



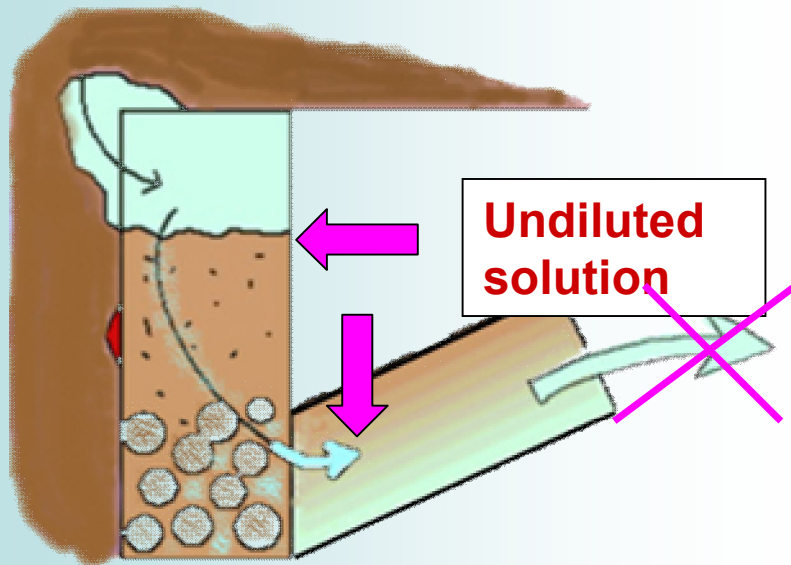
Gravel sand soil
changes to be soft
and smooth

Characteristics of TAC through

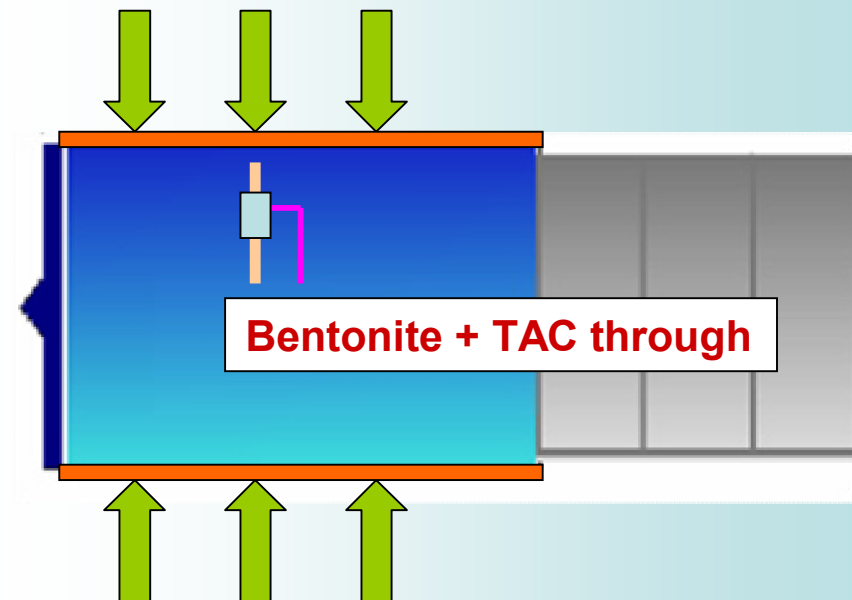
- Effect is big as material volume is small
- It fixes with fines in gravel sand soil and changes to be soft soil
- For diluvial clay or weathering granite, add 30~50% (0.1% density)
- For gravel sand soil (above 10% fines included), add 10~20% (0.1~0.3% density)
- For gravel sand soil (almost no fines), use bentonite with TAC through

Applied cases of TAC through

1. Protect to spout

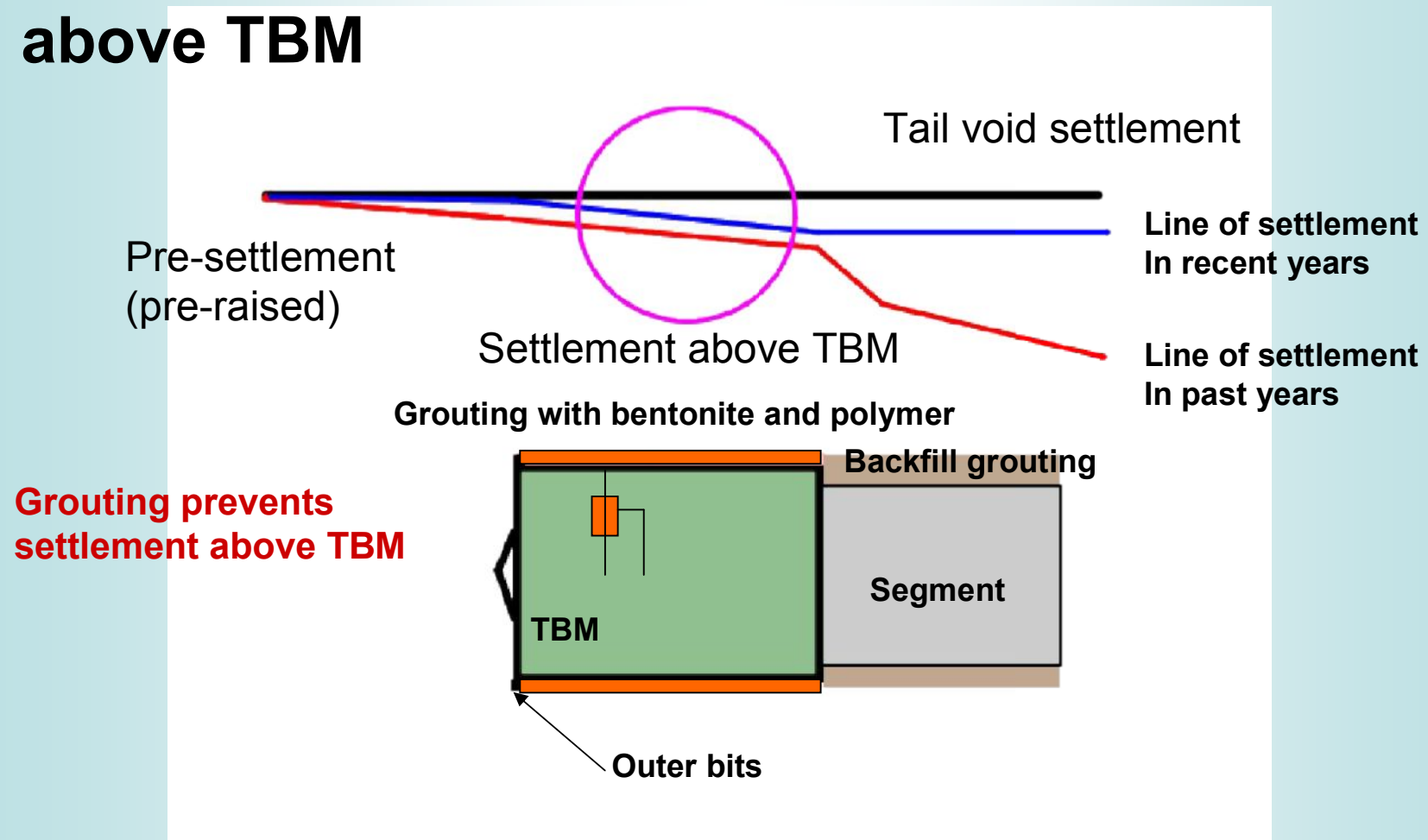


2. Reduce friction



Applied cases of TAC through

3. Prevention grouting against settlements above TBM



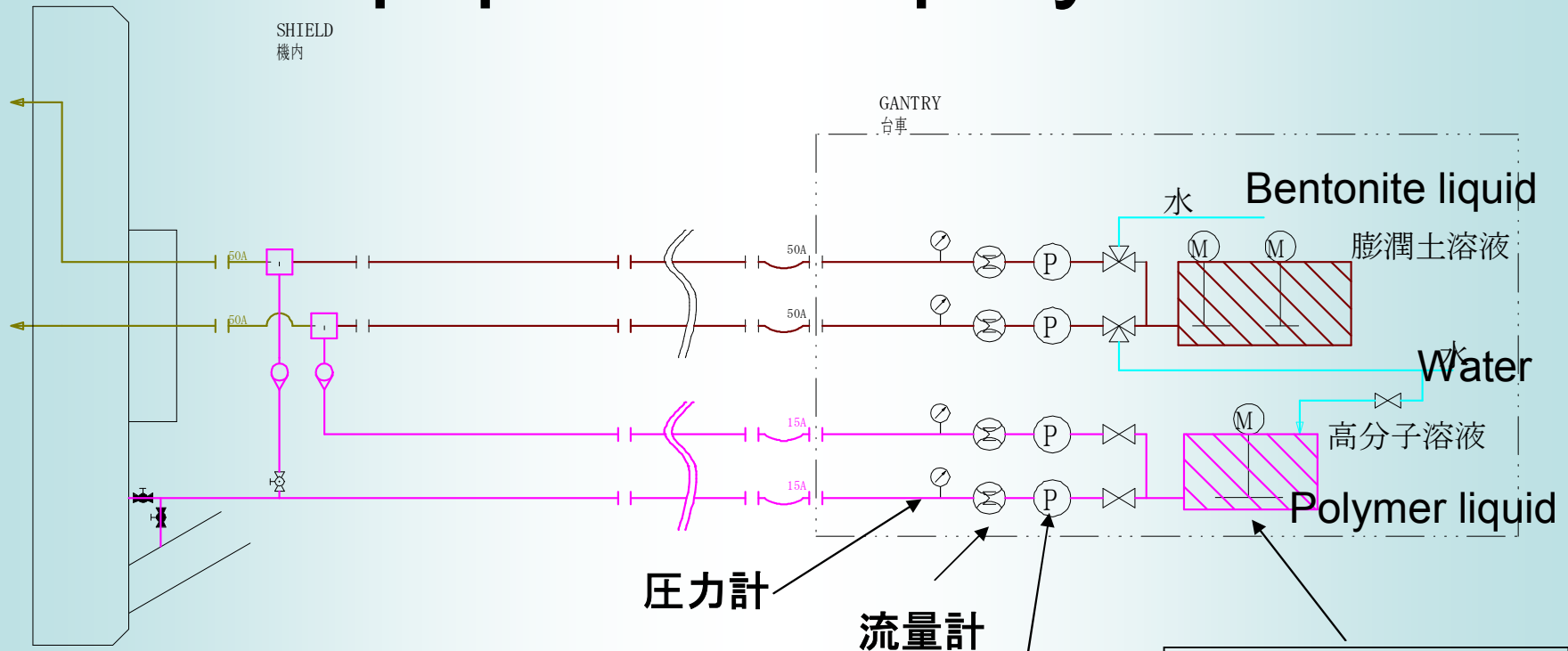
Calculation sample 1 (polymer + water)

1.	Condition						
1	TBM O.D					6.34	m
2	Excavation D					6.34	m
3	Segment O.D					6.00	m
4	Segment width					1.50	m/ 1R
5	TBM speed					50	mm/ min
6	Polymer injection ratio					15.0	%
7	Dilution ratio	(Polymer agent) / (Solution)				0.10	%
8	TBM cross-sectional area	$\pi / 4 \times$	6.34^2			31.57	m ²
9	Polymer injection volume / 1m	31.57	m ³ / 1m	\times	15.0	%	4.74 m ³
10	Polymer agent volume / 1m	4.74	m ³ / 1m	\times	0.1	%	4.74 L
11	Polymer injection volume / 1R	4.74	m ³ / 1m	\times	1.50	m/ 1R	7.11 m ³ / 1R
12	Polymer agent volume / 1R	4.74	L/ 1m	\times	1.50	m/ 1R	7.11 L/ 1R
13	Polymer injection flow	4.74	m ³ / 1m	\times	0.050	m/ min	237.0 L/ min
14	Polymer agent injection flow	4.74	L/ 1m	\times	0.050	m/ min	0.24 L/ min

Calculation sample 2

1. Condition (TAC through)		(polymer + Bentonite)				
1	TBM O.D				6.34	m
2	Excavation D				6.34	m
3	Segment O.D				6.00	m
4	Segment width				1.50	m/ 1R
5	TBM speed				50	mm/ min
6	Polymer injection ratio				2.0	%
7	Dilution ratio	(Polymer agent)/(Solution)			1.00	%
8	TBM cross-sectional area	$\pi / 4 \times$	6.34^2		31.57	m ²
9	Polymer injection volume / 1m	31.57	m ³ / 1m	\times 2.0 %	0.63	m ³ / 1m
10	Polymer agent volume / 1m	0.63	m ³ / 1m	\times 1.0 %	6.30	L/ 1m
11	Polymer injection volume / 1R	0.63	m ³ / 1m	\times 1.50 m/ 1R	0.95	m ³ / 1R
12	Polymer agent volume / 1R	0.63	L/ 1m	\times 1.50 m/ 1R	9.45	L/ 1R
13	Polymer injection flow	0.63	m ³ / 1m	\times 0.050 m/ min	31.5	L/ min
2. Condition (bentonite liquid)						
1	TBM O.D				6.340	m
2	Excavation D				6.340	m
3	Segment O.D				1.500	m/ 1R
4	Segment width				50	mm/ min
5	TBM speed				20.0	%
6	TBM cross-sectional area	$\pi / 4 \times$	6.340^2		31.57	m ²
7	Bentonite injection volume / 1m	31.57	m ³ / 1m	\times 20.0 %	6.31	m ³ / 1m
8	Bentonite injection volume / 1R	6.31	m ³ / 1m	\times 1.500 m/ 1R	9.47	m ³ / 1R
9	Bentonite injection flow	6.31	m ³ / 1m	\times 0.050 m/ min	315.5	L/ min

Equipment of polymer



**Pump injection
volume**
**Capacity is 1/10 of
Bentonite pump**

Tank
**Capacity is 1/10
of Bentonite tank**

Injection pump for TAC through

Tube type



Injection volume control by inverter

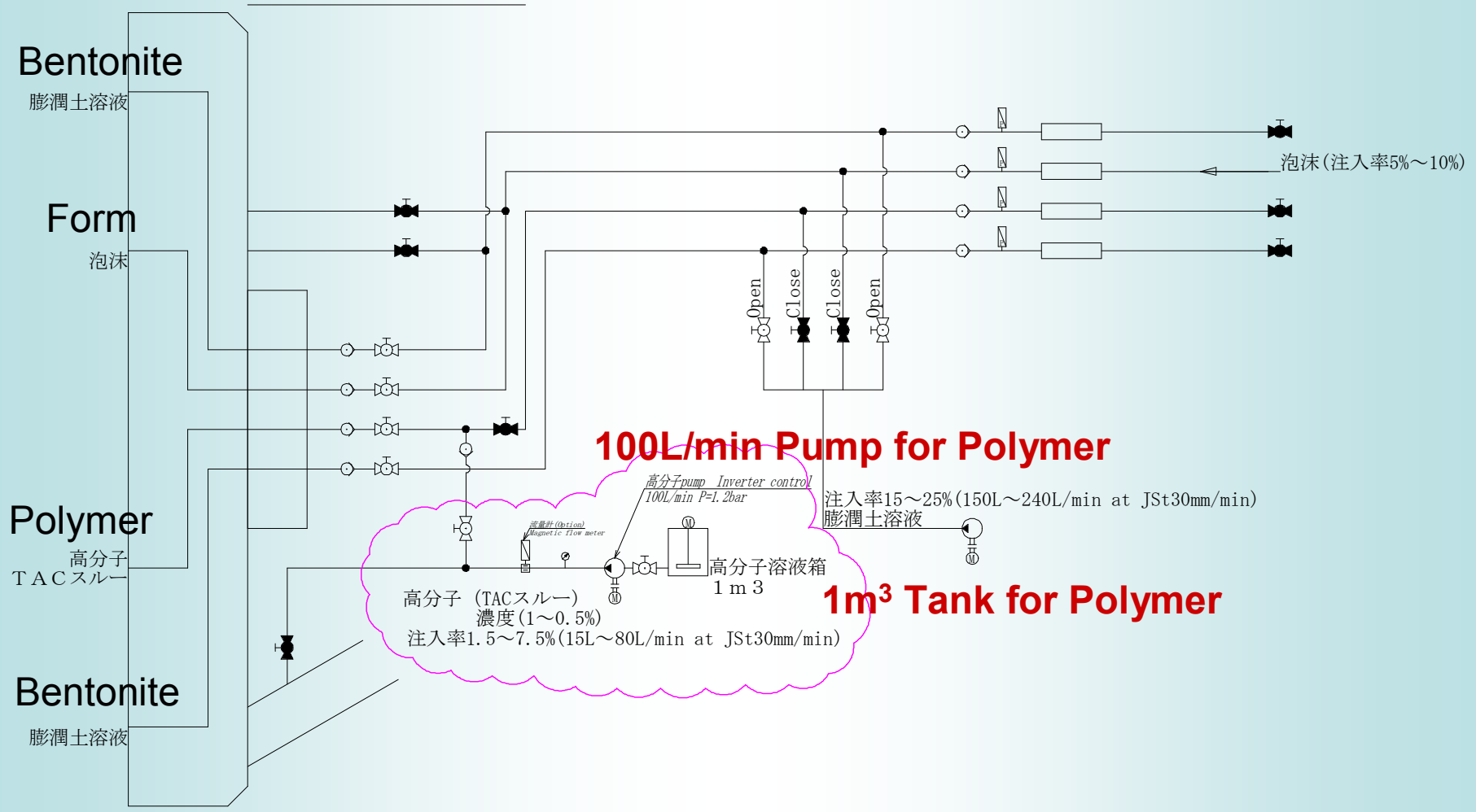
Screw type



Piston type



Sample of additional equipment for TAC through



Muck of using TAC through



muck on the conveyer is smooth and a close-knit soil. The muck doesn't fall out of the conveyer nor stick on the conveyer.

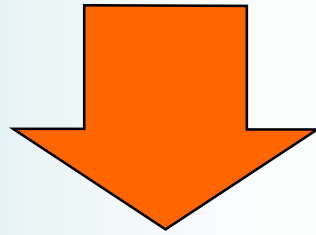
Collateral effects of using TAC through

time of cleaning the tunnel is shorter than ever.

troubles of conveyer becomes to be decrease.

muck stick on truck became to be decrease.

clean on the truck



Stable of excavation cycle

Excavation progress rate up

Improvement of working environment

Conclusion

- **smooth excavation** makes repression of face settlement.
- **using proper addition material** makes smooth excavation.
- **TAC through** is useful material which is **easy to use** and has **large application range**.
- TAC through with **changing of density and injection rate** can use for all kind of soils.
- TAC through with bentonite solution can use for **Gravel sand soil without fines**.
- Equipment can built more existent by **small money**.

Thank you for listening

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