



## Content :

- ▶ **Pendahuluan**
- ▶ **Berberapa Kejadian (Kegagalan) Pekerjaan Infrastruktur**
- ▶ **Pelapukan**
- ▶ **Penentuan Kuat Geser**
- ▶ **Penurunan Kekuatan Geser**
- ▶ **Penentuan Kekuatan Geser Pada Saat Slope Sliding**
- ▶ **Kesimpulan**



## Pendahuluan





## Pendahuluan

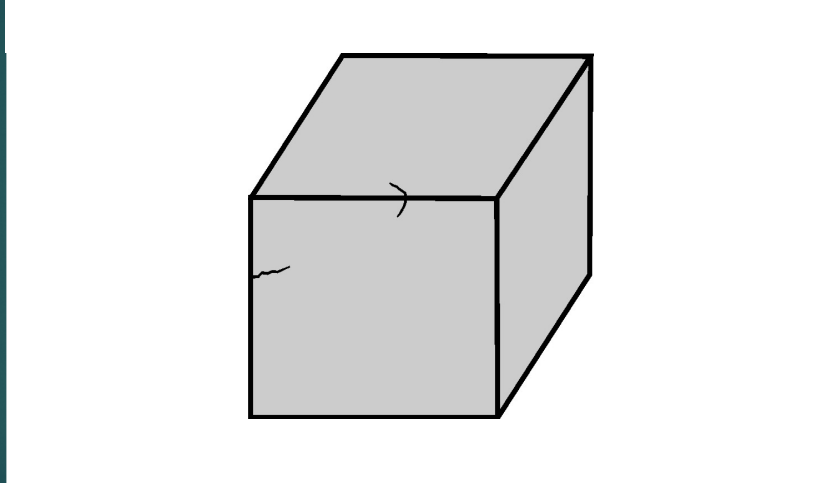
- ▶ Batuan argillaceous adalah formasi batuan sedimen dari endapan tanah liat atau dalam istilah lain disebut sebagai batu lempung dan lebih khusus lagi dengan istilah shale clay.
- ▶ Dengan menambahkan kata "**shale**" yang menggambarkan perilaku spesifik jenis batu lempung ini yang mudah lapuk. Ini karena kontak dengan atmosfer atau hidrosfer.
- ▶ Selama proses pelapukan batuan argillaceous melalui proses pengeringan dan siklus pengeringan pembasahan terdapat perubahan dalam sifat fisik dan indeks dan mekanik, yang akhirnya berubah dalam indeks dan parameter sifat fisik, parameter mekanik



## The Illustration of Weathering of Clay Shale



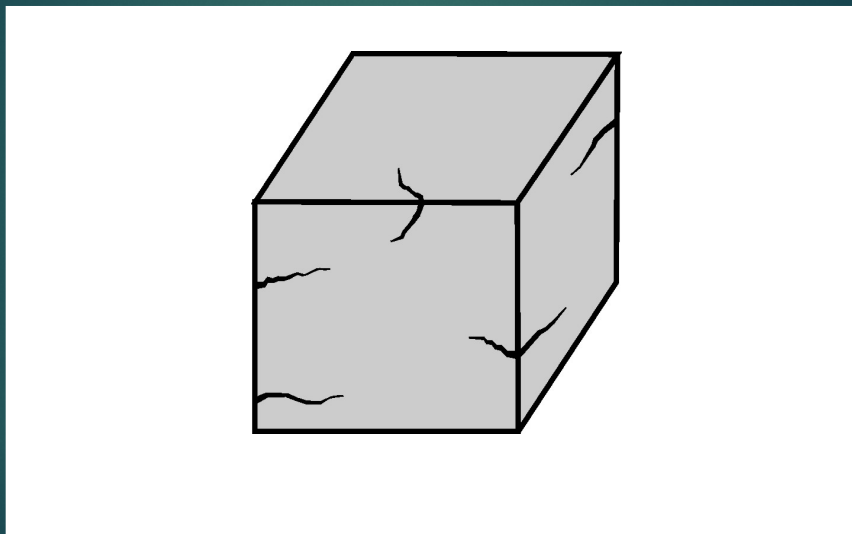
## Weathering Process on Clay Shale



Sadisun, 2008



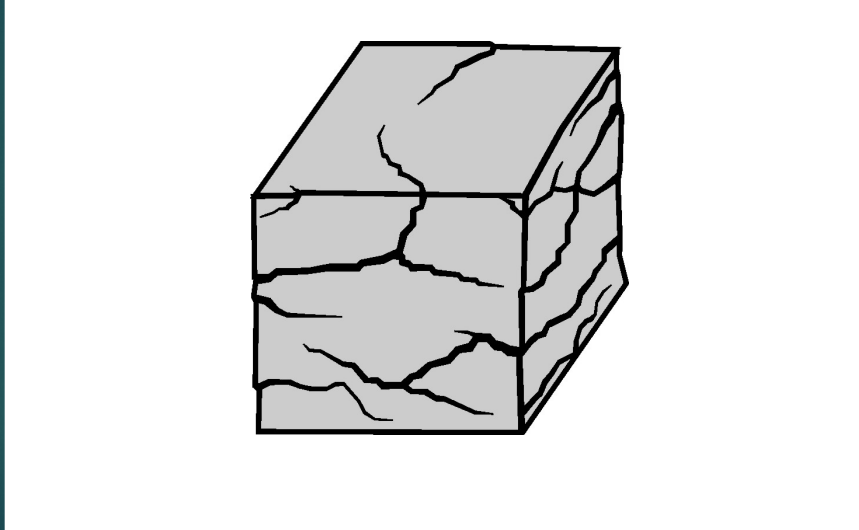
## Weathering Process on Clay Shale



Sadisun, 2008



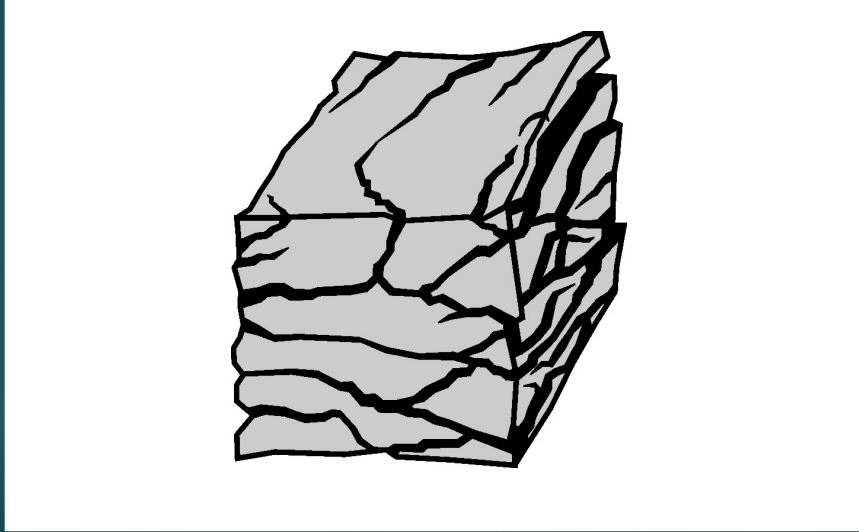
## Weathering Process on Clay Shale



Sadisun, 2008



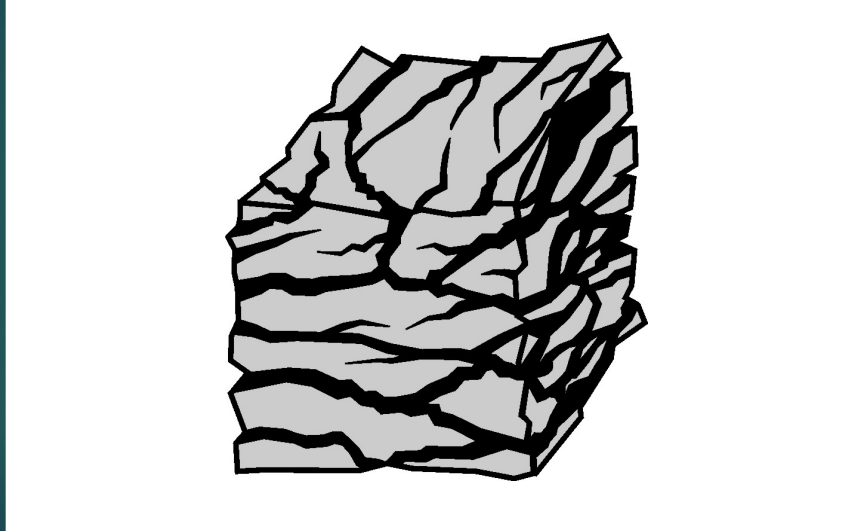
## Weathering Process on Clay Shale



Sadisun, 2008



## Weathering Process on Clay Shale



Sadisun, 2008

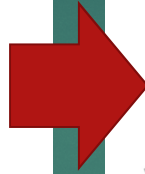
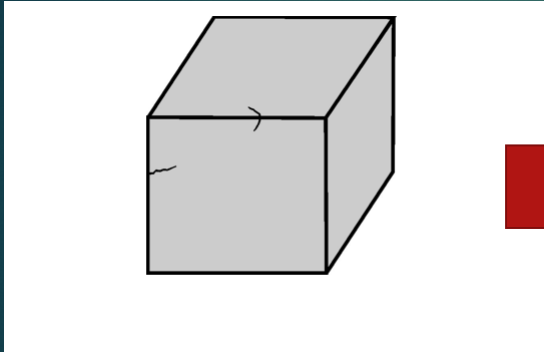


## Weathering Process on Clay Shale



Sadisun, 2008

# Disintegration Ratio ( $D_R$ )



$D_R = 1,000$  (Fresh Clay Shale/ initial condition)

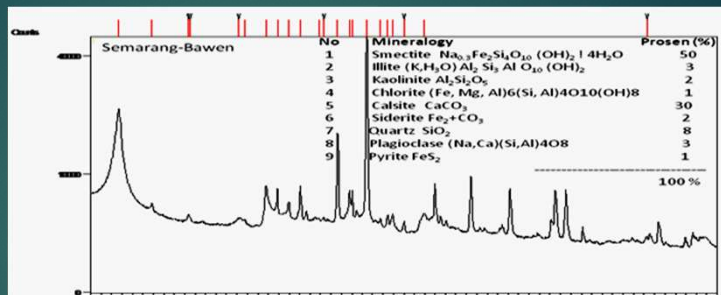
$D_R \ll 1,000$  (~0,00) (Fully Weathered Clay Shale / final condition)



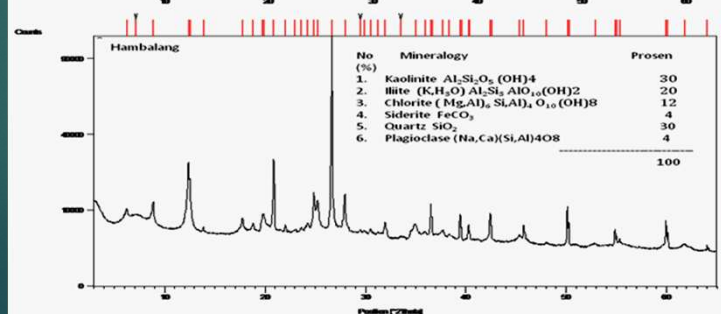
# Clay Shale Mineralogy



SEMARANG -BAWEN



HAMBALANG



LOKASI	MINERAL LEMPUNG (%)				JUMLAH (%)
	Smectite	Illite	Kaolinite	Chlorite	
Semarang	50	3	2	1	56
Hambalang	-	12	30	20	62

	MINERAL KARBONAT (%)			JUMLAH (%)	
	Calcite	Dolomite	Siderite		
Semarang	30	-	2	-	32
Hambalang	-	-	4	-	4

	MINERAL LAIN-LAIN (%)				JUMLAH (%)
	Quartz	K-Feldspar	Plagioclase	Pyrite	
Semarang	8	-	3	1	12
Hambalang	30	-	4	-	34

**SEM**

HAMBALANG  
SEMARANG-  
RAWEN

# Bererapa Kejadian (Kegagalan) Pekerjaan Infrastruktur

19



# Berberapa Kejadian (Kegagalan) Pekerjaan Infrastruktur





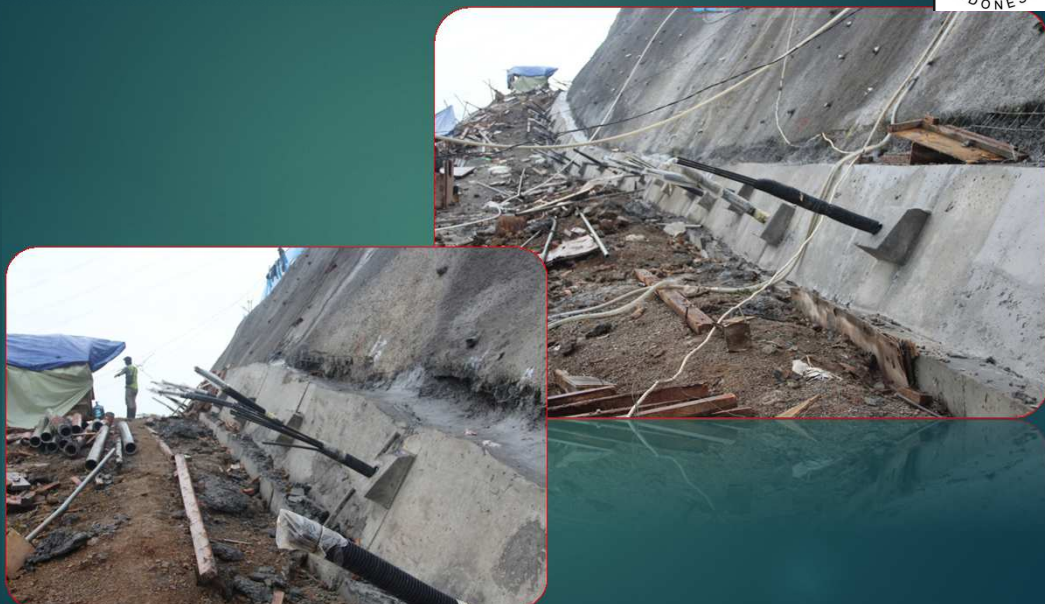
## Bored Pile and Final Excavation



# Bored Pile and Final Excavation



# Ground Anchor





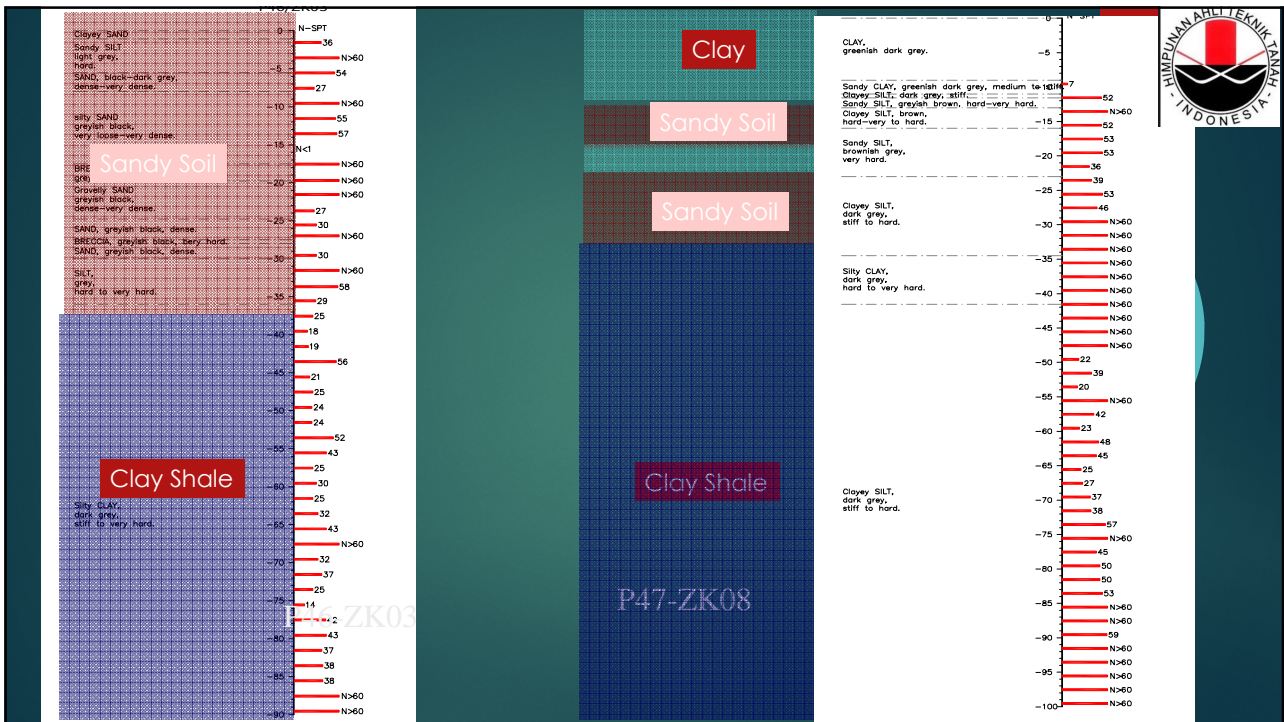
### Location of Clay Shale Area in Cipularang Toll Road



### Landslides at KM 92+400 Cipularang Toll Road





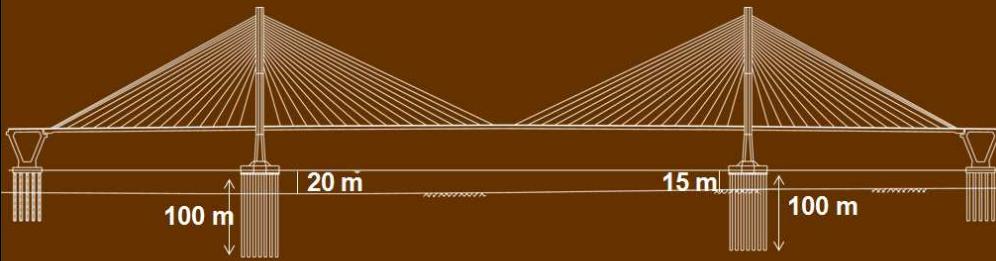


## Estimasi Daya Dukung Yang Sangat Bervariasi

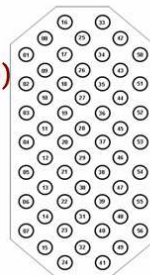
	Pile SZ1 (ton)	Pile SZ2 (ton)
Geotechnical Investigator	8.700	7.900
COWI-Denmark	1.850	2.060
China-Southeast Univ.	3.420	3.500



LENGTH OF BORED PILES FOR THE CABLE STAYED BRIDGE



- Diameter = 2.4m
- Required Ultimate Capacity =  $\pm 3500$  ton (SF=2.0)
- Pile length in initial design = 45m
- Pile length after redesign = 80m
- Pile length after loading test = 100-110m



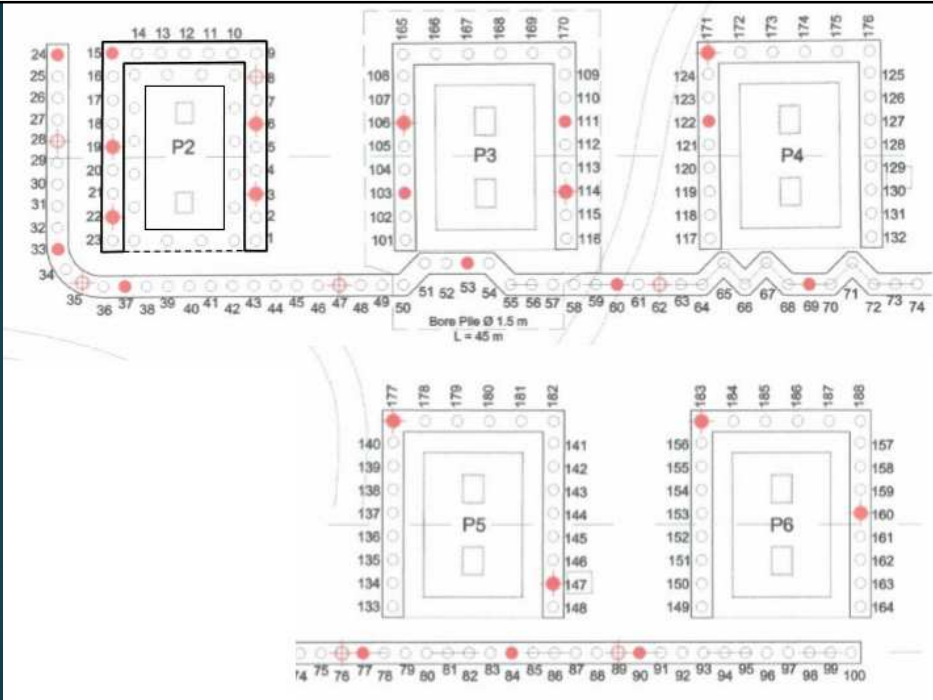
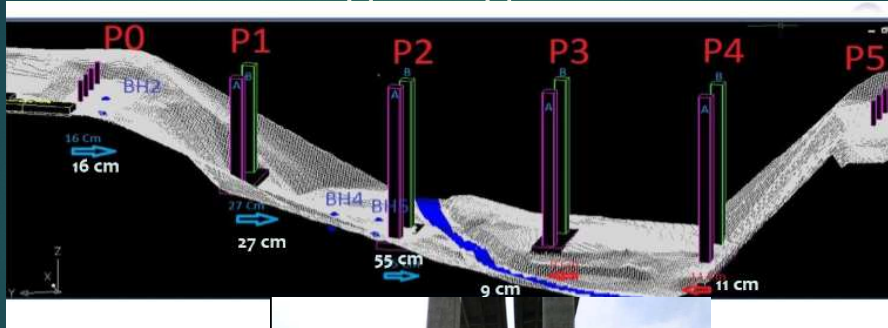
56 Tiang

Pergerakan Fondasi dan Pilar di Jembatan Penggaron, Tol Semarang-Ungaran



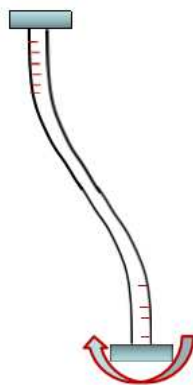


# Relative Lateral Displacement Pier of Cisomang Bridge





di P2



Fondasi masih mampu menahan moment dan beban vertikal

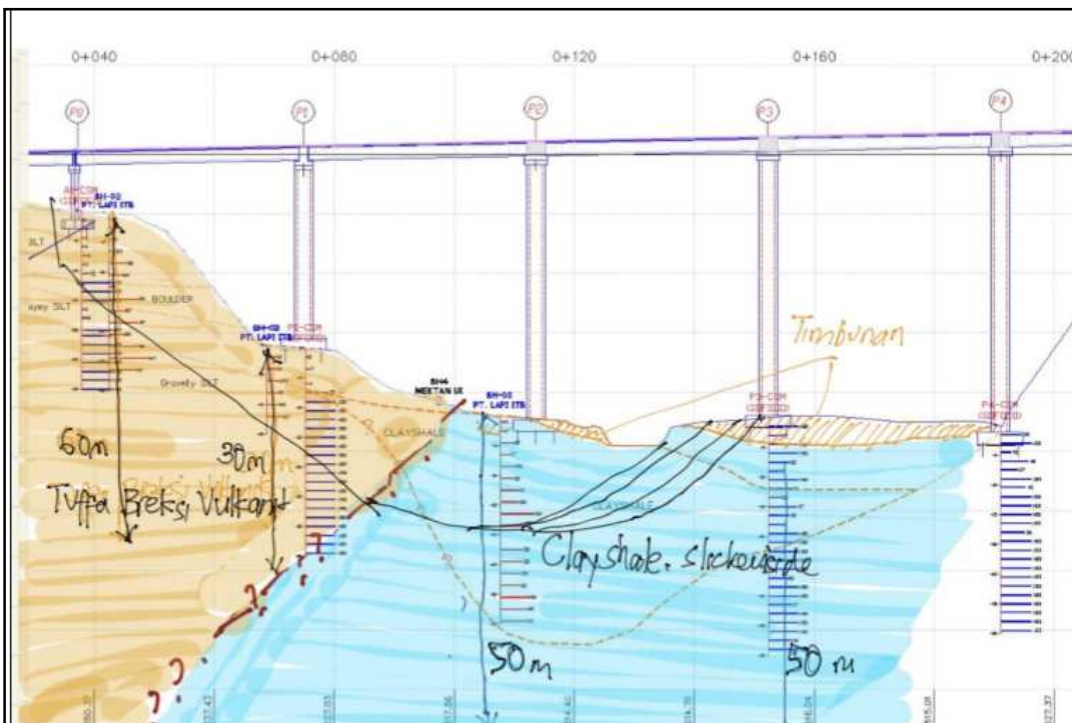
- Fondasi tiang masih kuat
- Deformasi pile cap 57cm

di P2



Ini kalau fondasi tidak mampu menahan momen dan vertikal

→ Not shallow slip surface





## Desain Perkuatan Ground Anchor di Pier P0 & P1

### Perkuatan GA Pier P0

Beban lateral pada Pier P0,

$$H_x = H_{xi} + H_{xd} = 193.73 \times 4 \times 50 = 393.7 \text{ ton}$$

Note: tambahan beban tanah ± 10%

Pada masing-masing pier digunakan 2x3 = 6 buah GA, gaya tiap Ground Anchor,

$$F_{wd} = 393.7 \times 1.1 / 6 = 72.2 \text{ ton (horizontal)}$$

$$F_{wd} = 83.4 \text{ ton (miring 30 deg)}$$

### Perkuatan GA Pier P1

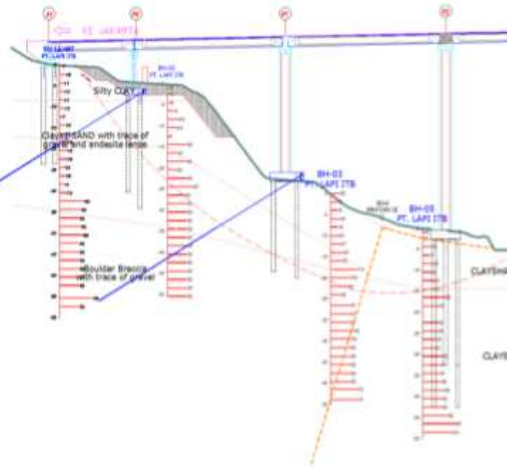
Beban lateral pada Pier P1,

$$H_x = H_{xi} + H_{xd} = 228.5 \times 2 \times 100 = 428.5 \text{ ton}$$

Pada masing-masing pier digunakan 2x3 = 6 buah GA, gaya tiap Ground Anchor,

$$F_{wd} = 428.5 \times 1.1 / 6 = 78.5 \text{ ton (horizontal)}$$

$$F_{wd} = 90 \text{ ton (miring 30 deg)}$$

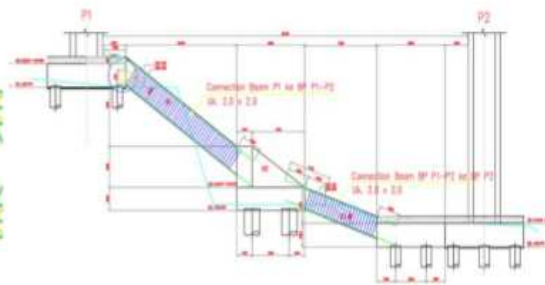
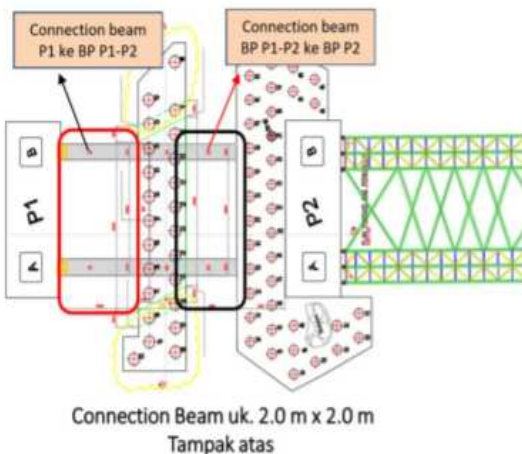


Sengara 2017

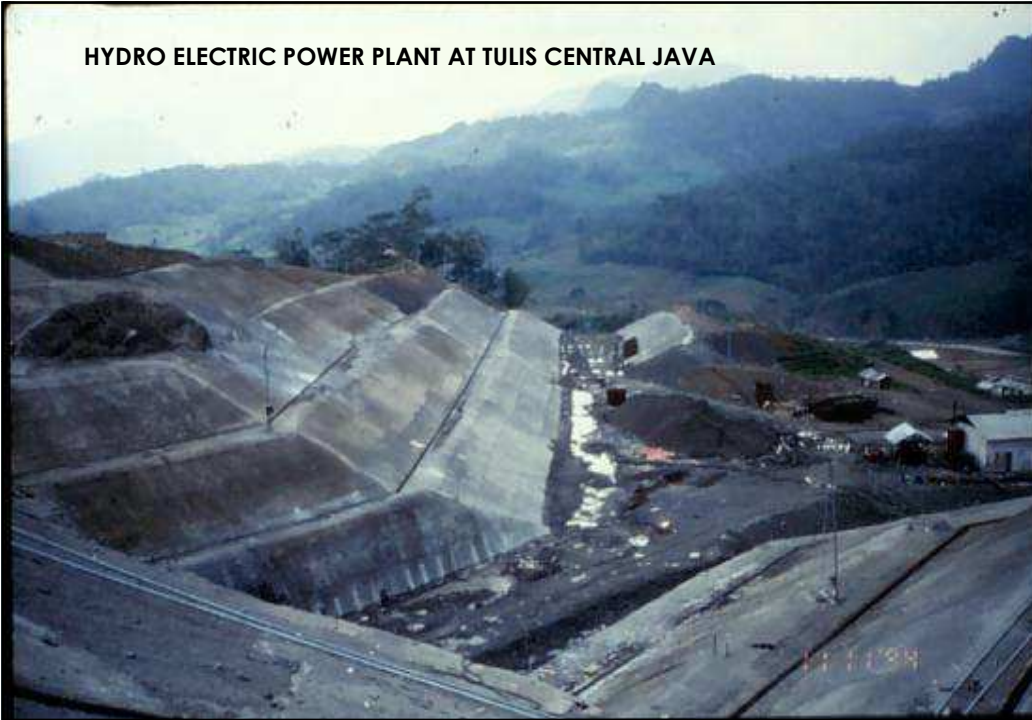
## Analisis Perkuatan Lereng Jembatan Cisomang

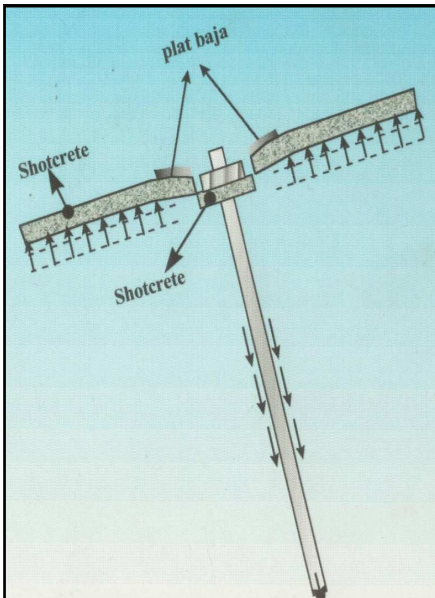
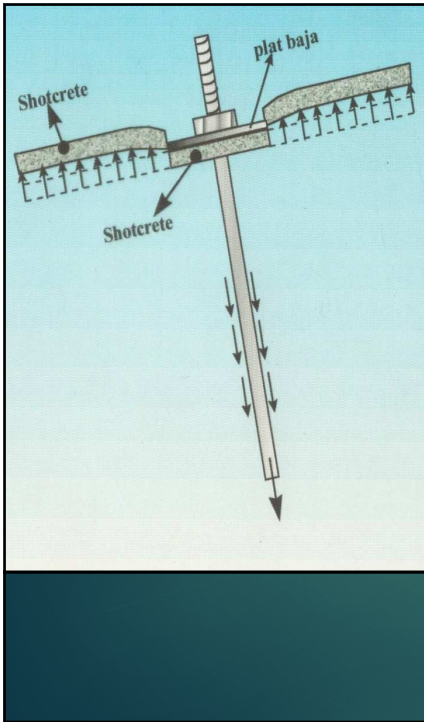


### 4. Pemasangan Connection Beam antara P1 ke BP P1-P2 dan BP P1-P2 ke BP 2



HYDRO ELECTRIC POWER PLANT AT TULIS CENTRAL JAVA



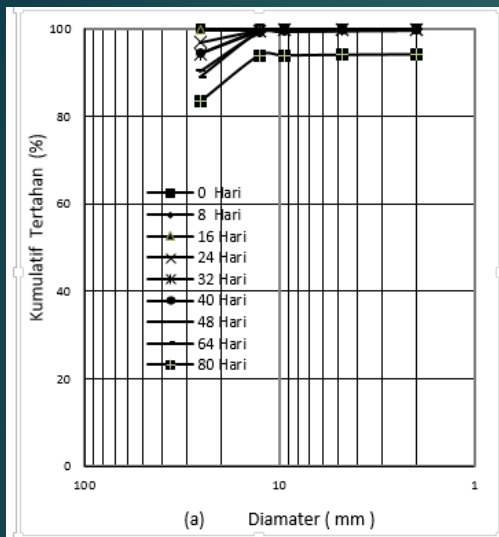


Punching Failure Antara Mur dan Plat Baja

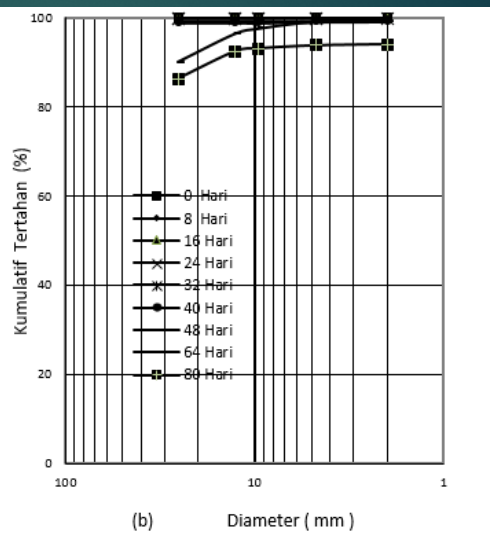


A dark teal background featuring a large, light teal circle on the right side. In the top right corner, there is a circular logo for 'HIMPUNAN AHLI TEKNIK TANAH INDONESIA'. The text 'Pelapukan Pada Clay Shale' is written in a bold, yellow font across the middle of the slide.

## Pelapukan Pada Clay Shale



A. Semarang-Bawen Clay Shale

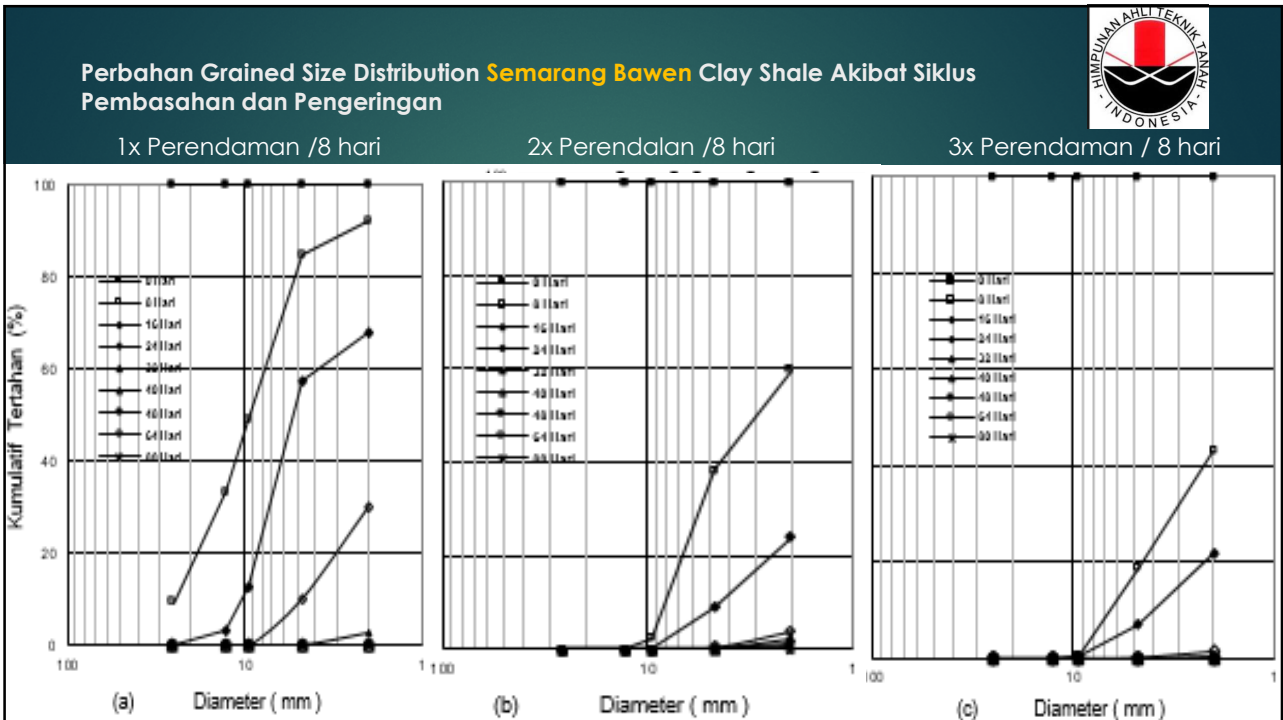


B. Hambalang Clay Shale

Perubahan Grained Size Distribution Clay Shale Akibat Pelapukan Proses Pengeringan



Pelapukan clay shale Hambalang dan Semarang Bawen Akibat Proses Siklus Pembasahan – Pengeringan dengan 2 kali pembasahan dalam 1 minggu





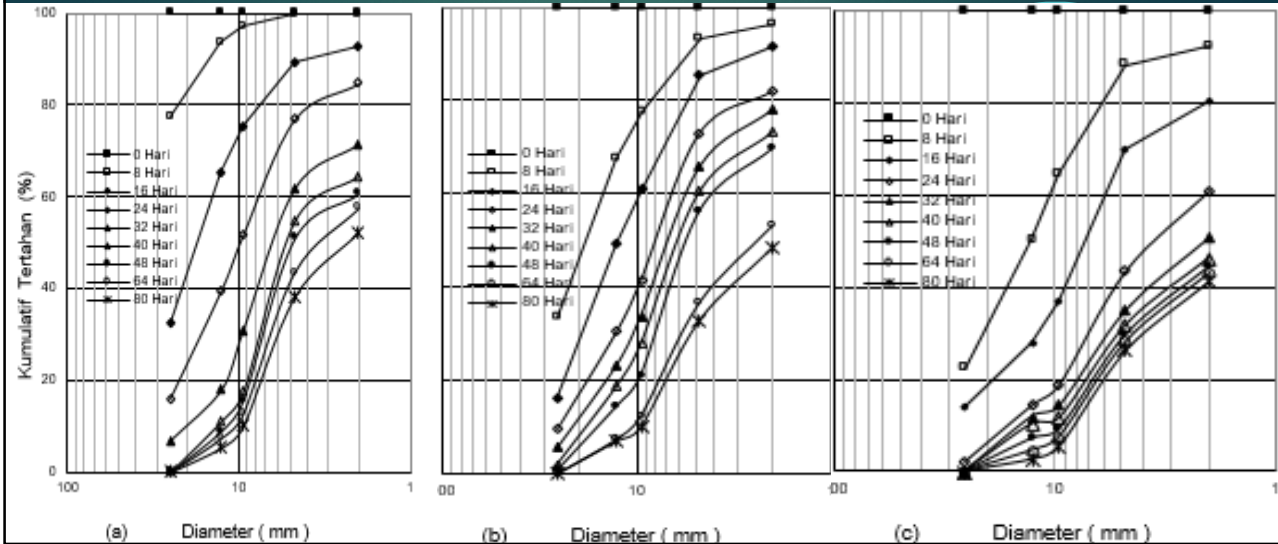


Perubahan Grained Size Distribution **Hambalang** Clay Shale Akibat Siklus Pembasahan dan Pengeringan

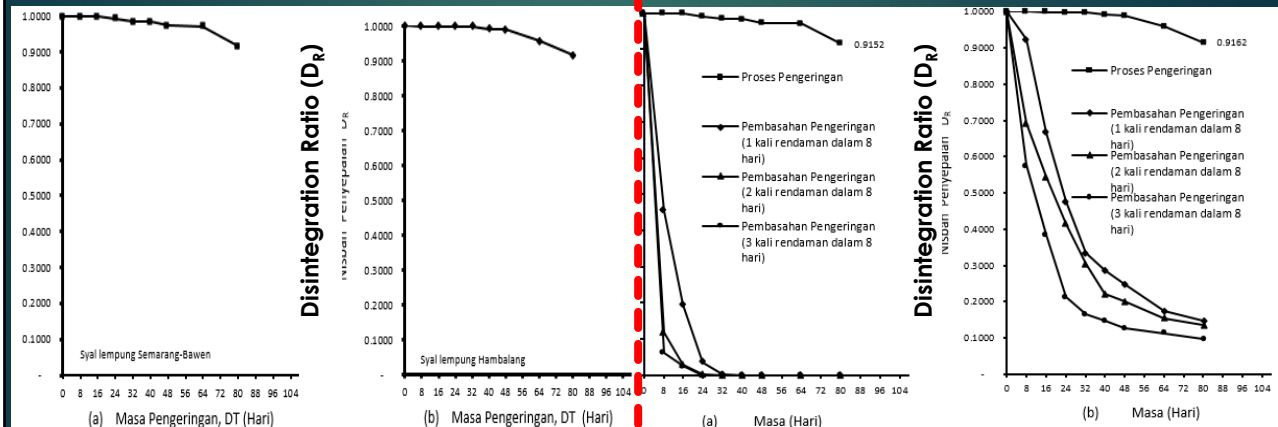
1x Perendaman / 8 hari

2x Perendaman / 8 hari

3x Perendaman / 8 hari



Perubahan Disintegration Ratio ( $D_R$ )



SEMARANG-BAWEN

HAMBALANG

SEMARANG-BAWEN

HAMBALANG

Drying Process 80 days

Drying Process 80 days

Wet-Drying Pr. 80 Days

Wet-Drying Pr, 80 Days



## Penentuan Kuat Geser Clay Shale

## Clay Shale Sampling



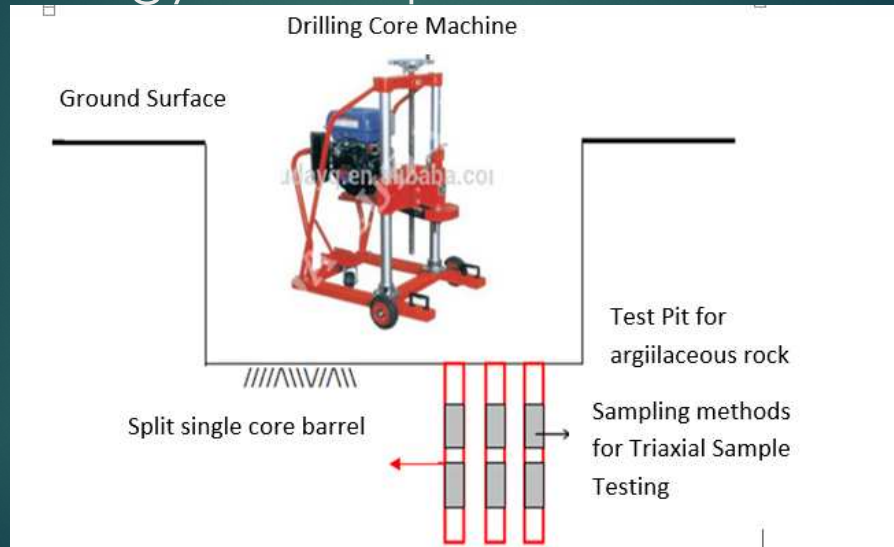
### For Undisturbed Sampling

- Standard Rotary Core Drilling ( Dry Drilling), Low to medium speed, (shallow medium to depth sampling).
- Sampling using Double Core Barrel, Triple Core Barrel.

### Test Pit

- Using High Speed Drilling Machine (Core drilling), Shallow sampling
- Sampling using modified core barrel (**Split Single Core Barrel**)
- Obtained lots of soil undisturbed samples (at the same depth, used in research)
- Soil Samples are made directly in the field, protected cover sampling and followed by testing in the laboratory (Triaxial Testing)

# Argillaceous Rock Sampling Methodology Developed

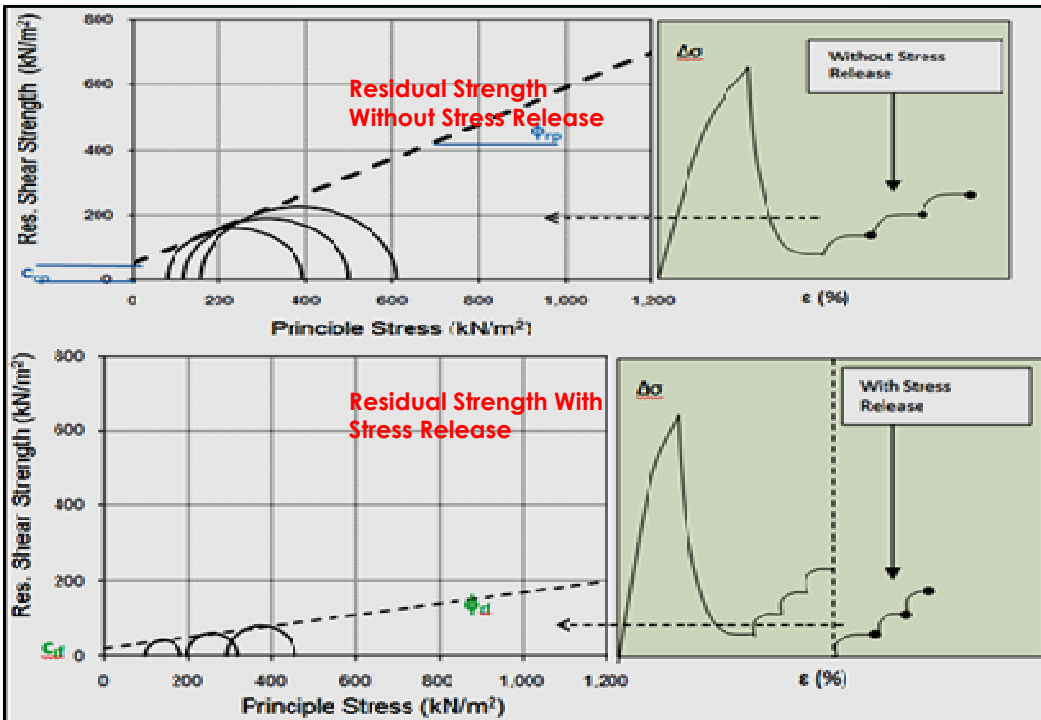
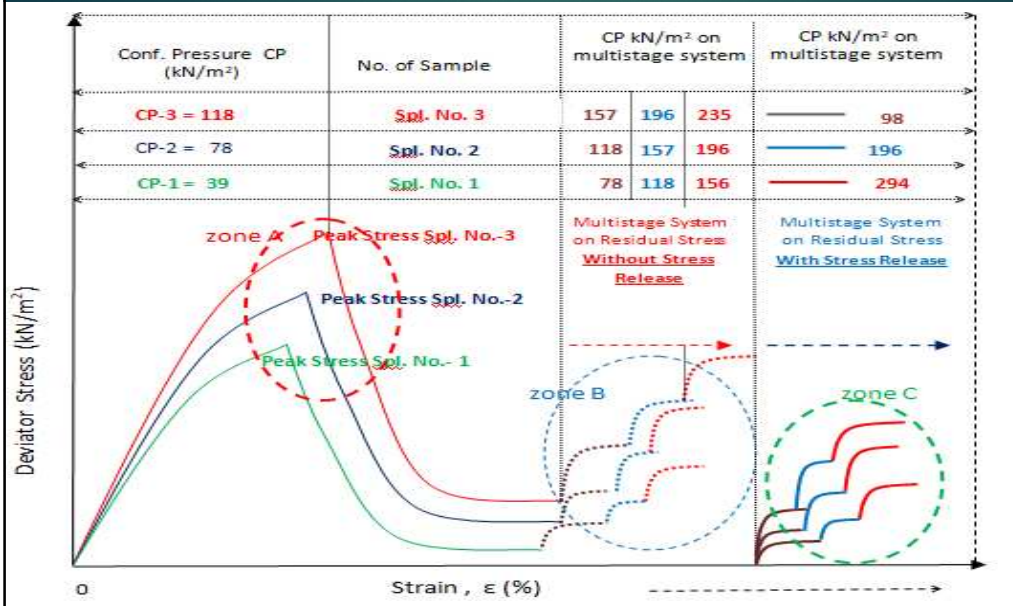


## Comparison of standard sampling with the developed methodology for taking argillaceous rock



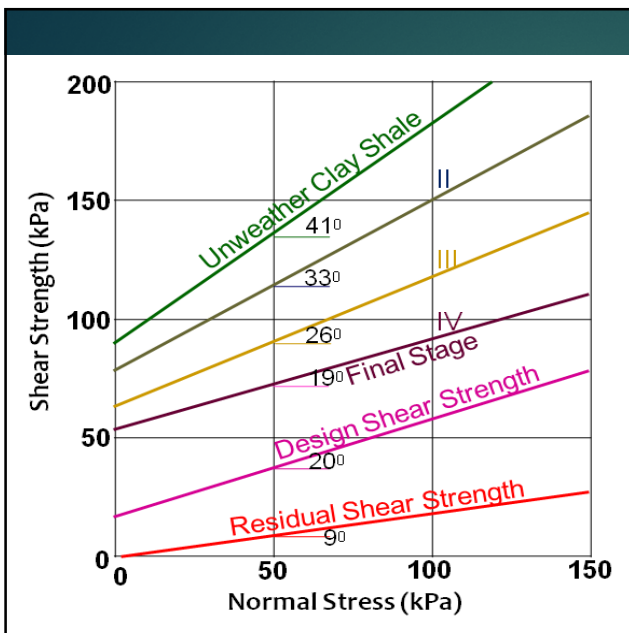
<b>STANDARD UNDISTURBED SAMPLING METHODS</b>				
<b>SITE INVESTIGATION</b>		<b>LABORATORY TEST</b>		
From BORING TEST or TEST PIT as Thin Walled Tube Sampling Core/ Barrel Sampling/ Box Sampling	Mobilization to Laboratory	Triaxial UD Sampling Using Moulding, Extruder, Trimming	<b>Weathering Process</b>	Triaxial Testing
<b>ARGILLACEOUS SAMPLING DEVELOPMENT METHODS</b>				
<b>Undisturbed Sampling using Split Single Core Barrel</b>	Mobilization to Laboratory	----->		Triaxial Testing

# Determination Residual Shear Strength of Clay Shale at Laboratory with Triaxial Test

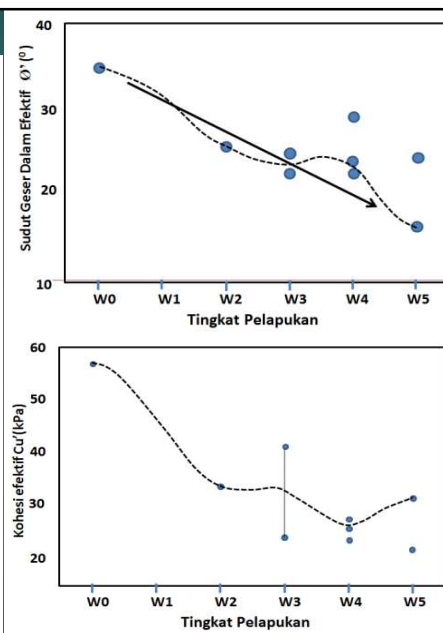




# Penurunan Kekuatan Geser

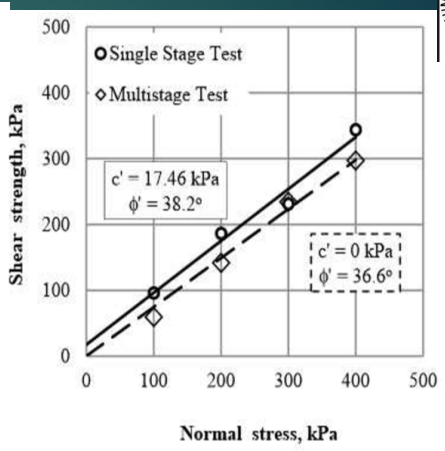
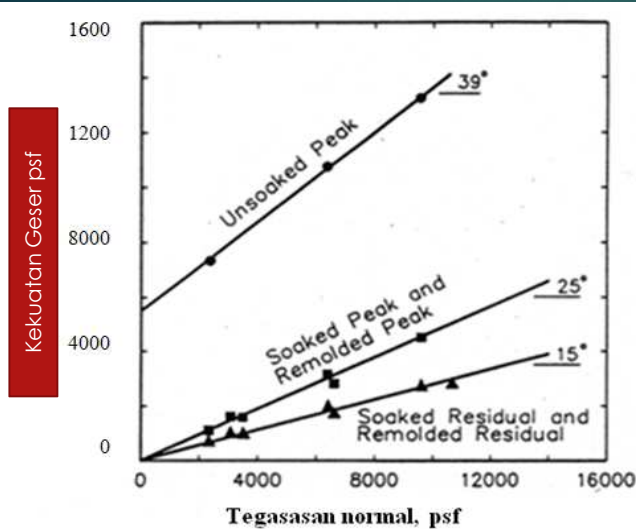


Parameter kuat geser *clay shale* yang disampaikan oleh Gartung 1986



Penurunan kuat geser efektif terhadap tingkat pelapukan *clay shale* (Emberhardt E. 2004)



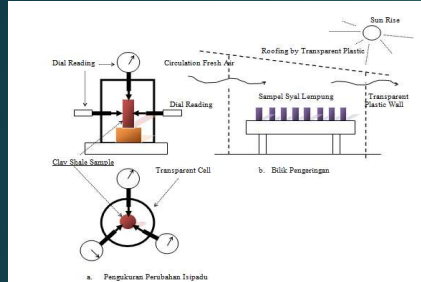


Kekuatan Geser psf

Perubahan kekuatan geser clay shale (Timothy et al., 1991)

Perbedaan hasil single stage test dan multistage test dari direct shear test (Horndee et al., 2012)

# Drying ; Wetting and Drying Process



		Hari																														
Ujian Paksi Tipe 0 hari	Pengeringan	Hari ke 0 - 2	Hari ke 2	Hari ke 2 - 6	Hari ke 6	Ujian Paksi Tipe 8 hari	Pengeringan	Hari ke 6 - 10	Hari ke 10	Hari ke 10 - 14	Hari ke 14	Hari ke 14 - 18	Hari ke 18	Ujian Paksi Tipe 16 hari	Pengeringan	Hari ke 18 - 22	Hari ke 22	Hari ke 22 - 26	Hari ke 26	Ujian Paksi Tipe 24 hari	Pengeringan	Hari ke 26 - 30	Hari ke 30	Hari ke 30 - 34	Hari ke 34	Ujian Paksi Tipe 32 hari	Pengeringan	Hari ke 34 - 38	Hari ke 38	Ujian Paksi Tipe 40 hari	Pengeringan	Hari ke 40
	Berendam 5 min	Berendam 5 min	Berendam 5 min	Berendam 5 min	Berendam 5 min		Berendam 5 min	Berendam 5 min	Berendam 5 min	Berendam 5 min	Berendam 5 min	Berendam 5 min	Berendam 5 min		Berendam 5 min	Berendam 5 min	Berendam 5 min	Berendam 5 min	Berendam 5 min		Berendam 5 min	Berendam 5 min	Berendam 5 min	Berendam 5 min	Berendam 5 min		Berendam 5 min	Berendam 5 min	Berendam 5 min		Berendam 5 min	Berendam 5 min

Ruang Pengeringan



Hingga 80 hari



Pengeringan



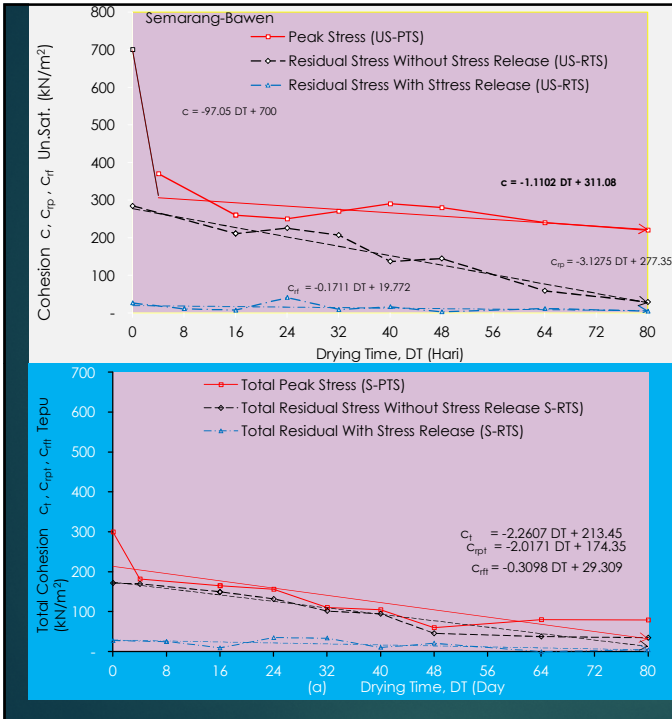
Perendaman 5 menit

Proses Pengeringan | Proses Siklus Pembasahan dan Pengeringan

## Drying Room (Weathering by Drying Process) Undisturbed Sampling



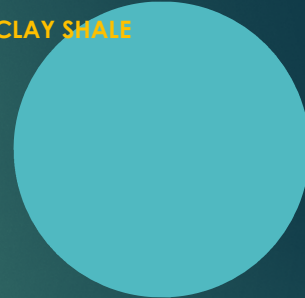
Three dimension (3D) of undisturbed sample volume changes device in wetting-drying



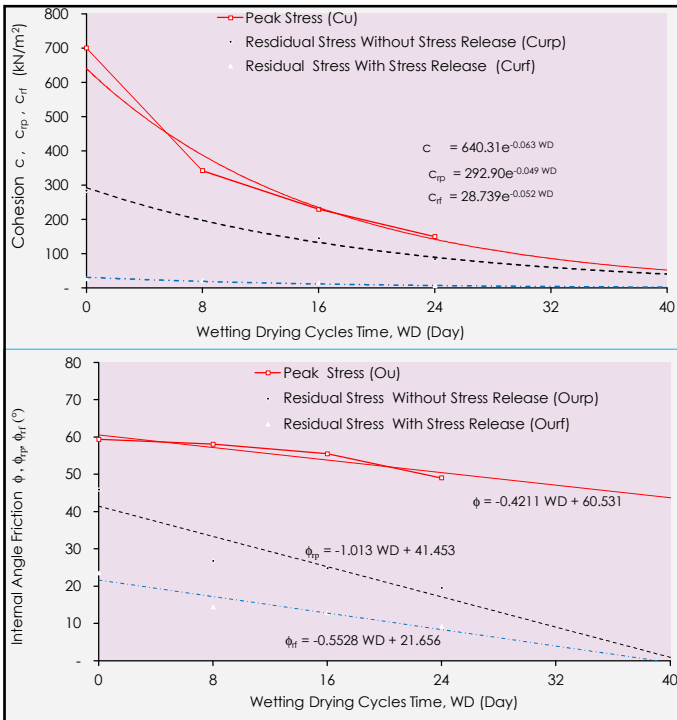
## WEATHERING BY DRYING PROCESS



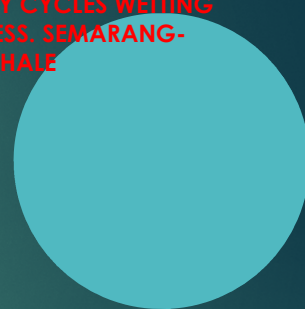
UNSATURATED CLAY SHALE



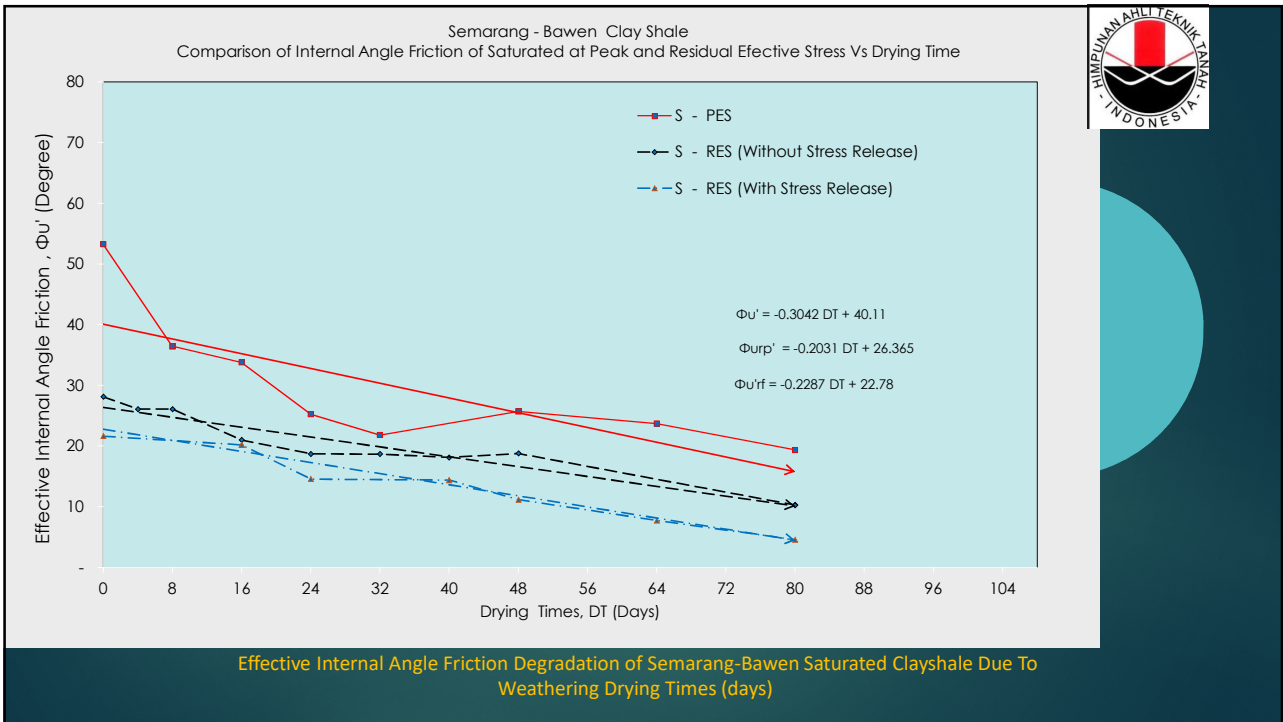
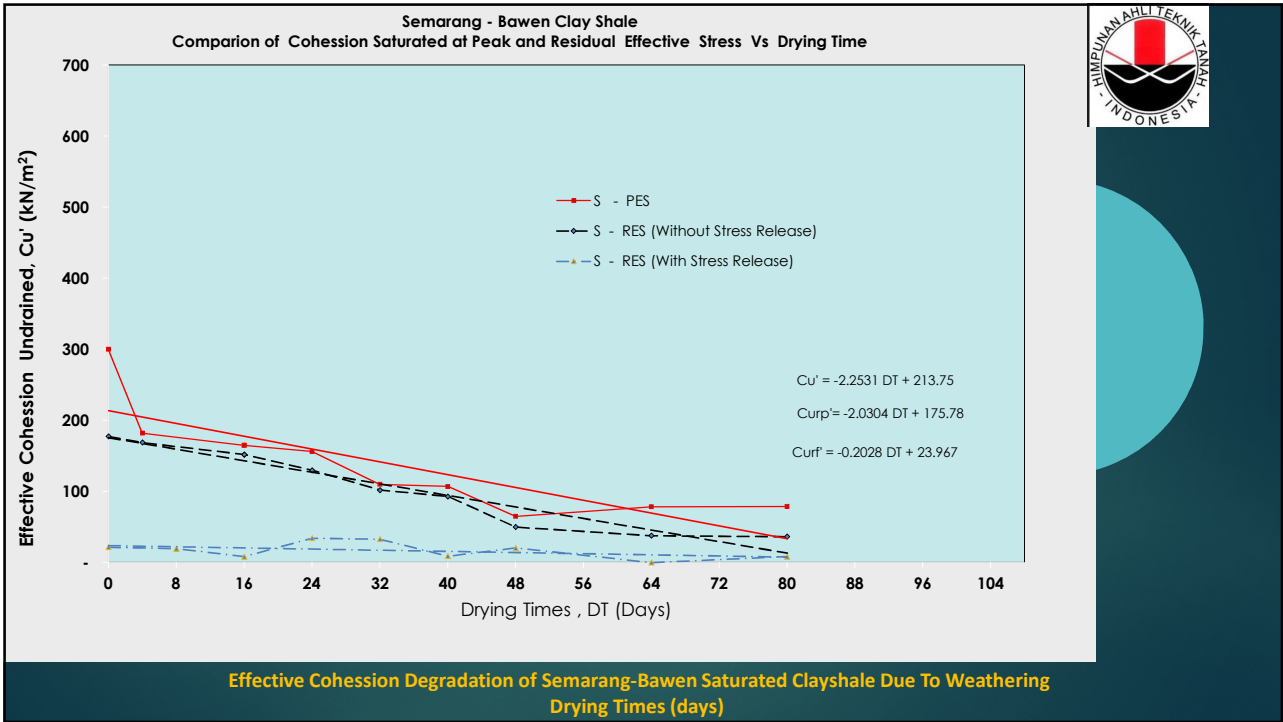
SATURATED CLAY SHALE

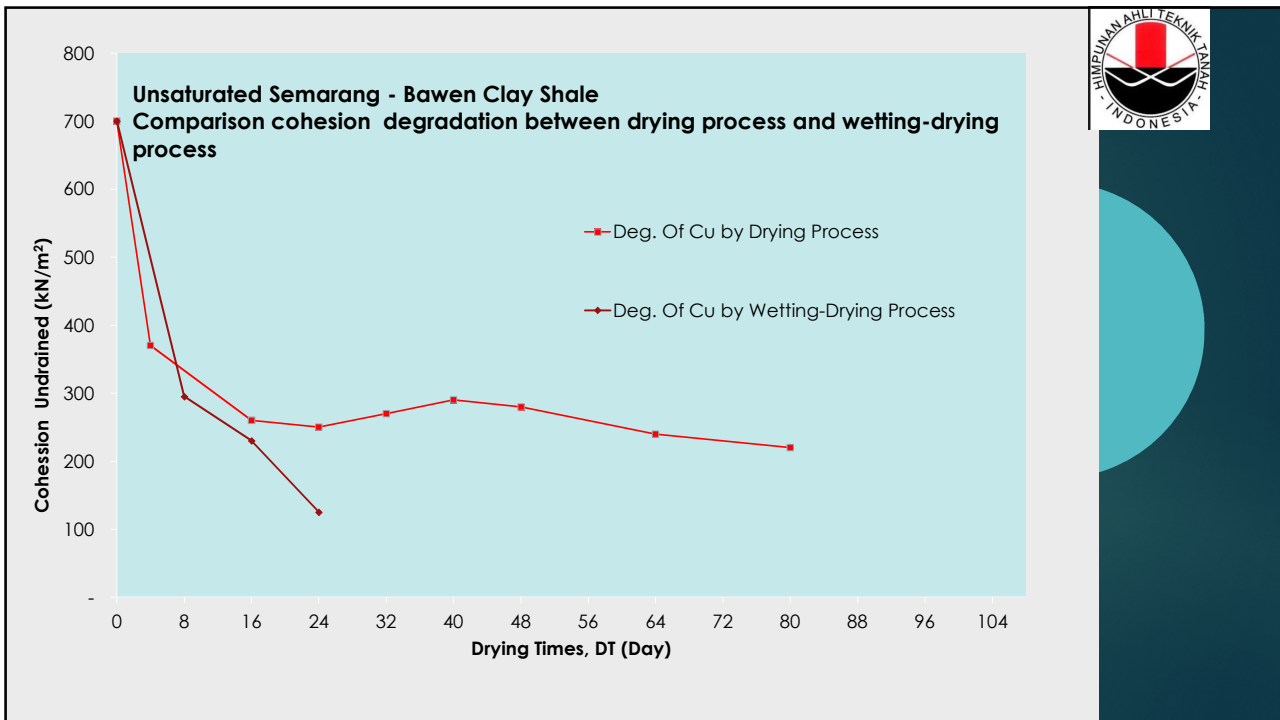


## WEATHERING BY CYCLES WETTING DRYING PROCESS, SEMARANG-BAWEN CLAY SHALE







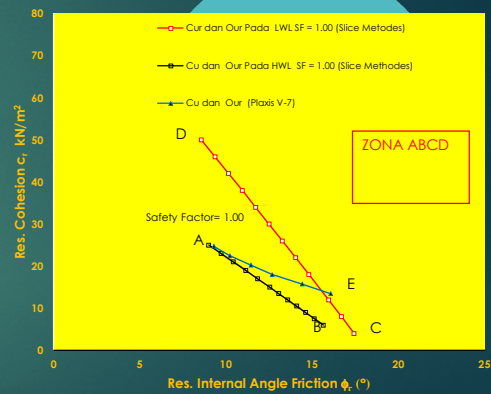
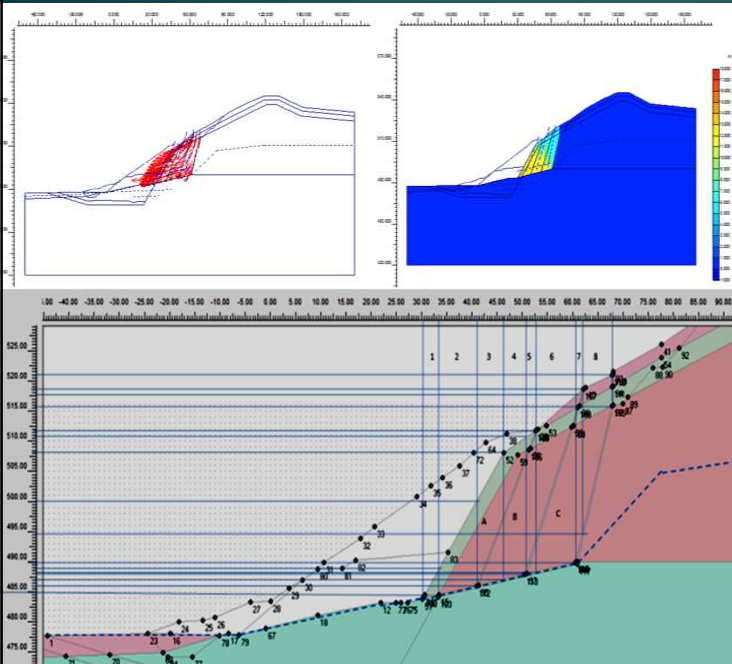


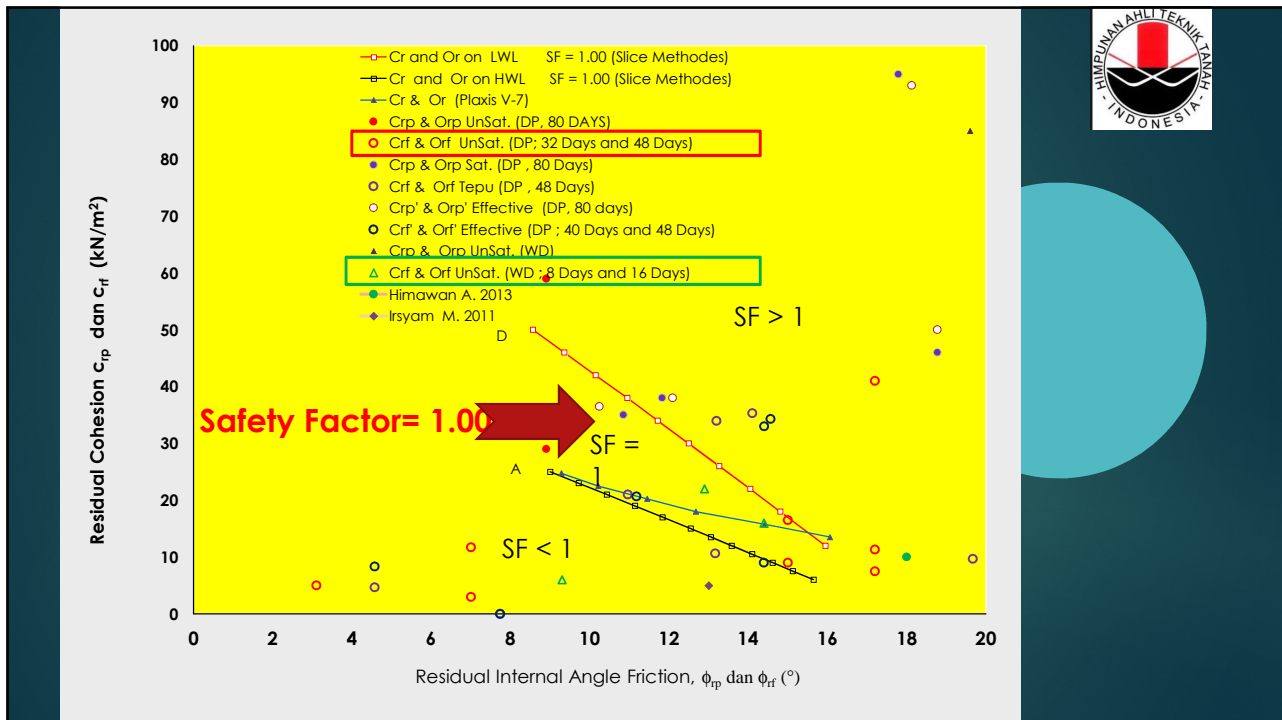
## Penentuan Kekuatan Geser Pada Saat Slope Sliding

SLOPE FAILURE ON CLAY SHALE IN SEMARANG BAWEN TOLL ROAD STA 19+250



BACK ANALYSIS WITH FEM and LEM METHODS





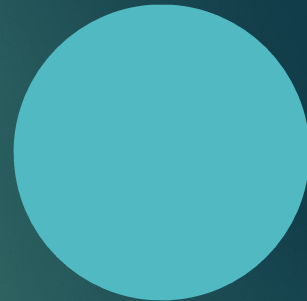
## KESIMPULAN

Dari Kajian diatas, dapat disimpulkan sebagai berikut :

- ▶ Pengujian kekuatan geser dengan *stress release* pada *clay shale* sangat tepat dilakukan untuk menentukan kekuatan geser residual saat kelongsoran terjadi akibat pekerjaan galian
- ▶ Dengan proses pengeringan, paling cepat memerlukan waktu selama 32 hari hingga 80 hari untuk memperoleh kekuatan geser residual yang akurat (cukup lama)
- ▶ dengan proses pelapukan dengan siklus pembasahan dan pengeringan dengan masa 8 hari hingga 16 hari sangat tepat dilakukan untuk memperoleh kekuatan geser residual tersebut (relatif lebih cepat)



TERIMA KASIH



## C and $\phi$ SUMMARY



CASE	Pembasahan dan Pengeringan (8 dan 16 hari)		Pengeringan (80 hari)	
	% c pd <i>interface</i> yang digunakan terhadap c puncak	% $\phi$ pd <i>interface</i> yang digunakan terhadap $\phi$ puncak	% c pd <i>interface</i> yang digunakan terhadap c puncak	% $\phi$ pd <i>interface</i> yang digunakan terhadap $\phi$ puncak
1	$c = (31\sim 49)\% c$	$\phi = (81\sim 98)\% \phi$	$c = (17\sim 31)\% c$	$\phi = (55\sim 65)\% \phi$
2	$c_{rp} = (21\sim 28)\% c$	$\phi_{rp} = (32\sim 45)\% \phi$	$c_{rp} = (3 \sim 4)\% c$	$\phi_{rp} = (15 \sim 16)\% \phi$
3	$c_{rt} = (2 \sim 9)\% c$	$\phi_{rt} = (19\sim 24)\% \phi$	$c_{rt} = (0\sim 4)\% c$	$\phi_{rt} = (5 \sim 8)\% \phi$

