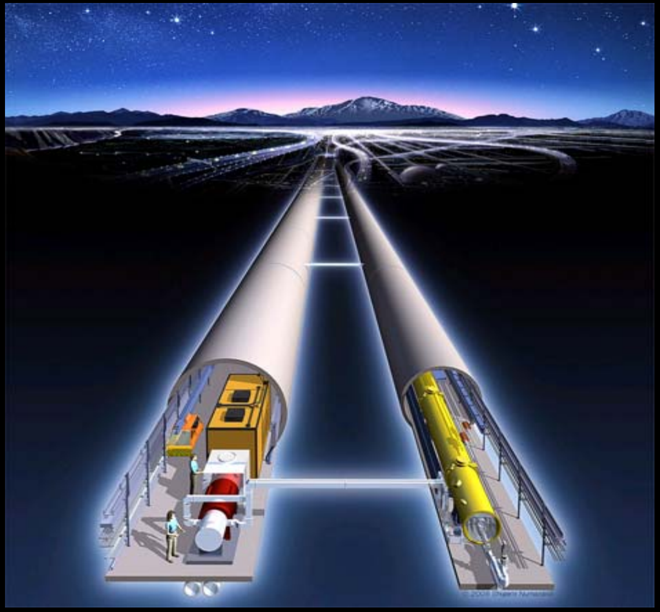
Civil Works in Japan

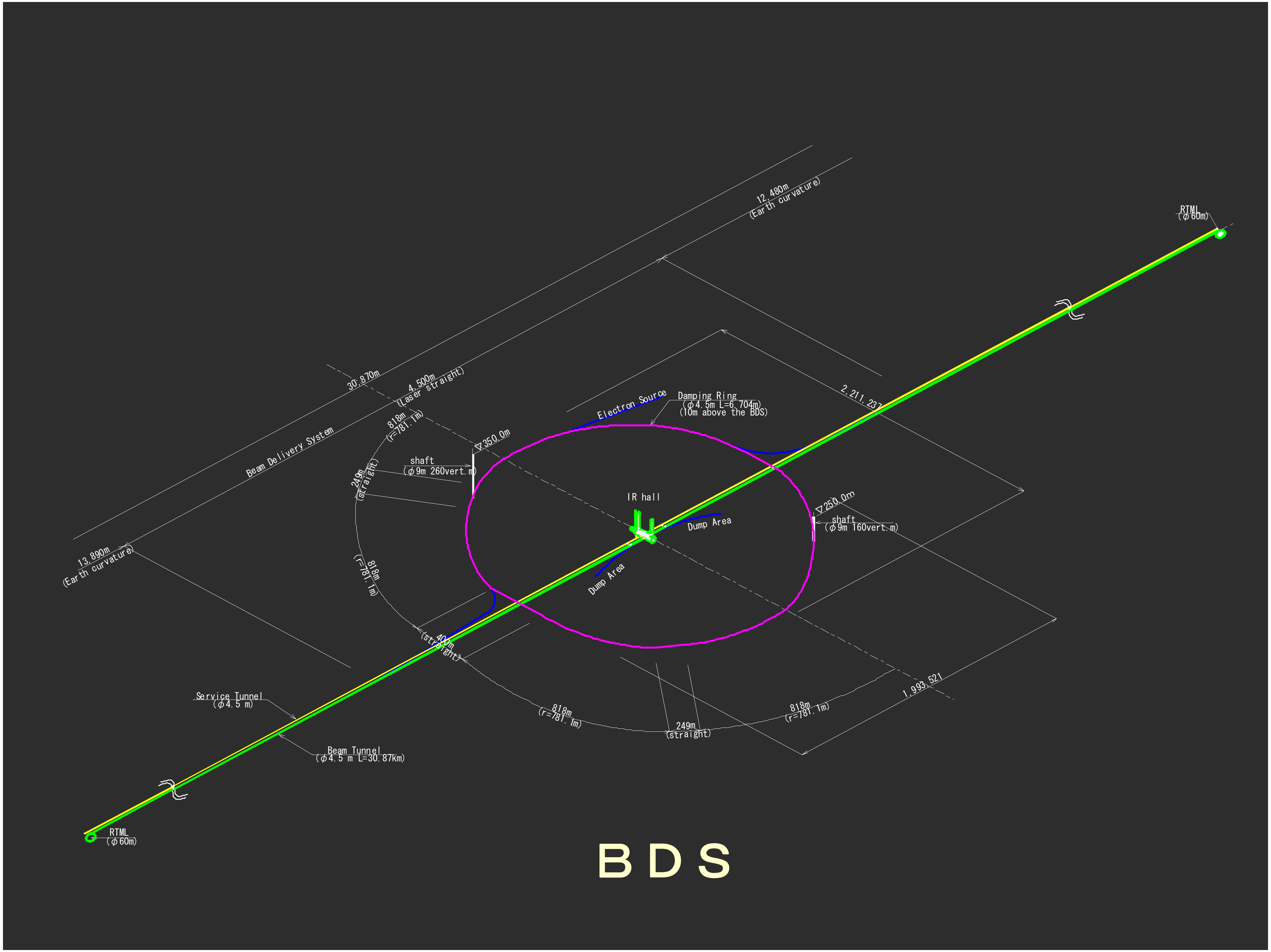
for Cavern Construction



S.Shikama（Kumagaigumi Co.Ltd. JAPAN）

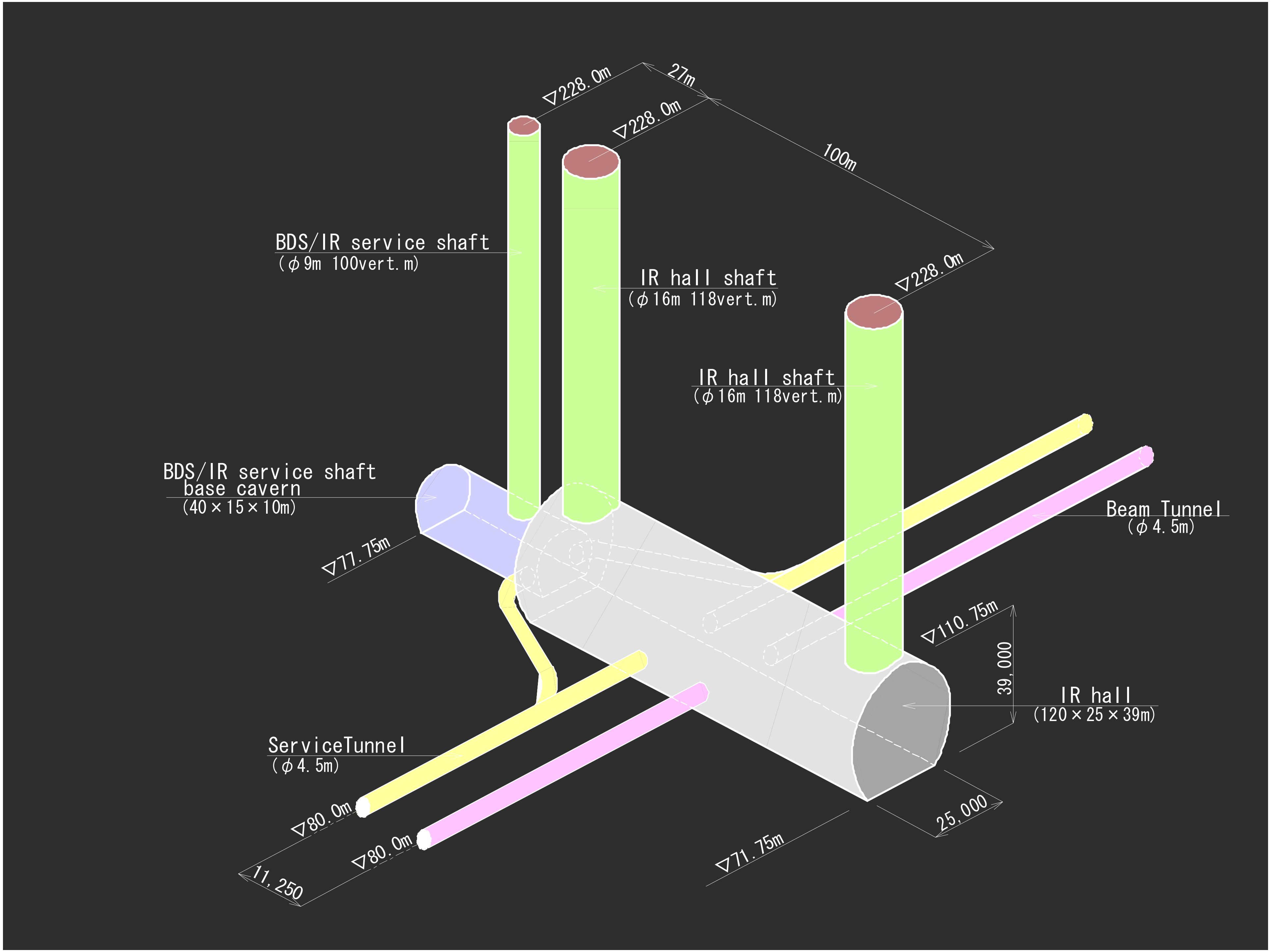
Activities in LCF/Japan
-Infrastructure Development Subcommittee-

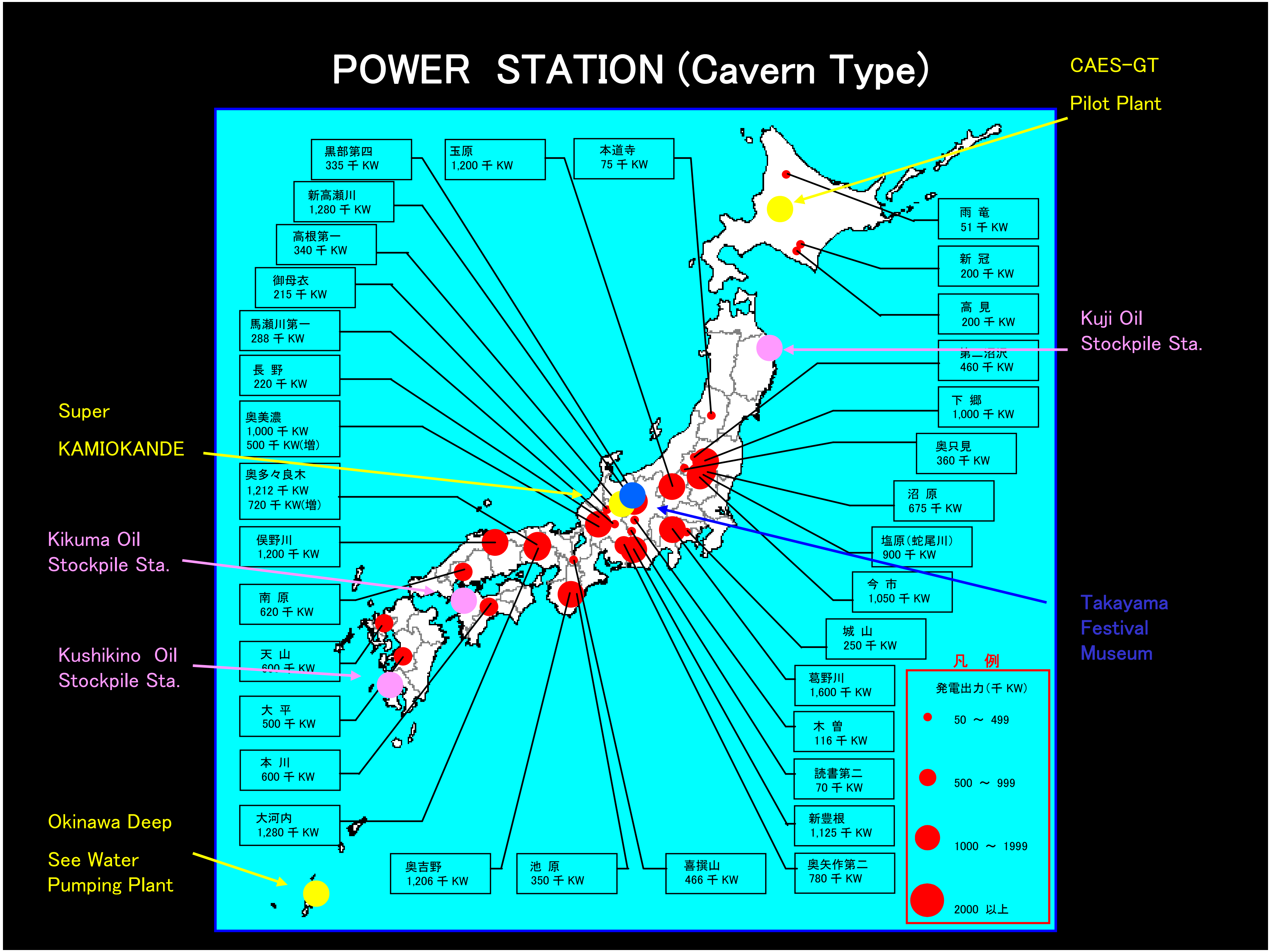
- Site Study of LC Candidate
- Study of Facility Utilization after completion of LC-task
- Study of ILC Conventional Facility
- Research of Cavern Construction in Japan
- Study of Construction Planning for Cavern(IR-hall)
- Visiting & Research for Accelerator Lab.
  EU(DESY/CERN/ESRF) USA(J-Lab./ORNL/FNAL)
  ASIA(PAL/IHEP/SSRF)
- Attending KEK professor's Lecture

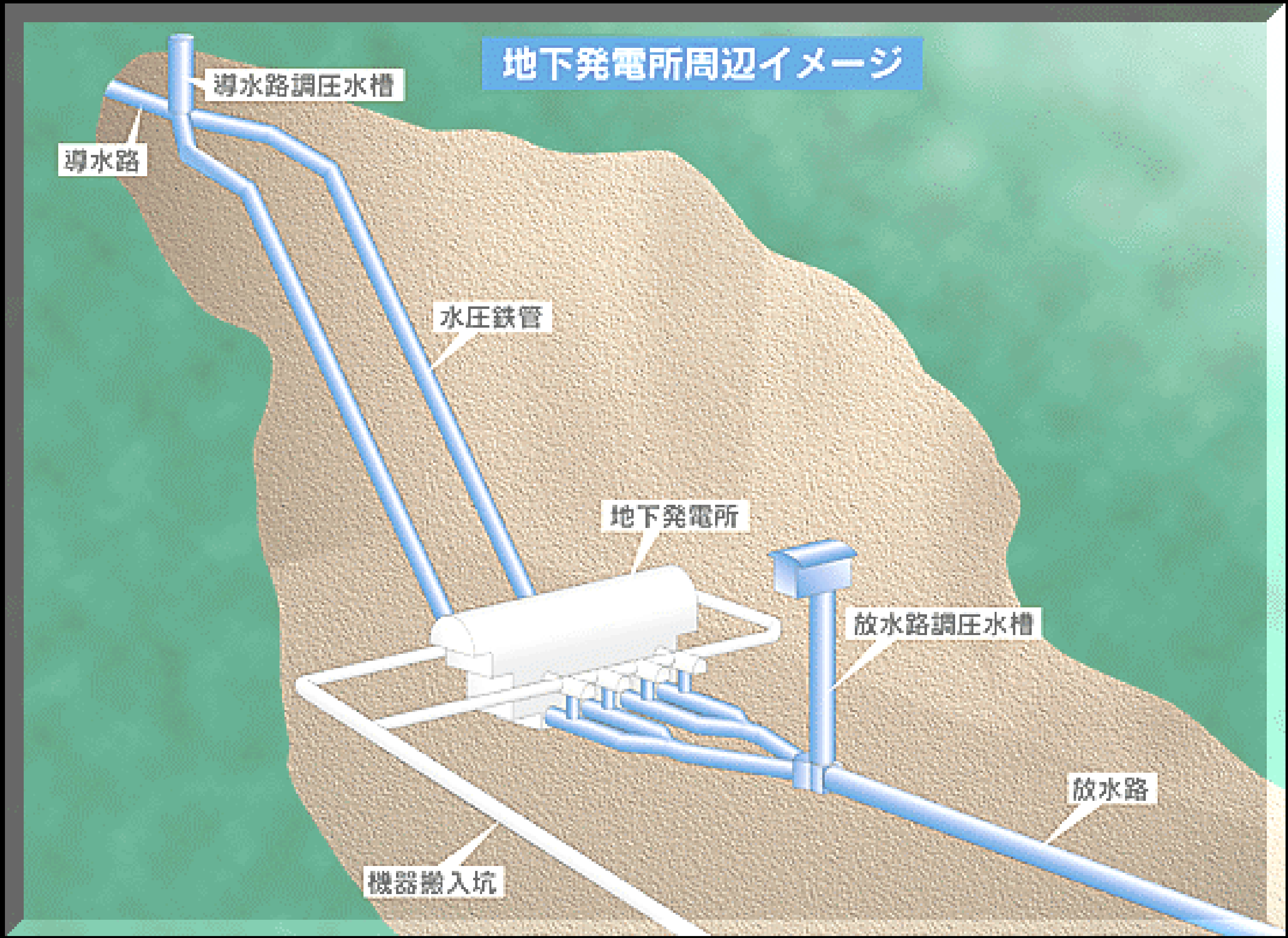


RTML
(φ60m)
12,480m
(Earth curvature)
30,870m
4,500m
(Laser straight)
818m
(r=781.1m)
Beam Delivery System
∇350.0m
shaft
(φ9m 260vert.m)
249m
(straight)
Electron Source
Damping Ring
(φ4.5m L=6,704m)
(10m above the BDS)
2,211,237
IR hall
Dump Area
∇250.0m
shaft
(φ9m 160vert.m)
13,890m
(Earth curvature)
818m
(r=781.1m)
Dump Area
400m
(straight)
Service Tunnel
(φ4.5 m)
Beam Tunnel
(φ4.5 m L=30.87km)
818m
(r=781.1m)
249m
(straight)
818m
(r=781.1m)
1,993,521
RTML
(φ60m)

B D S


▽228.0m
27m
▽228.0m
100m
BDS/IR service shaft
(φ9m 100vert.m)
IR hall shaft
(φ16m 118vert.m)
▽228.0m
IR hall shaft
(φ16m 118vert.m)
BDS/IR service shaft
base cavern
(40×15×10m)
Beam Tunnel
(φ4.5m)
▽77.75m
▽110.75m
39,000
IR hall
(120×25×39m)
ServiceTunnel
(φ4.5m)
▽80.0m
▽80.0m
25,000
▽71.75m
11,250


POWER STATION (Cavern Type)
CAES-GT
Pilot Plant
Kuji Oil
Stockpile Sta.
Super
KAMIOKANDE
Kikuma Oil
Stockpile Sta.
Kushikino Oil
Stockpile Sta.
Okinawa Deep
See Water
Pumping Plant
Takayama
Festival
Museum
黒部第四
335 千 KW
玉原
1,200 千 KW
本道寺
75 千 KW
新高瀬川
1,280 千 KW
高根第一
340 千 KW
御母衣
215 千 KW
馬瀬川第一
288 千 KW
長 野
220 千 KW
奥美濃
1,000 千 KW
500 千 KW(増)
奥多々良木
1,212 千 KW
720 千 KW(増)
俣野川
1,200 千 KW
南 原
620 千 KW
天 山
600 千 KW
大 平
500 千 KW
本 川
600 千 KW
大河内
1,280 千 KW
奥吉野
1,206 千 KW
池 原
350 千 KW
喜撰山
466 千 KW
奥矢作第二
780 千 KW
新豊根
1,125 千 KW
読書第二
70 千 KW
木 曽
116 千 KW
葛野川
1,600 千 KW
城 山
250 千 KW
今 市
1,050 千 KW
塩原(蛇尾川)
900 千 KW
沼 原
675 千 KW
奥只見
360 千 KW
下 郷
1,000 千 KW
第二沼沢
460 千 KW
高 見
200 千 KW
新 冠
200 千 KW
雨 竜
51 千 KW
凡 例
発電出力(千 KW)
50 ～ 499
500 ～ 999
1000 ～ 1999
2000 以上



POWER STATION (CAVERN TYPE)

SUPER-KAMIOKANDE

(Kamiokande HP)

KUSHIKINO OIL STOCKPILE STA.

TAKAYAMA FESTIVAL MUSEUM

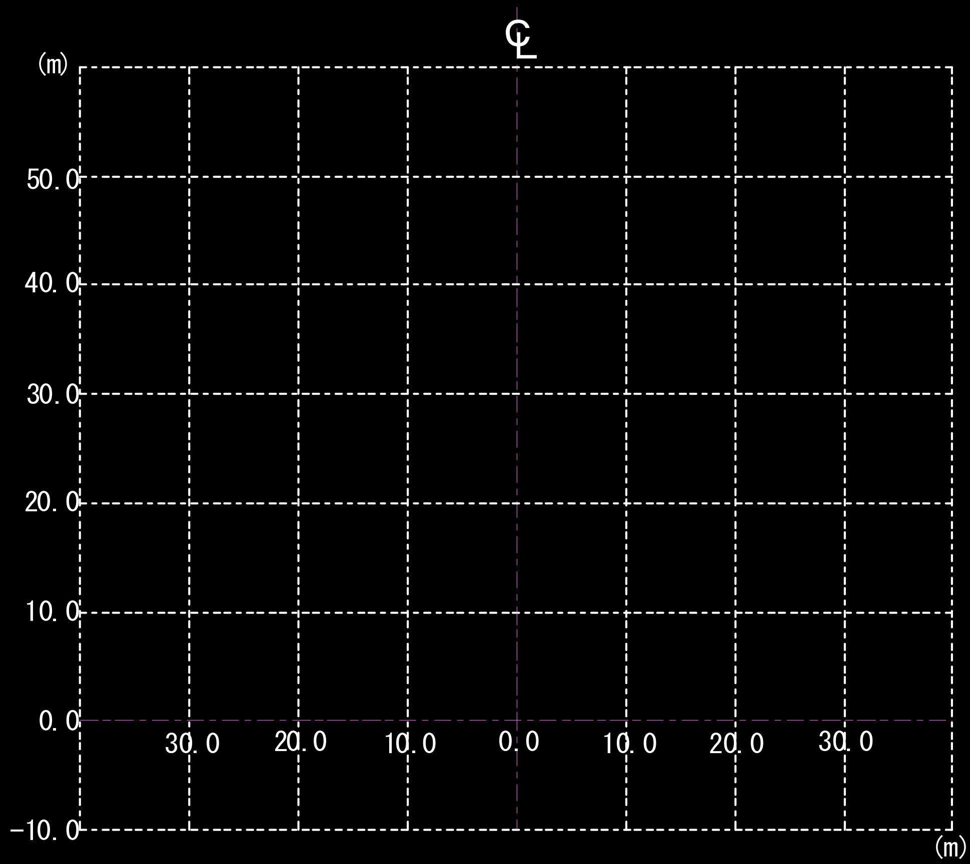
SHOW ROOM

ACCESS TUNNEL & HALL

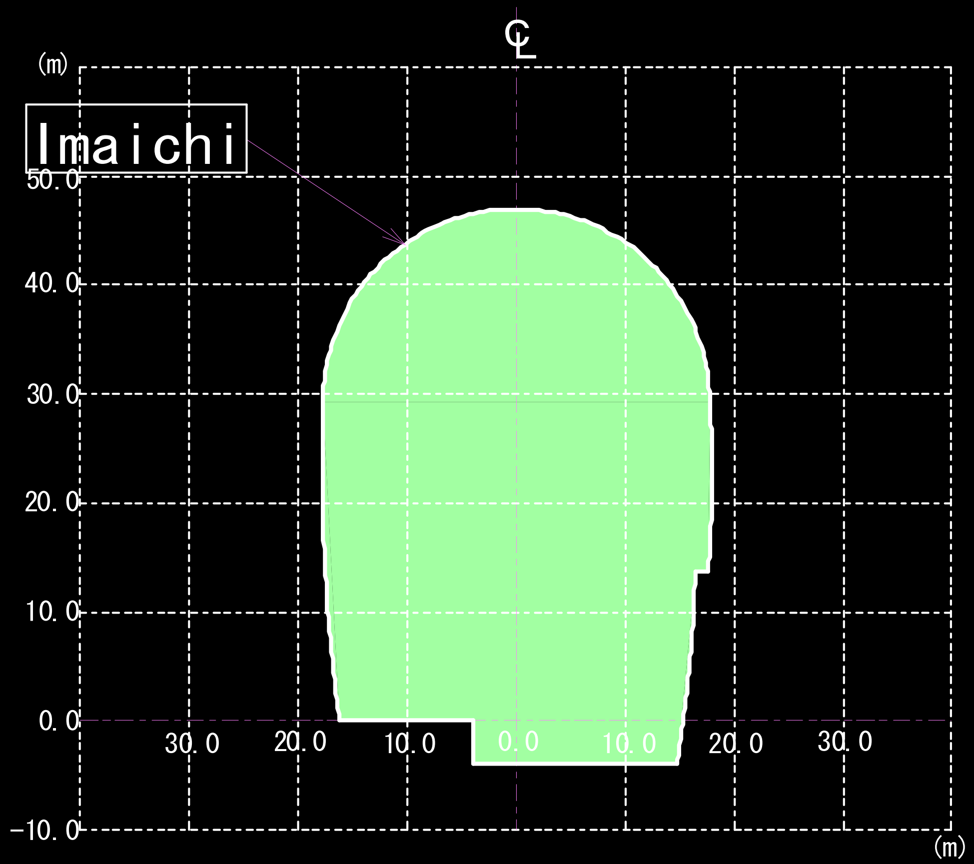
(Tobishima Co.Ltd.)

Typical Shape of Cavern Section

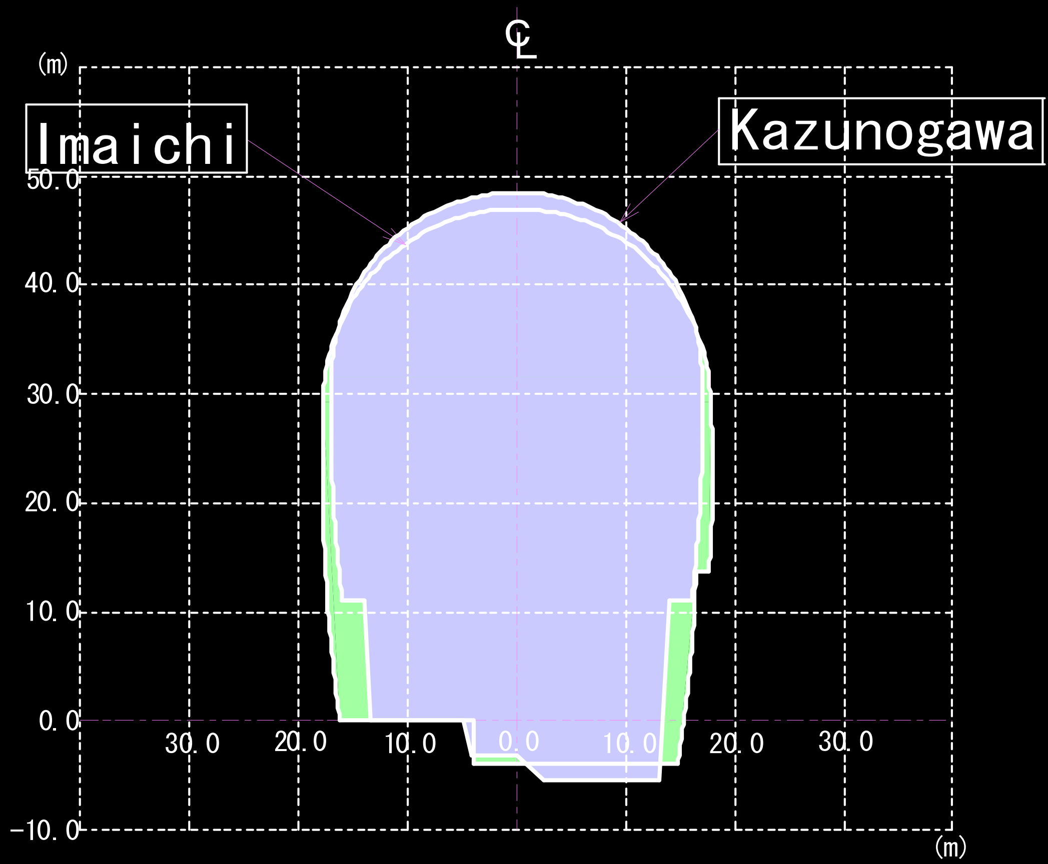
Total 40
(other =2)



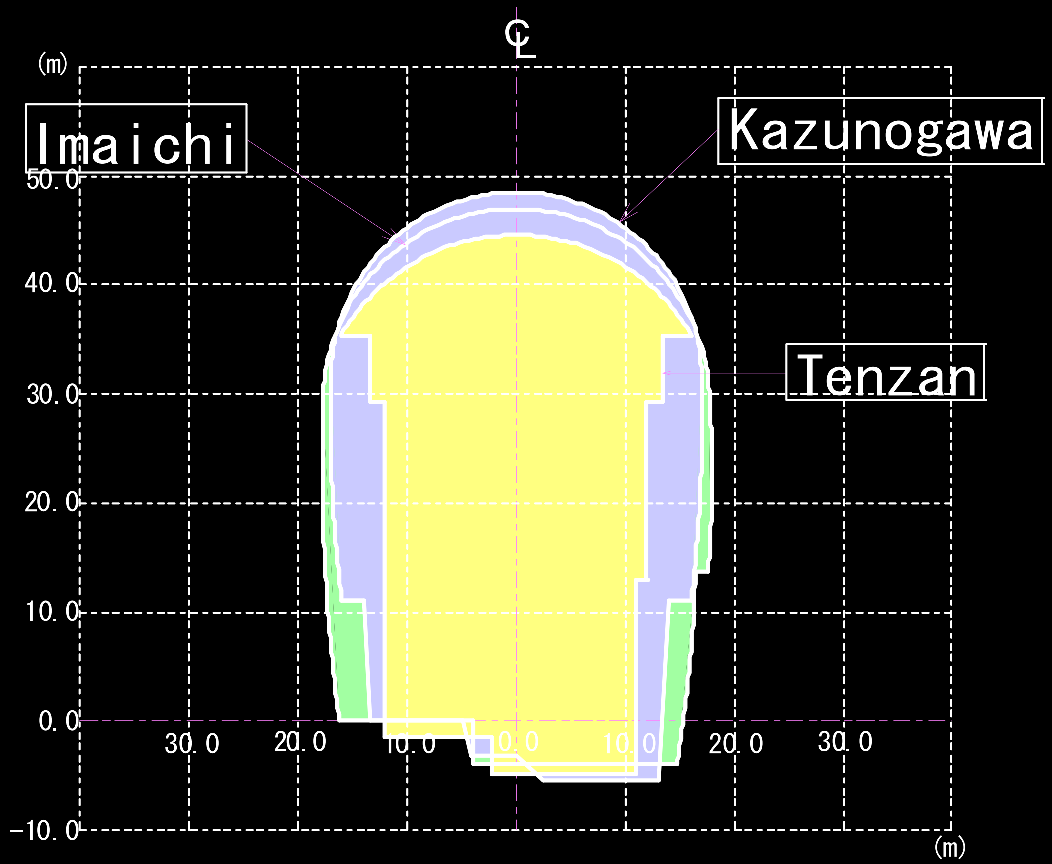
CAVERN SECTIONAL SHAPE



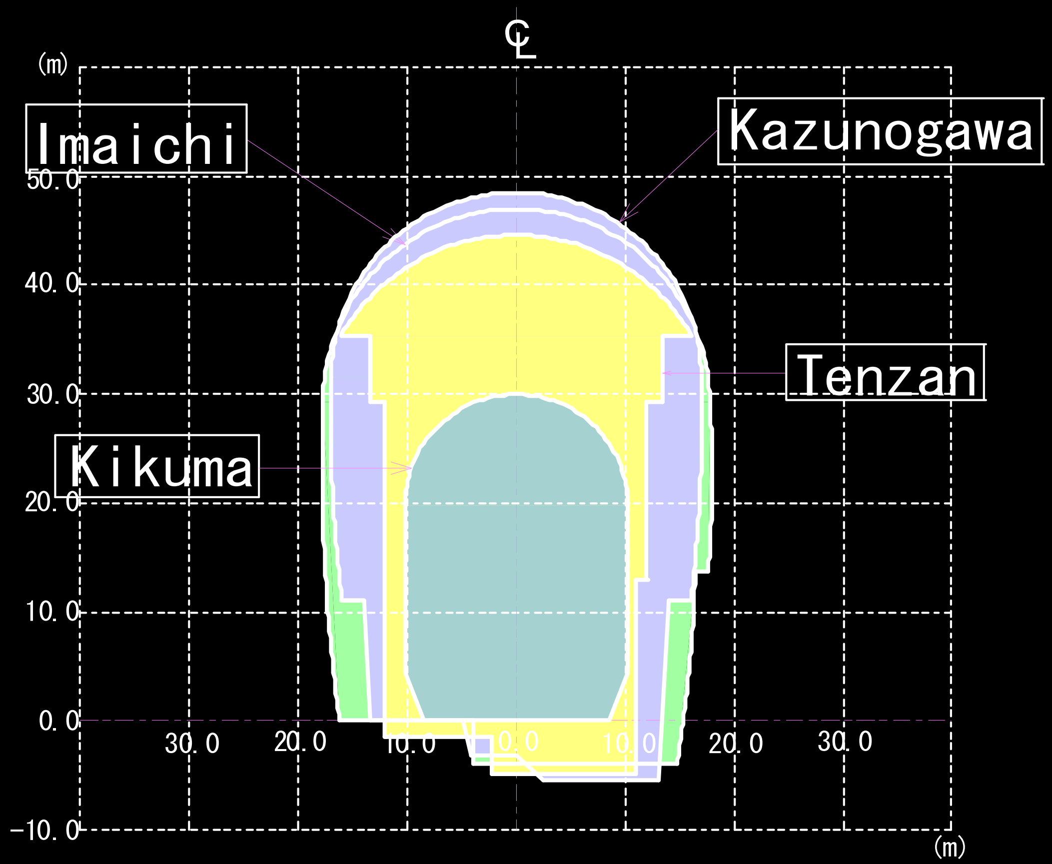
CAVERN SECTIONAL SHAPE



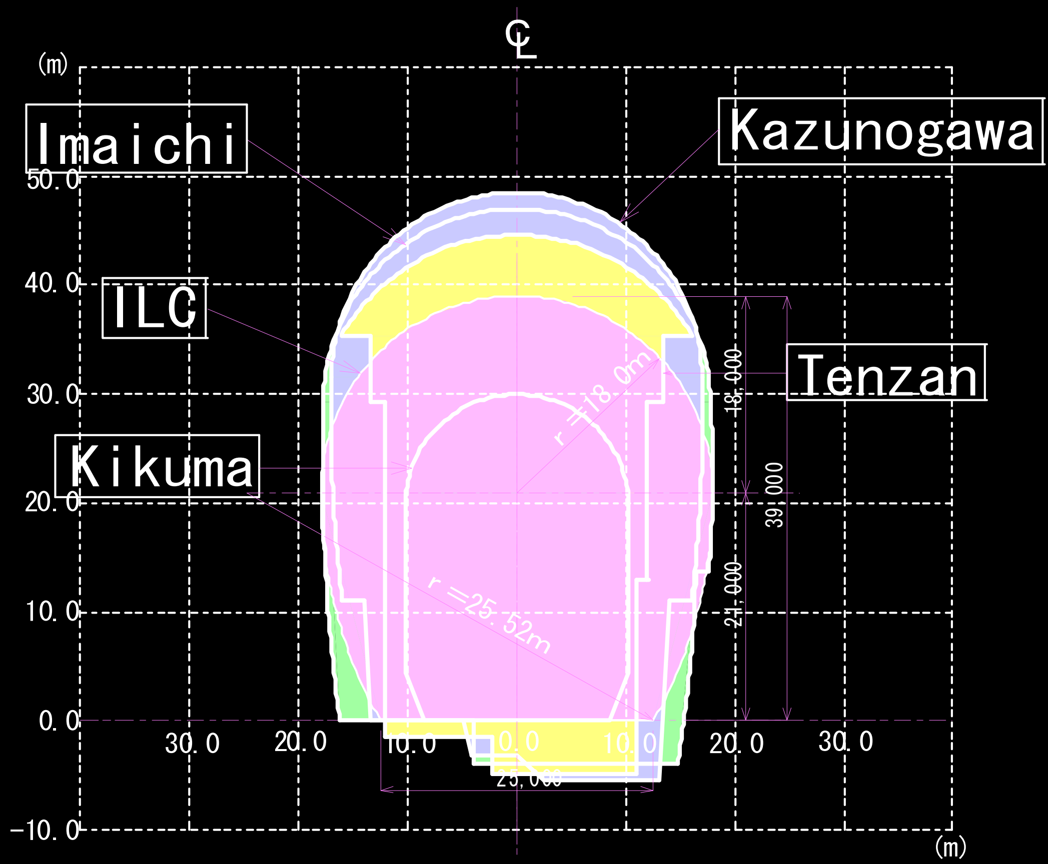
CAVERN SECTIONAL SHAPE



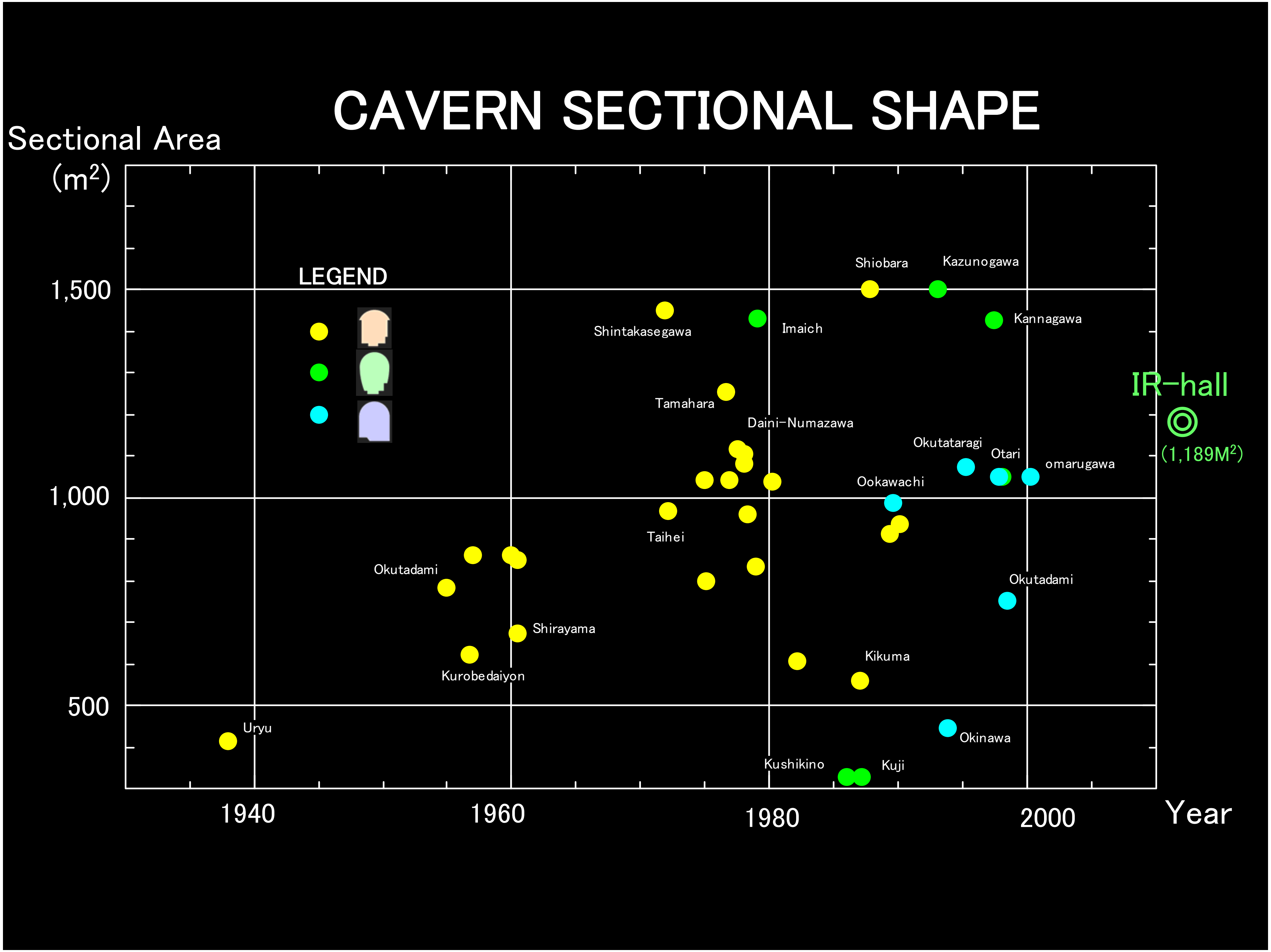
CAVERN SECTIONAL SHAPE



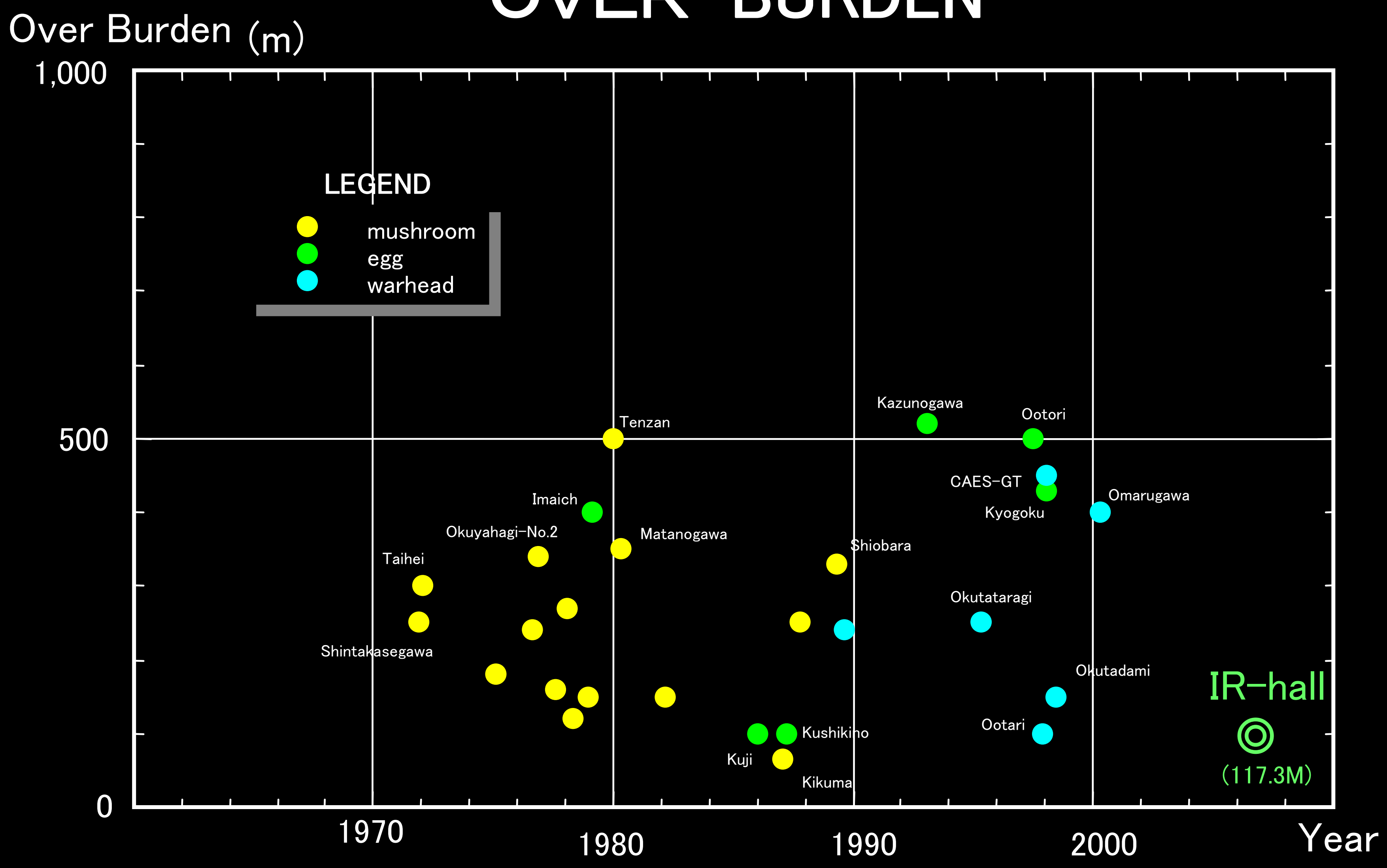
CAVERN SECTIONAL SHAPE

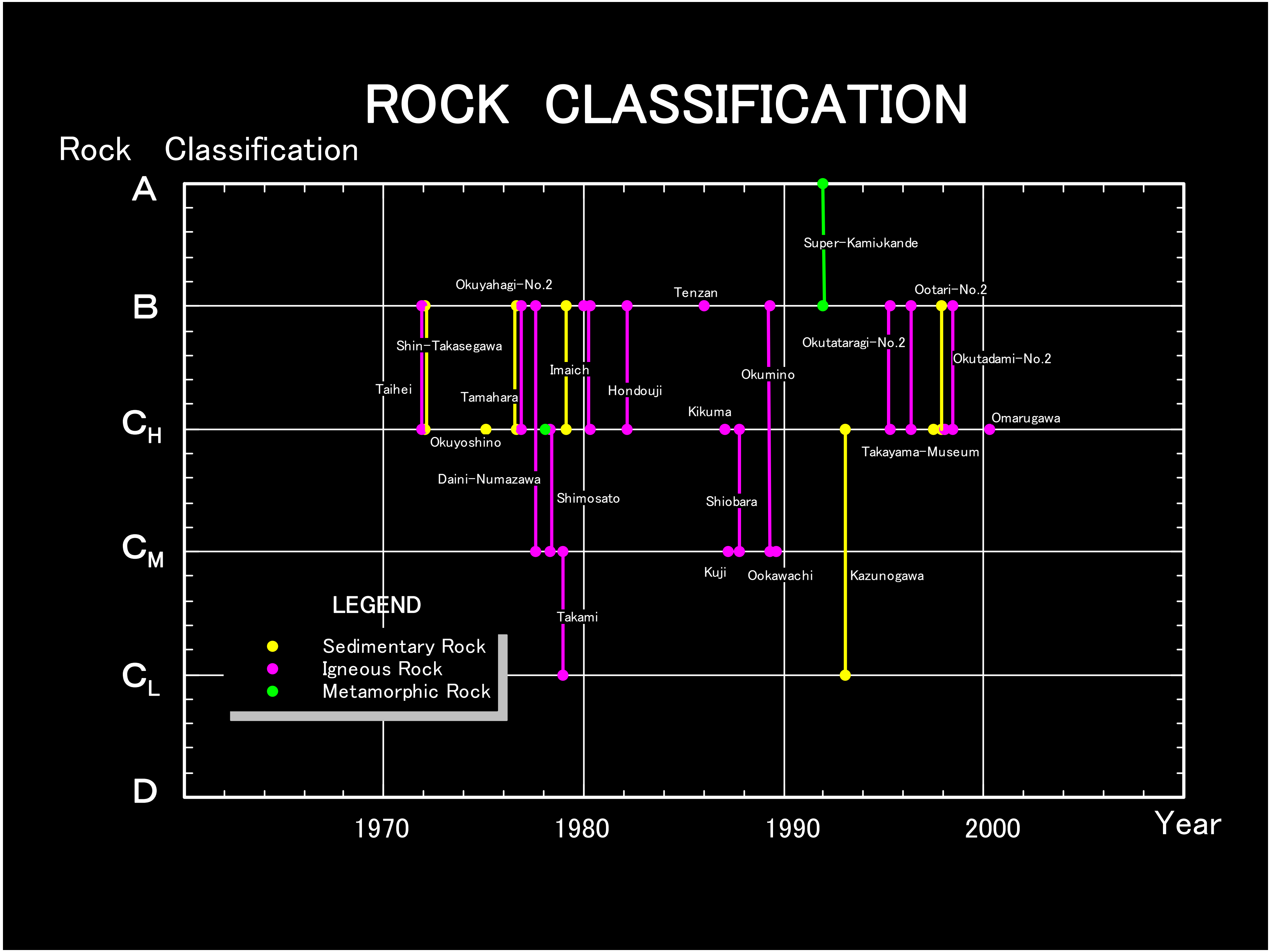


CAVERN SECTIONAL SHAPE


CAVERN SECTIONAL SHAPE
Sectional Area
(m2)
1,500
1,000
500
1940
1960
1980
2000
Year
LEGEND
Uryu
Okutadami
Kurobedaiyon
Shirayama
Shintakasegawa
Tamahara
Taihei
Imaich
Daini-Numazawa
Shiobara
Kazunogawa
Kannagawa
Okutataragi
Otari
omarugawa
Ookawachi
Okutadami
Kikuma
Okinawa
Kushikino
Kuji
IR-hall
◎
(1,189M2)

OVER BURDEN


Over Burden (m)
1,000
500
0
LEGEND
mushroom
egg
warhead
Tenzan
Kazunogawa
Ootori
CAES-GT
Kyogoku
Omarugawa
Imaich
Okuyahagi-No.2
Matanogawa
Shiobara
Taihei
Okutataragi
Shintakasegawa
Okutadami
IR-hall
Ootari
Kushikino
Kuji
Kikuma
(117.3M)
1970
1980
1990
2000
Year



ROCK CLASSIFICATION
Rock Classification
A
B
C H
C M
C L
D
1970
1980
1990
2000
Year
Super-Kamiokande
Okuyahagi-No.2
Tenzan
Ootari-No.2
Shin-Takasegawa
Okutataragi-No.2
Okutadami-No.2
Imaich
Okumino
Taihei
Tamahara
Hondouji
Kikuma
Omarugawa
Okuyoshino
Takayama-Museum
Daini-Numazawa
Shimosato
Shiobara
Kuji
Ookawachi
Kazunogawa
Takami
LEGEND
Sedimentary Rock
Igneous Rock
Metamorphic Rock

Kazunogawa-Power Station

owner： Tokyo Electric Power Co.Ltd.

location： Yamanashi prf. Ootuki City

total output： 1.60 GW (4no.×412MW)

commencement： Jan. 1993

completion： Dec. 1999

geological structure： Sandstone、Mudstone

rock classification： C_H ～ C_L

Kazunogawa-Power Station

cavern size: B = 34m H = 54m L=210m

sectional area: A = 1,500 m^2

excavation Volume: V = 250,000 m^3

over burden: D = 520 m

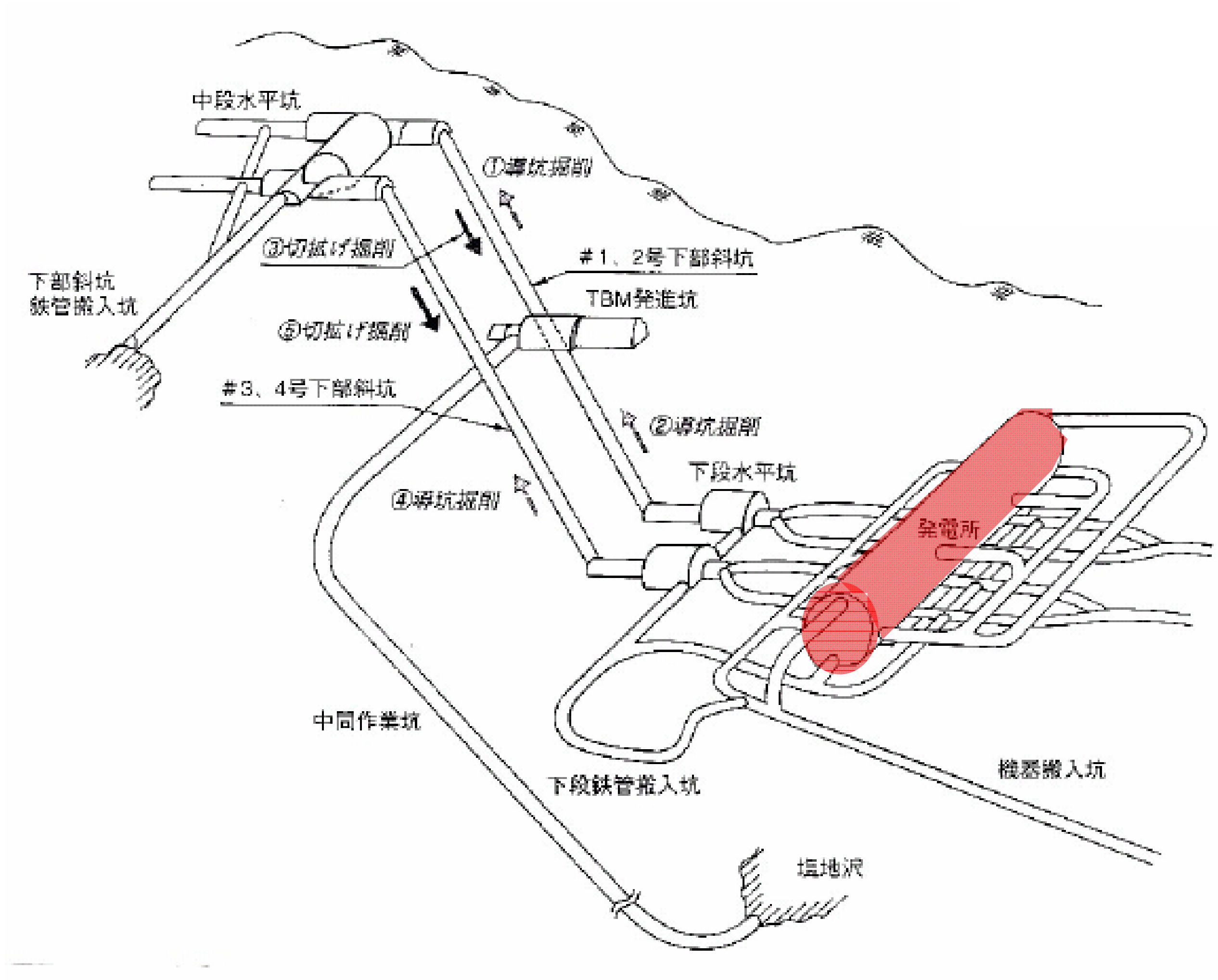
construction methods: Drill and blast (NATM)

tunnel support: Shotcrete + Cable-bolt

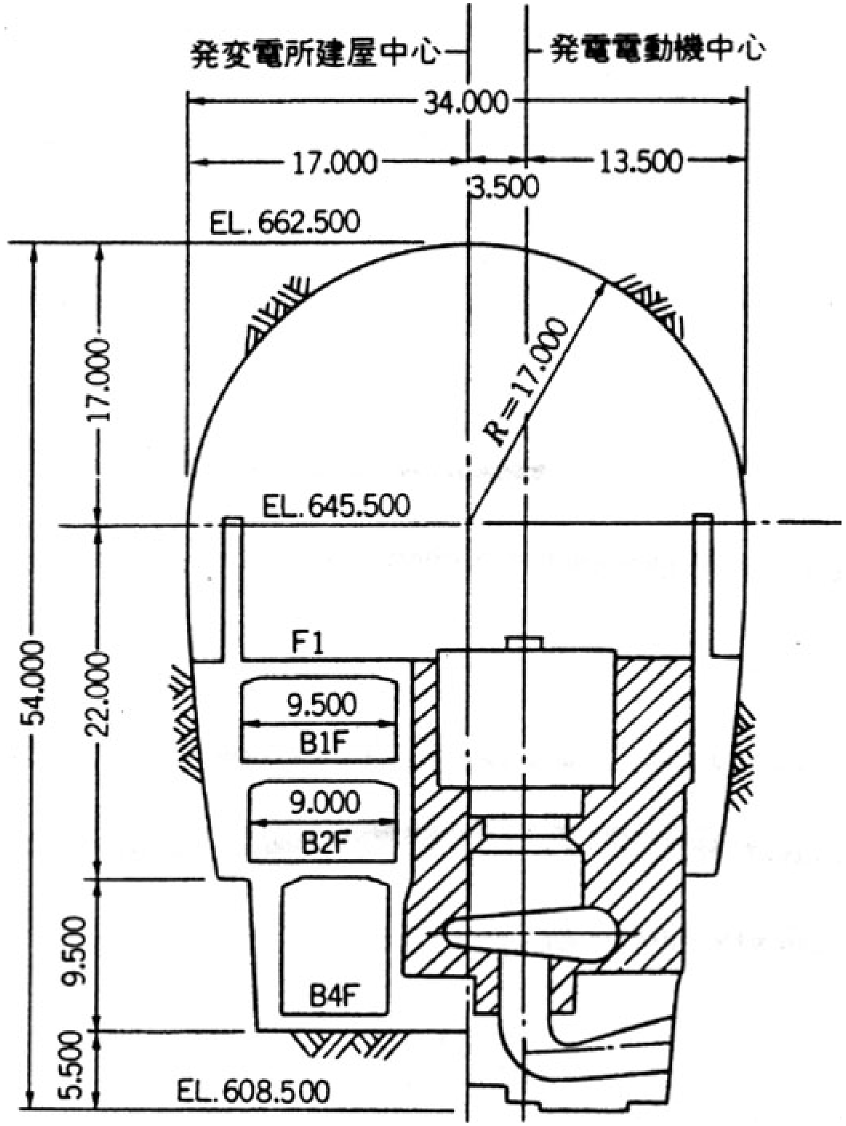
Yamanashi Prf.

Oothuki/Enzan City

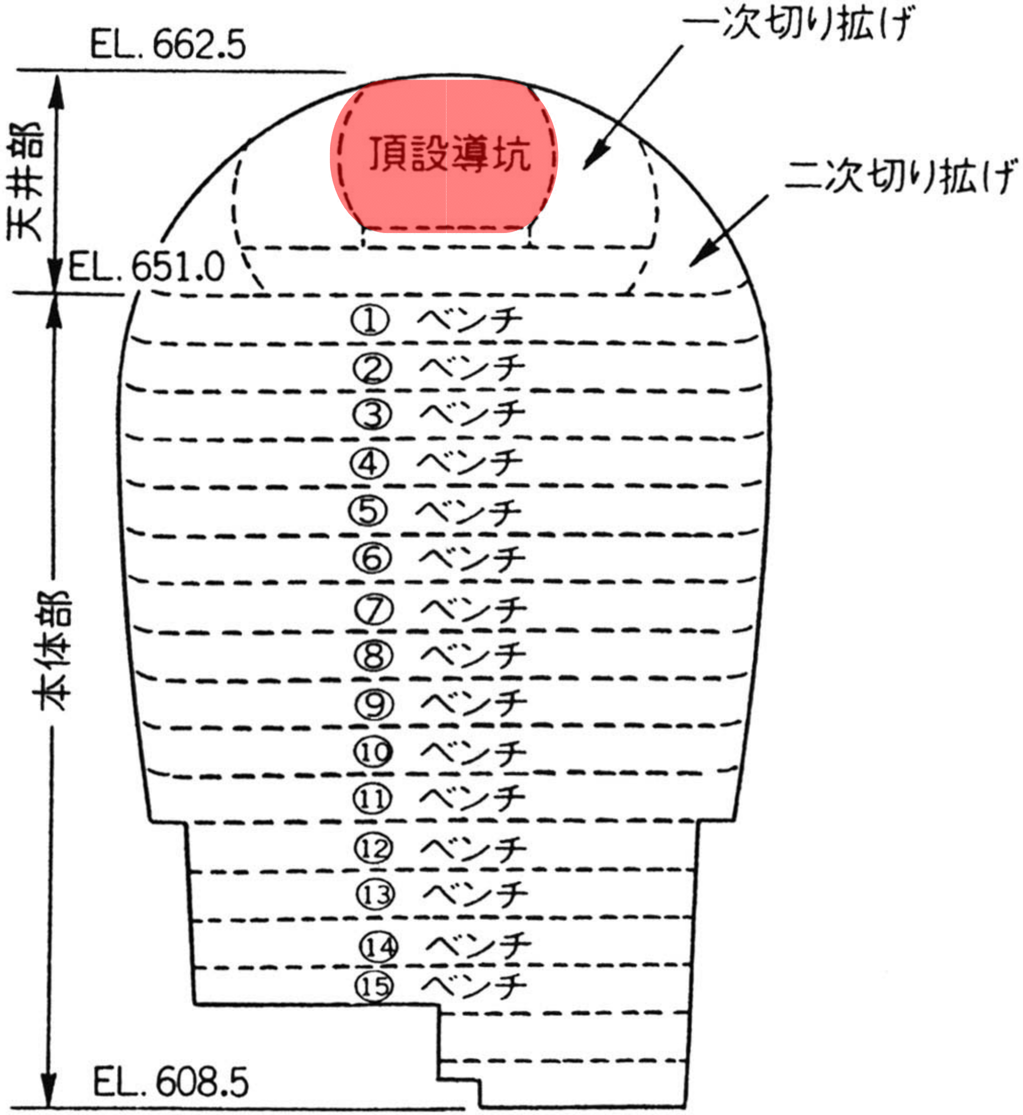
Lcation



Facility Layout

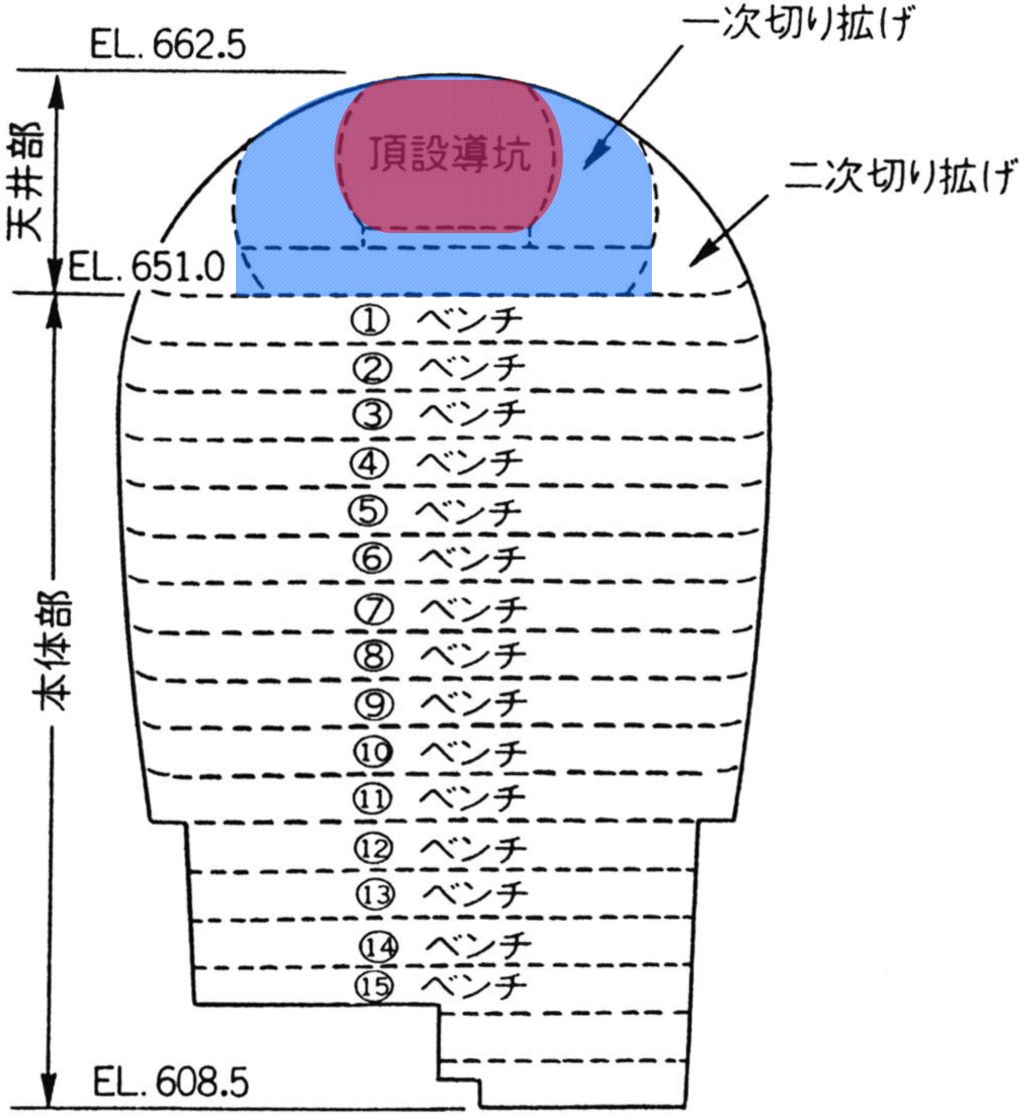


Structural Cut Section



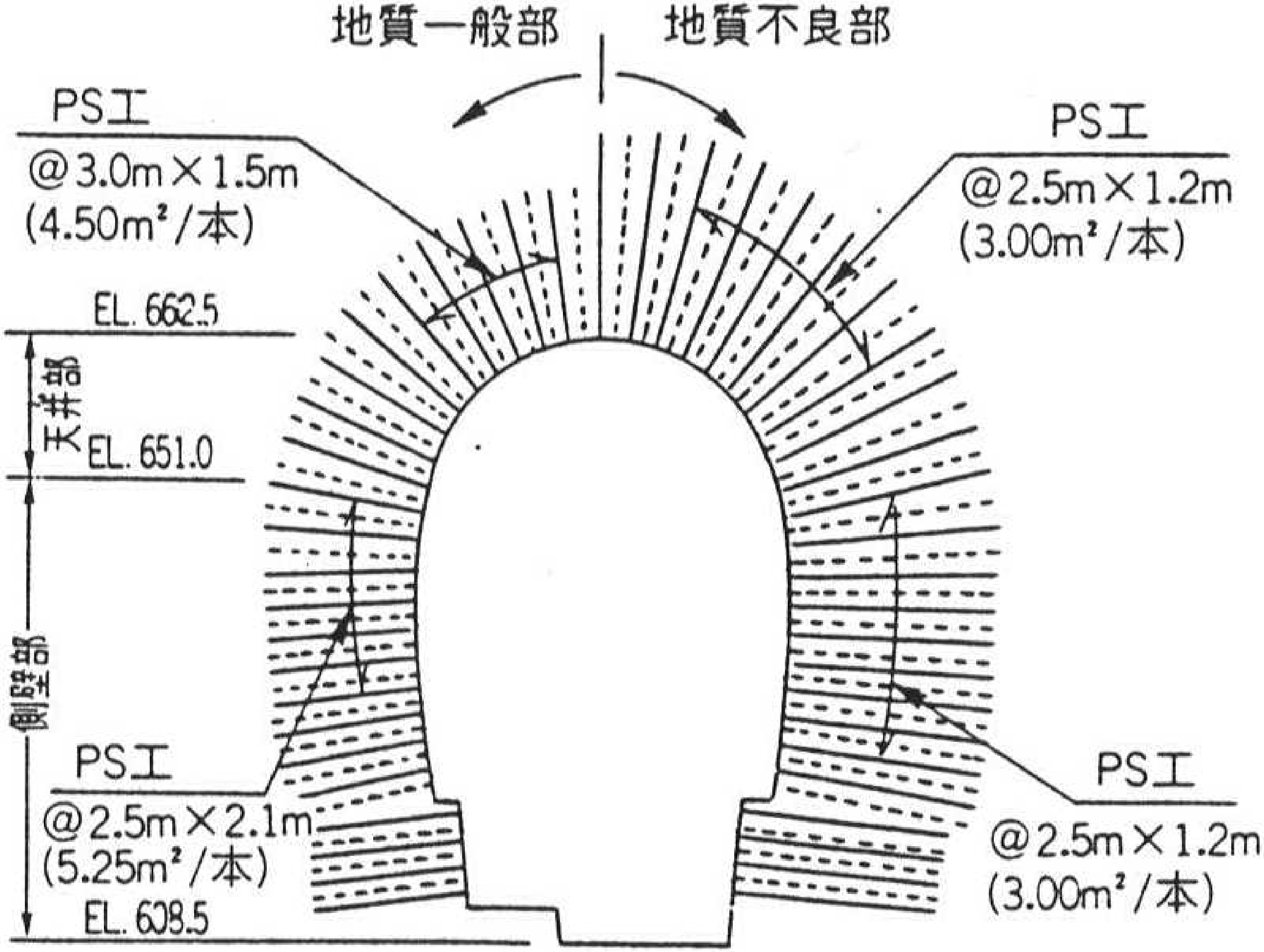
Division of Heading

Drift Tunnel Excavation

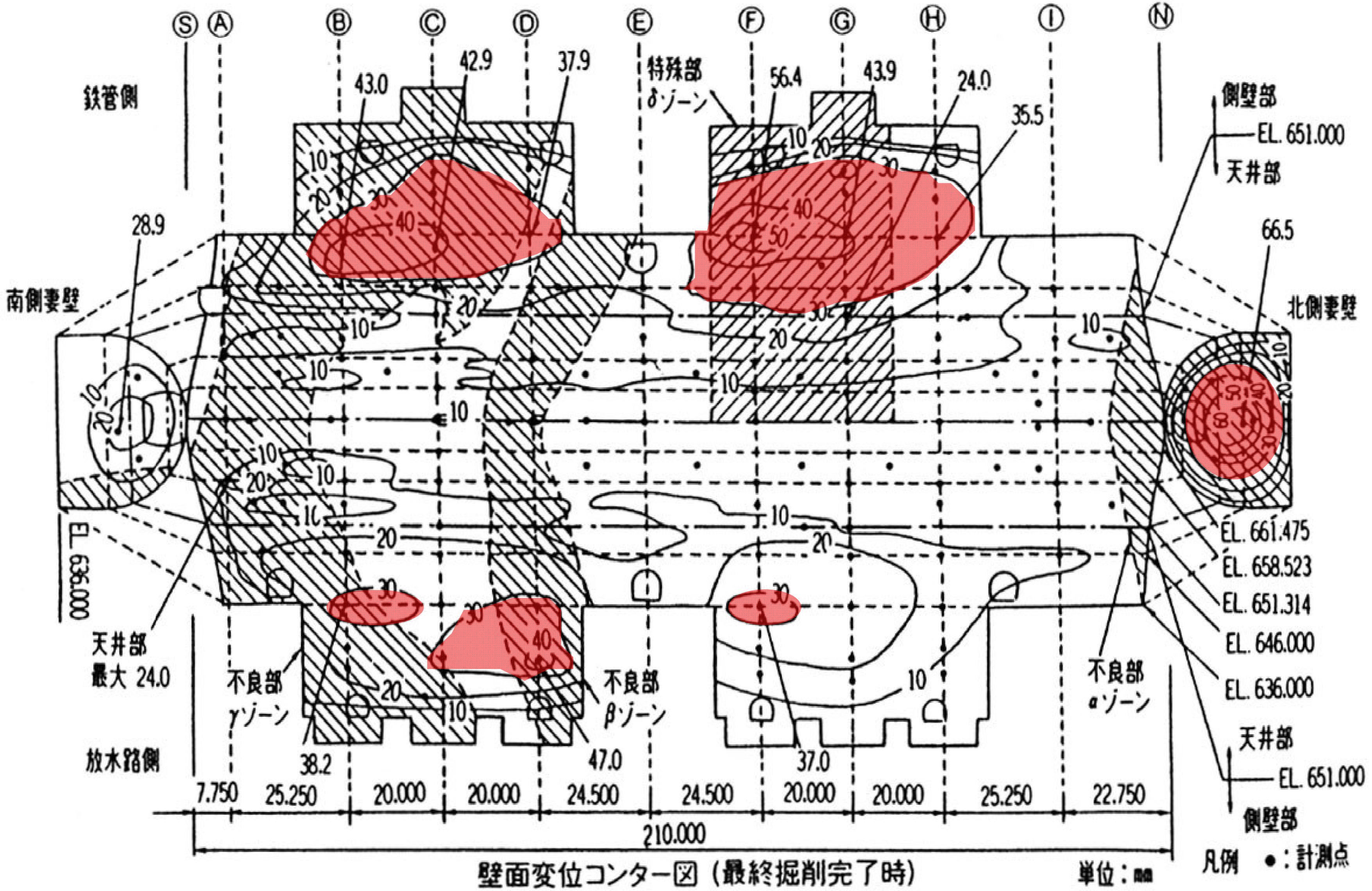


Division of Heading

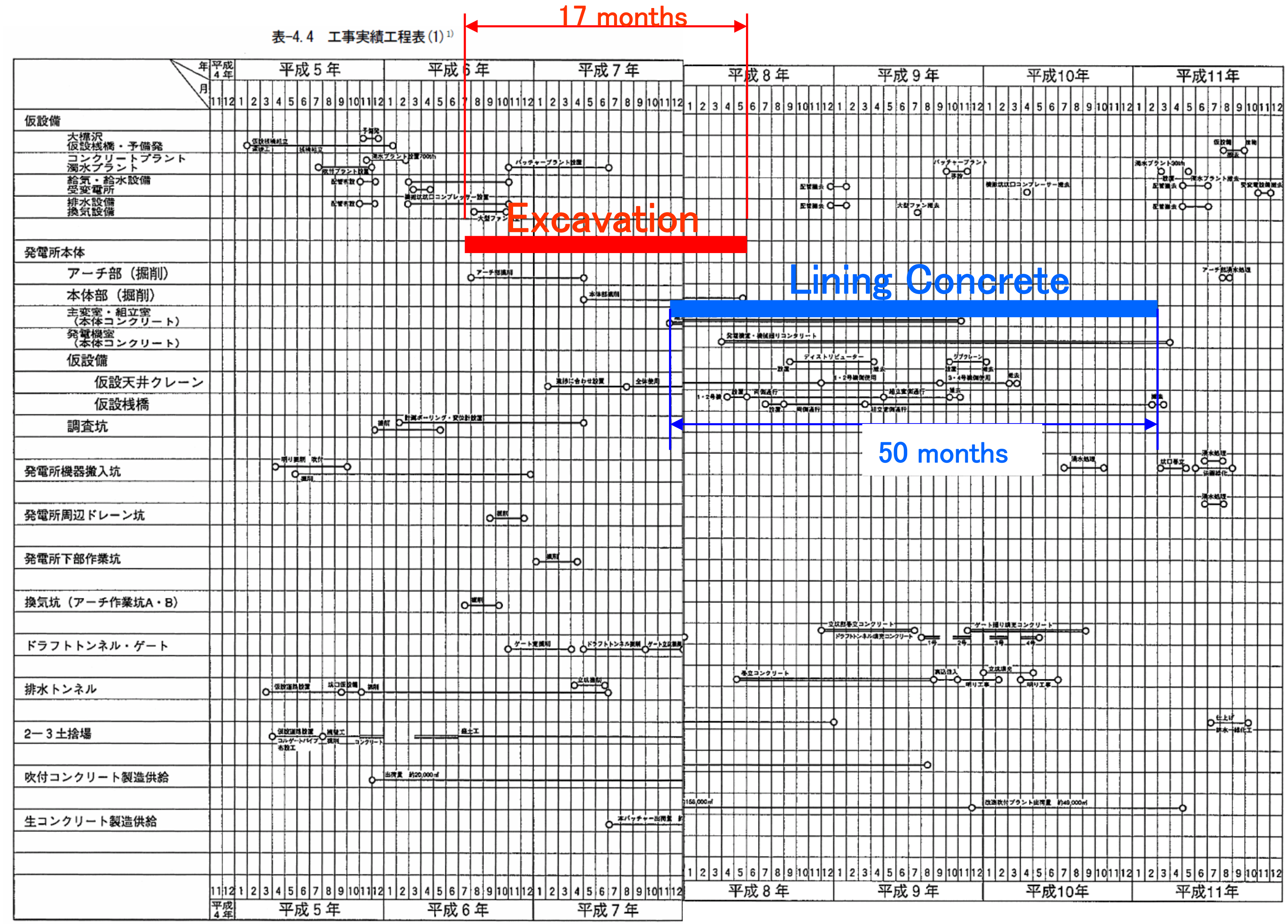
Arch Crown Area Excavation



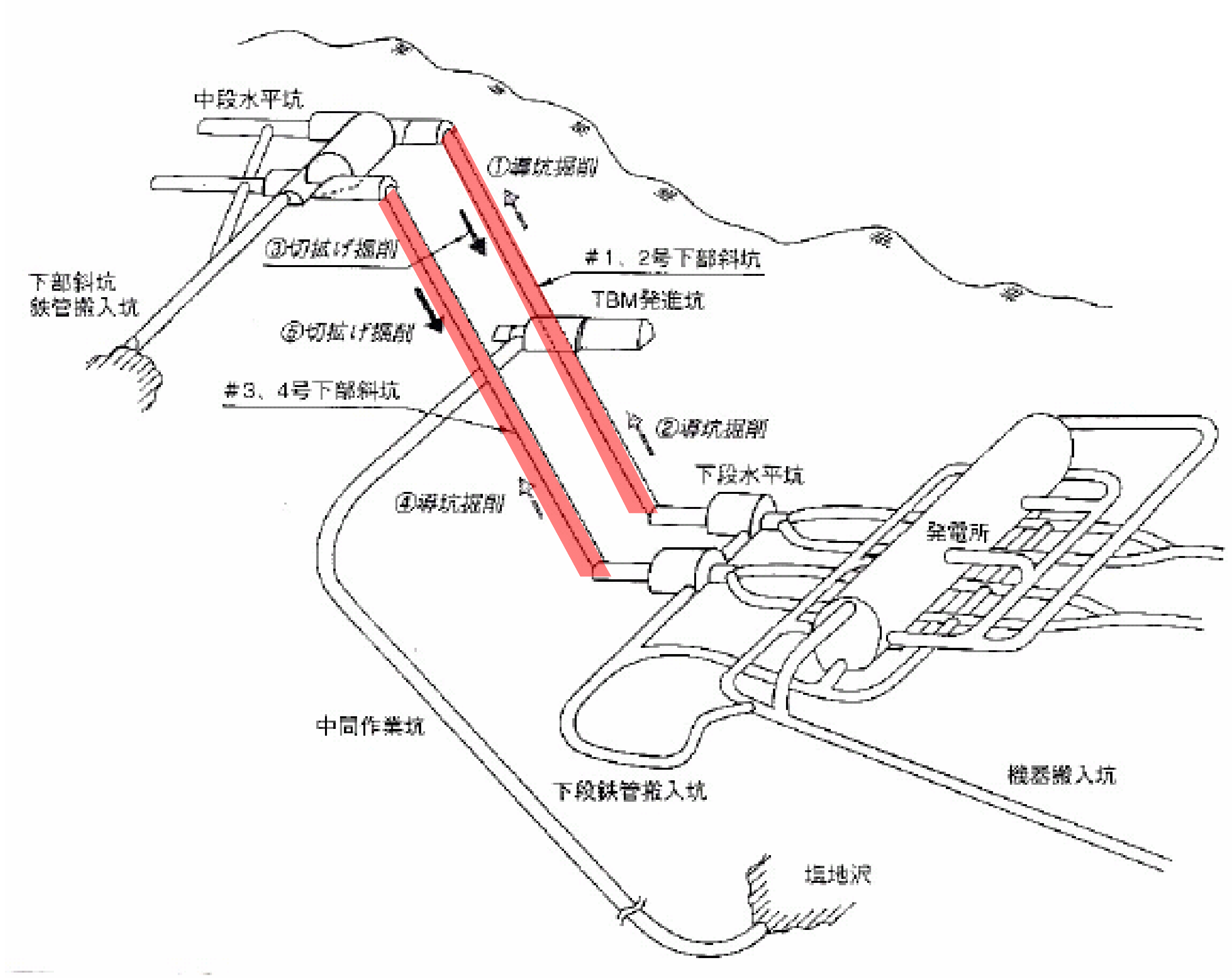
Tunnel Support



Contour Line of Displacement on Wall

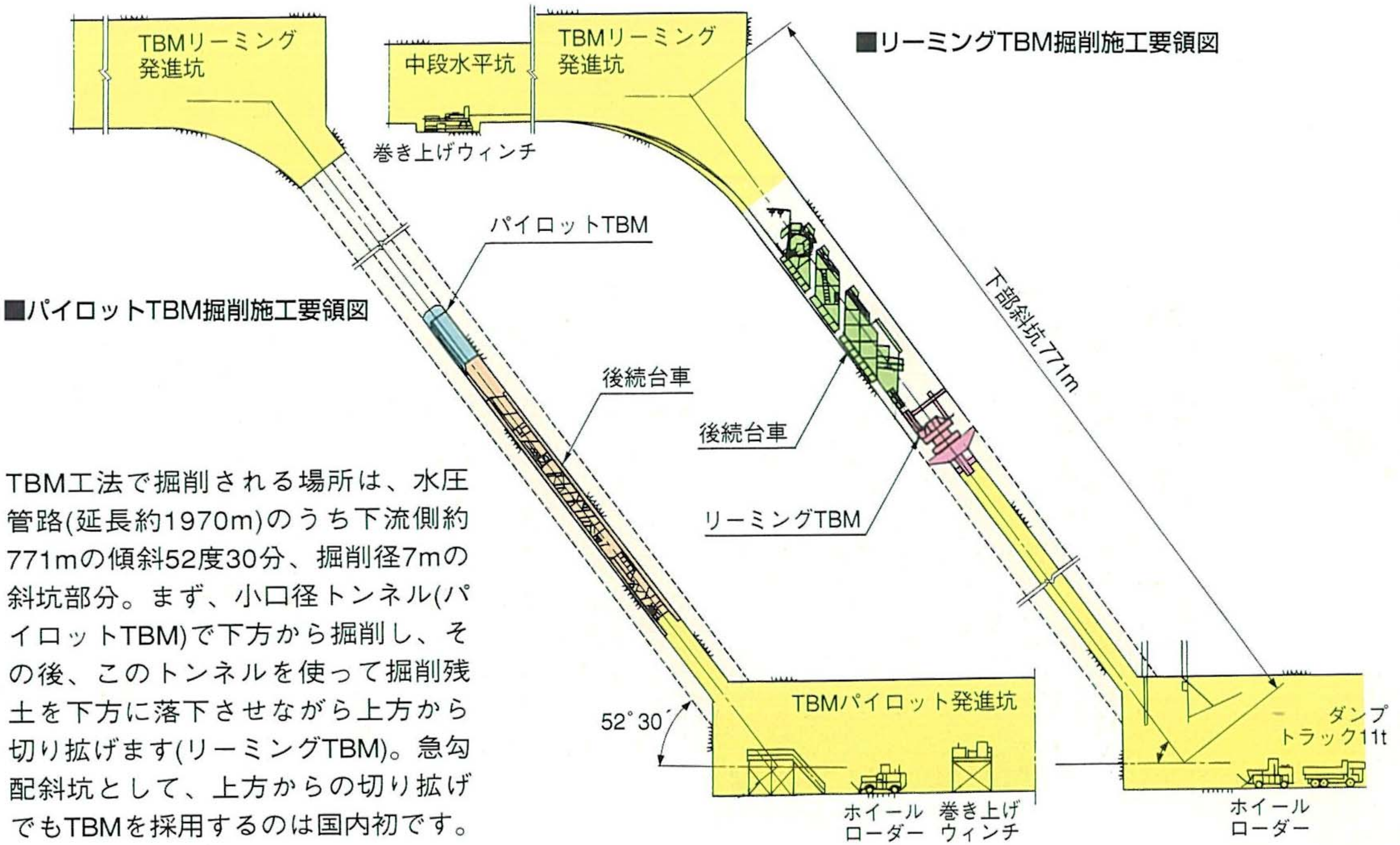


Actual Schedule chart



Facility Layout

■TBMによる斜坑掘削工事の施工法



TBM工法で掘削される場所は、水圧管路(延長約1970m)のうち下流側約771mの傾斜52度30分、掘削径7mの斜坑部分。まず、小口径トンネル(パイロットTBM)で下方から掘削し、その後、このトンネルを使って掘削残土を下方に落下させながら上方から切り拡げます(リーミングTBM)。急勾配斜坑として、上方からの切り拡げでもTBMを採用するのは国内初です。

TBM for Inclined Tunnel

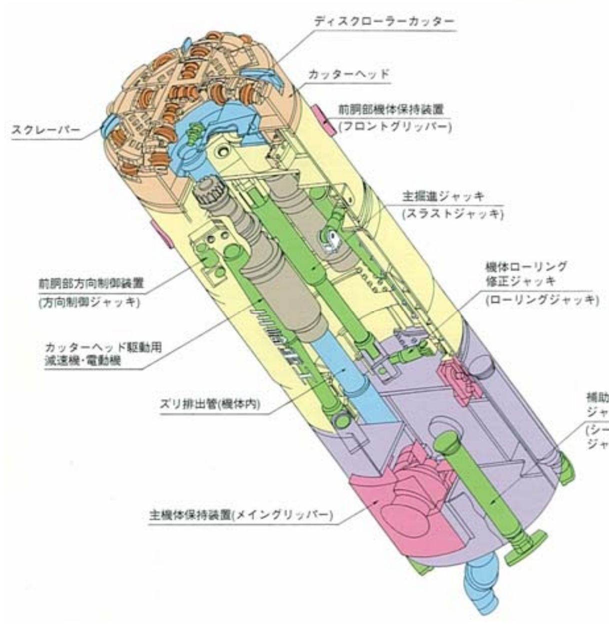
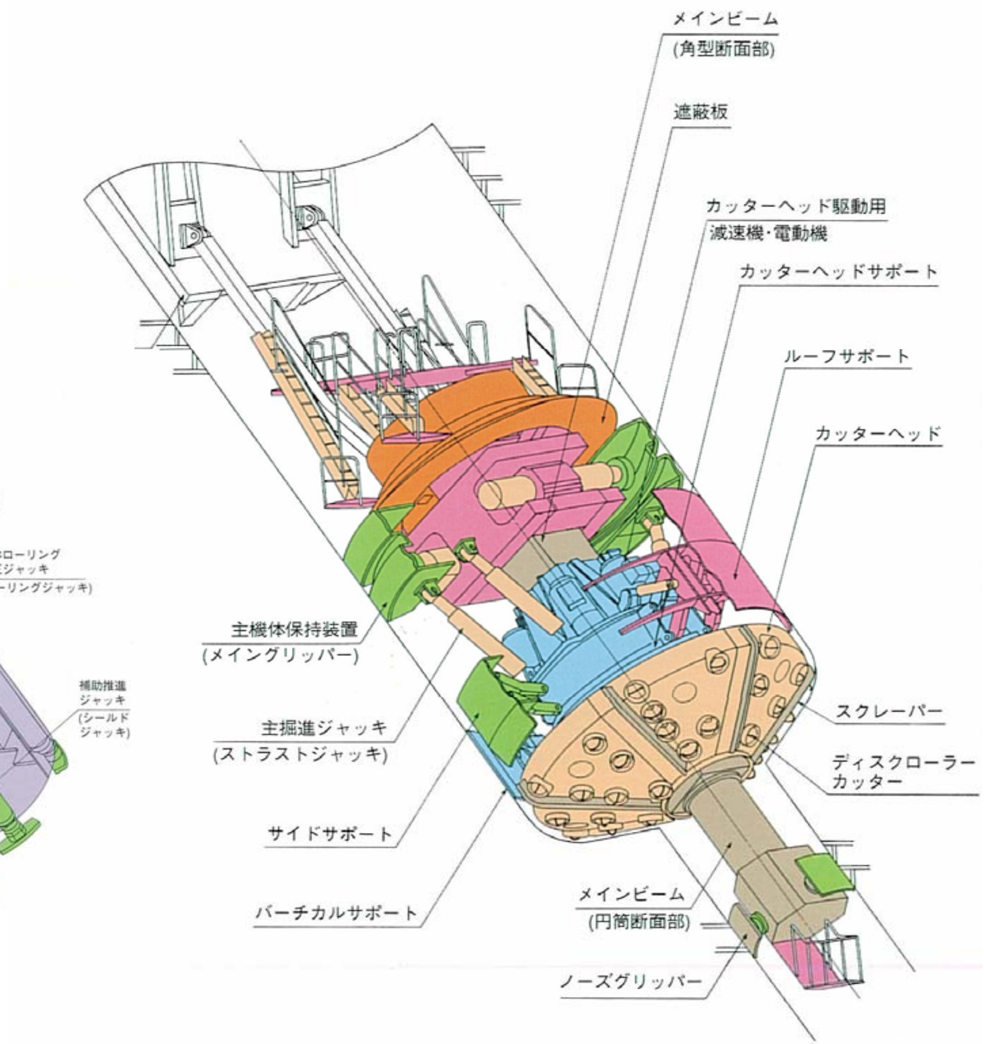
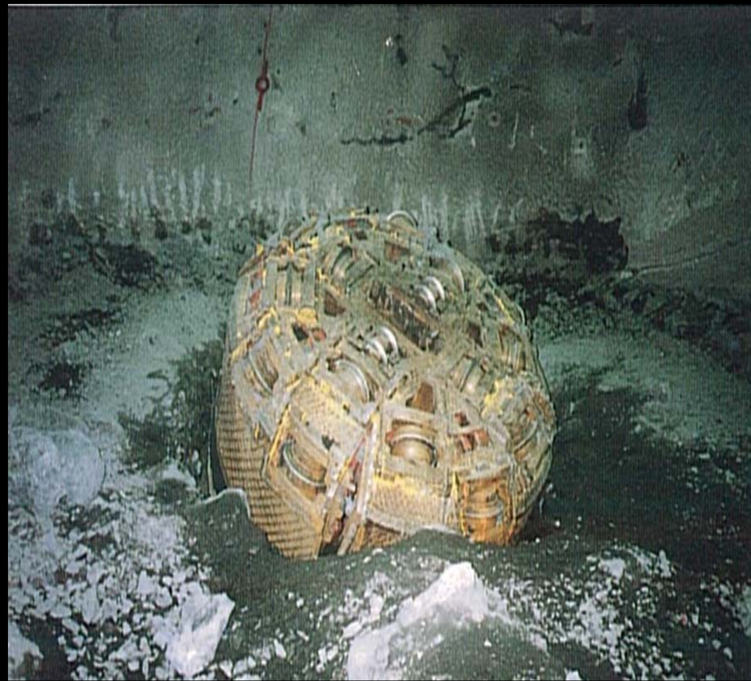


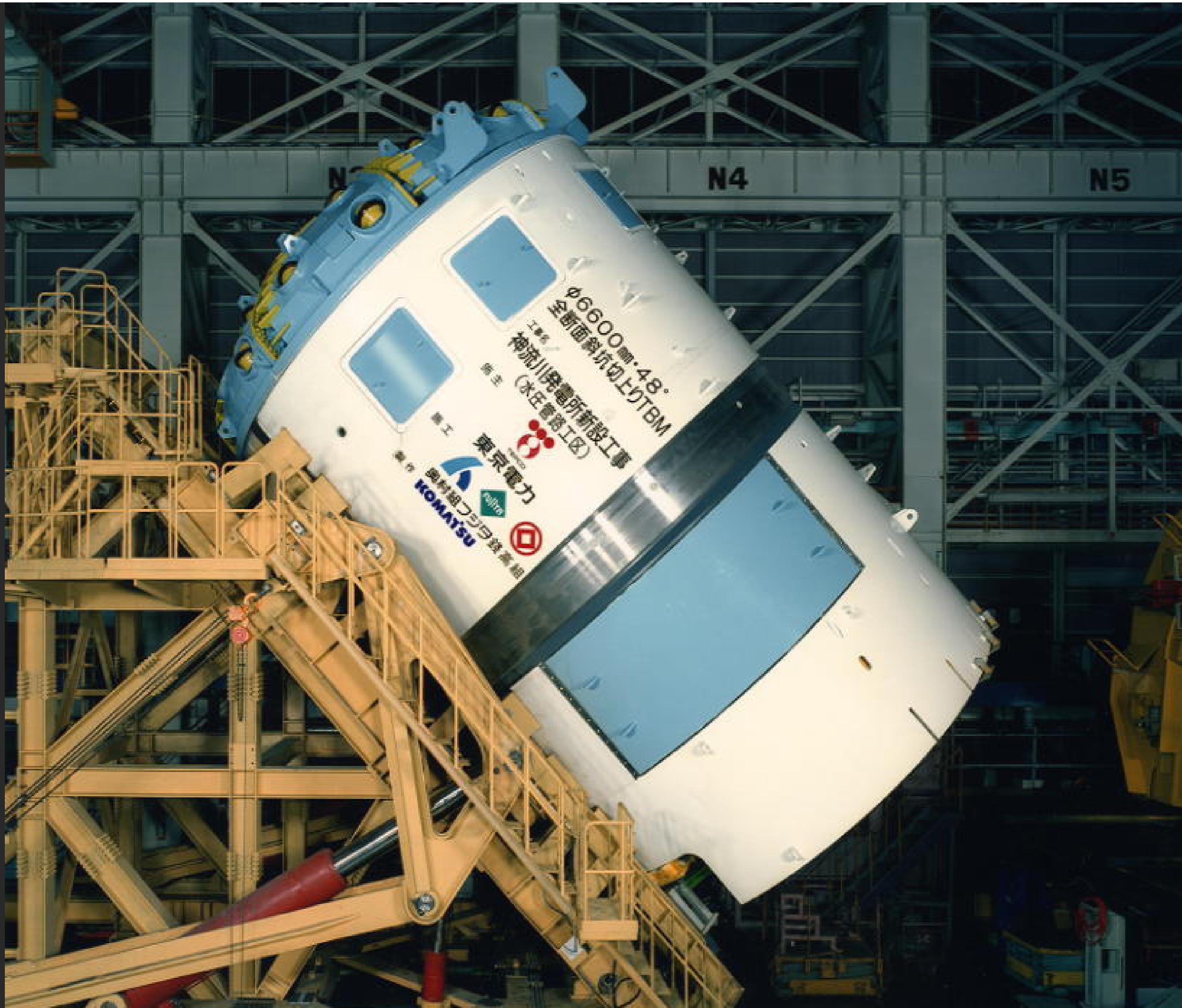
図-Ⅱ.6.22　パイロットＴＢＭ



TBM for Inclined Tunnel



TBM for Inclined Tunnel



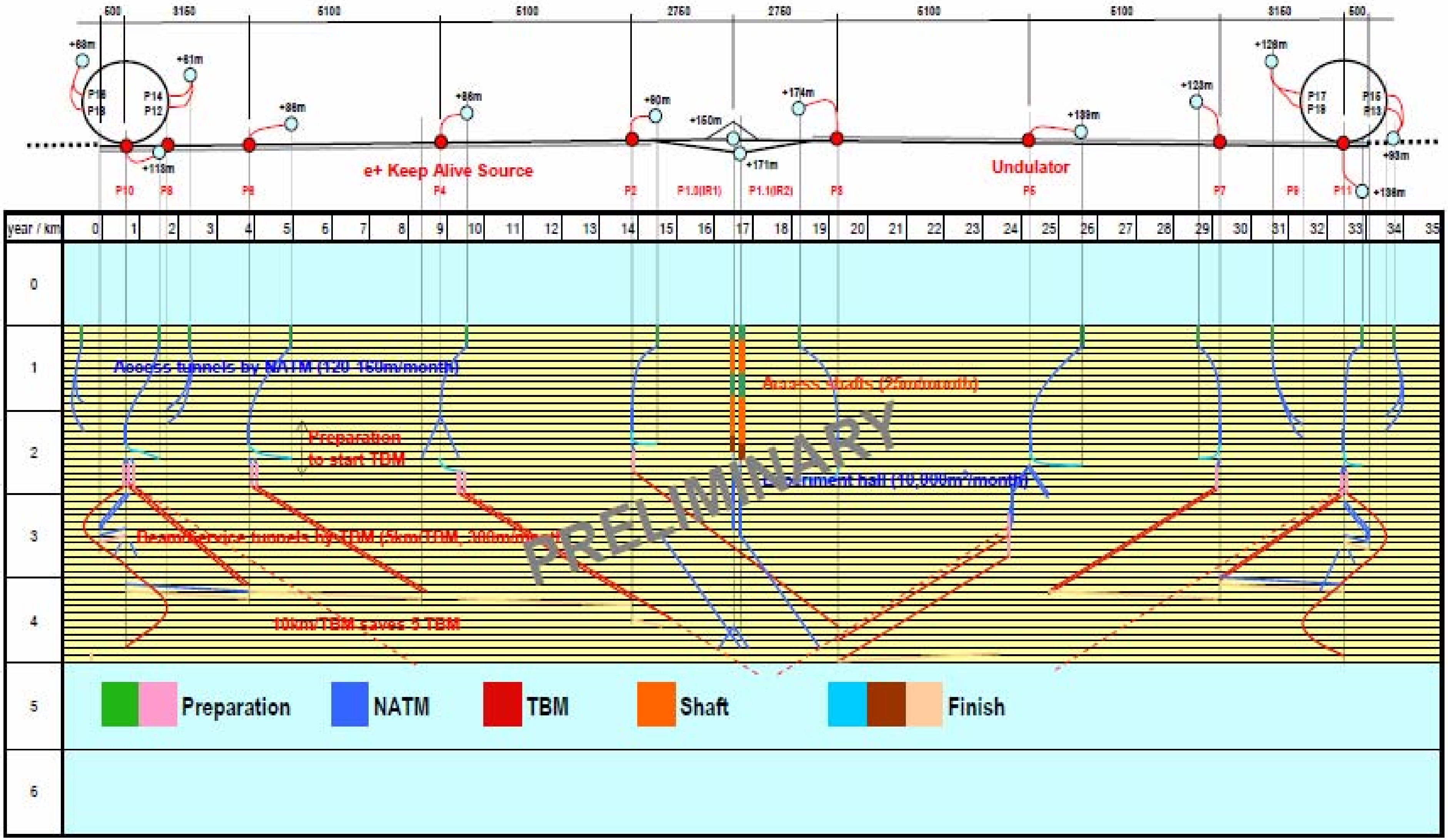
Inclined TBM（Full Face）

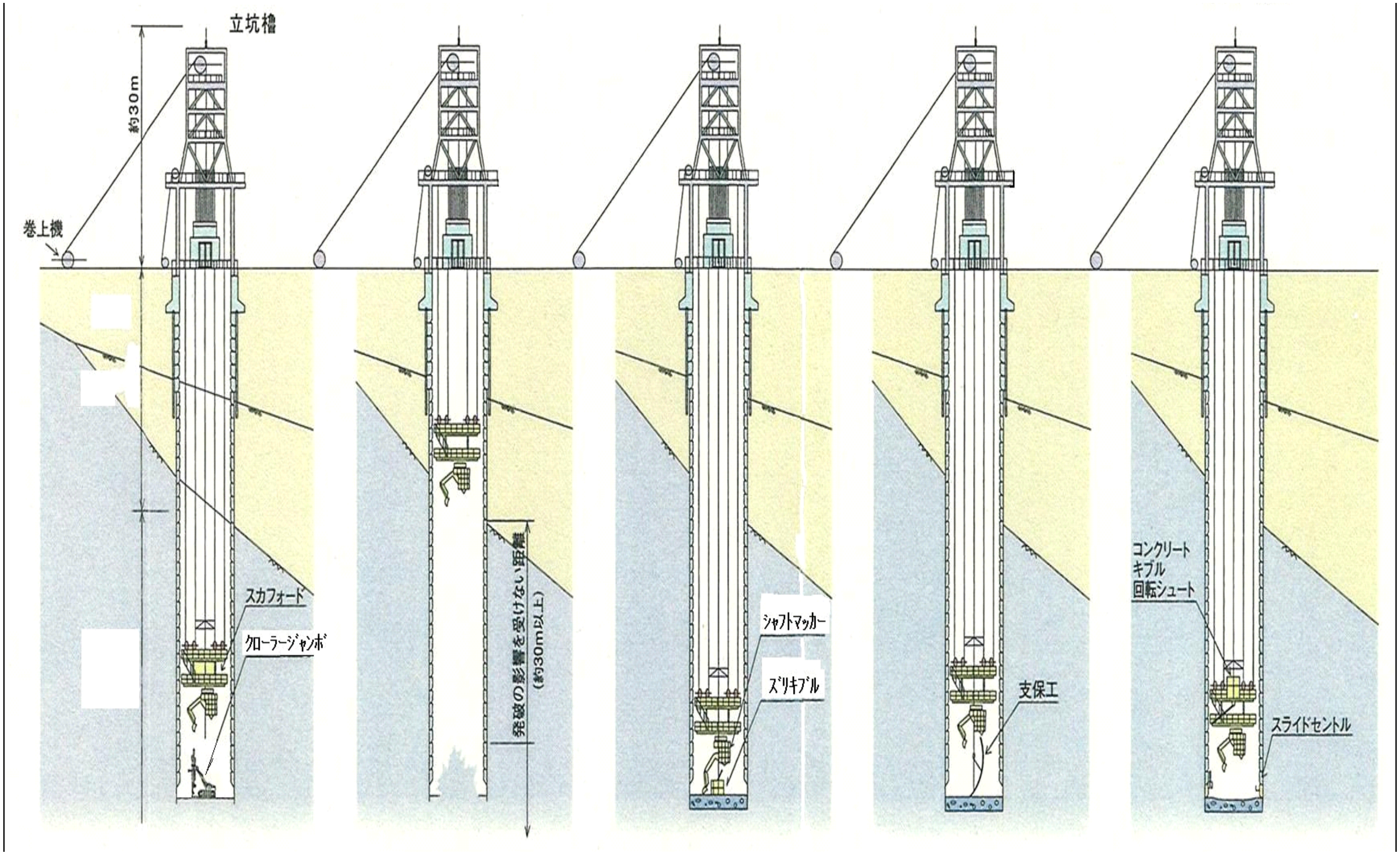
One Idea for ILC IR-hall Construction Method

Civil Engineering Scenario

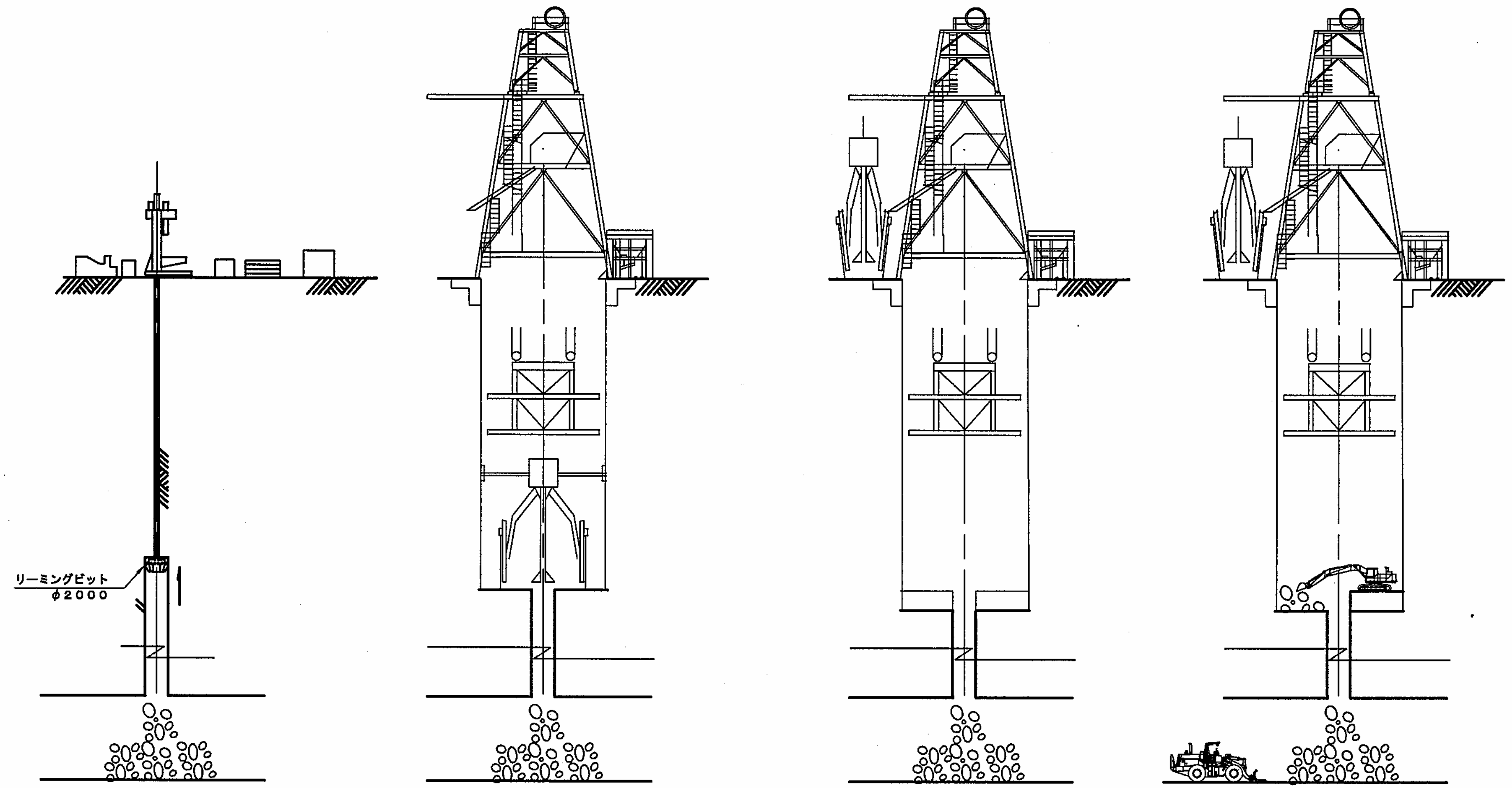
in Asian sample site

A.E.

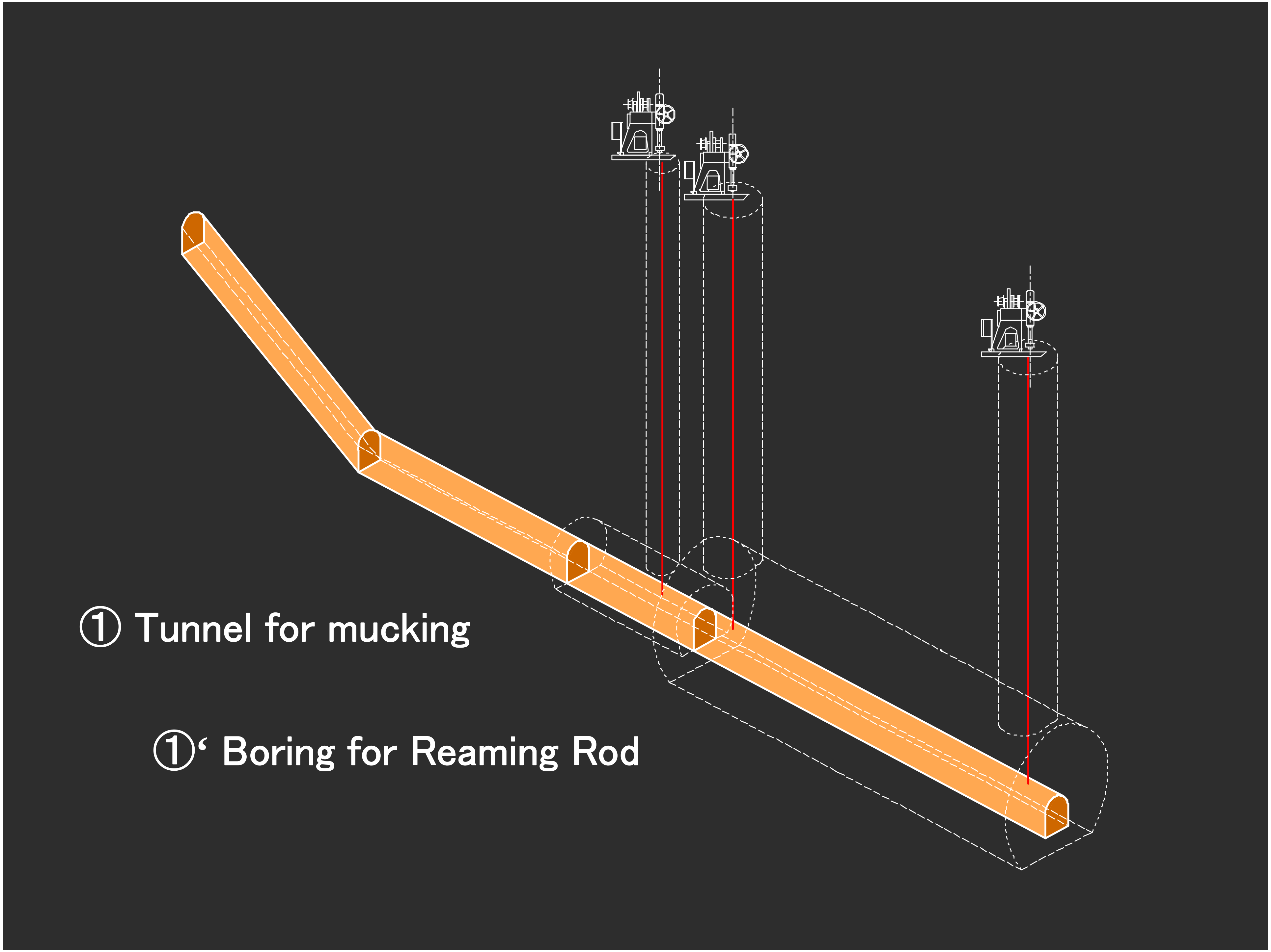


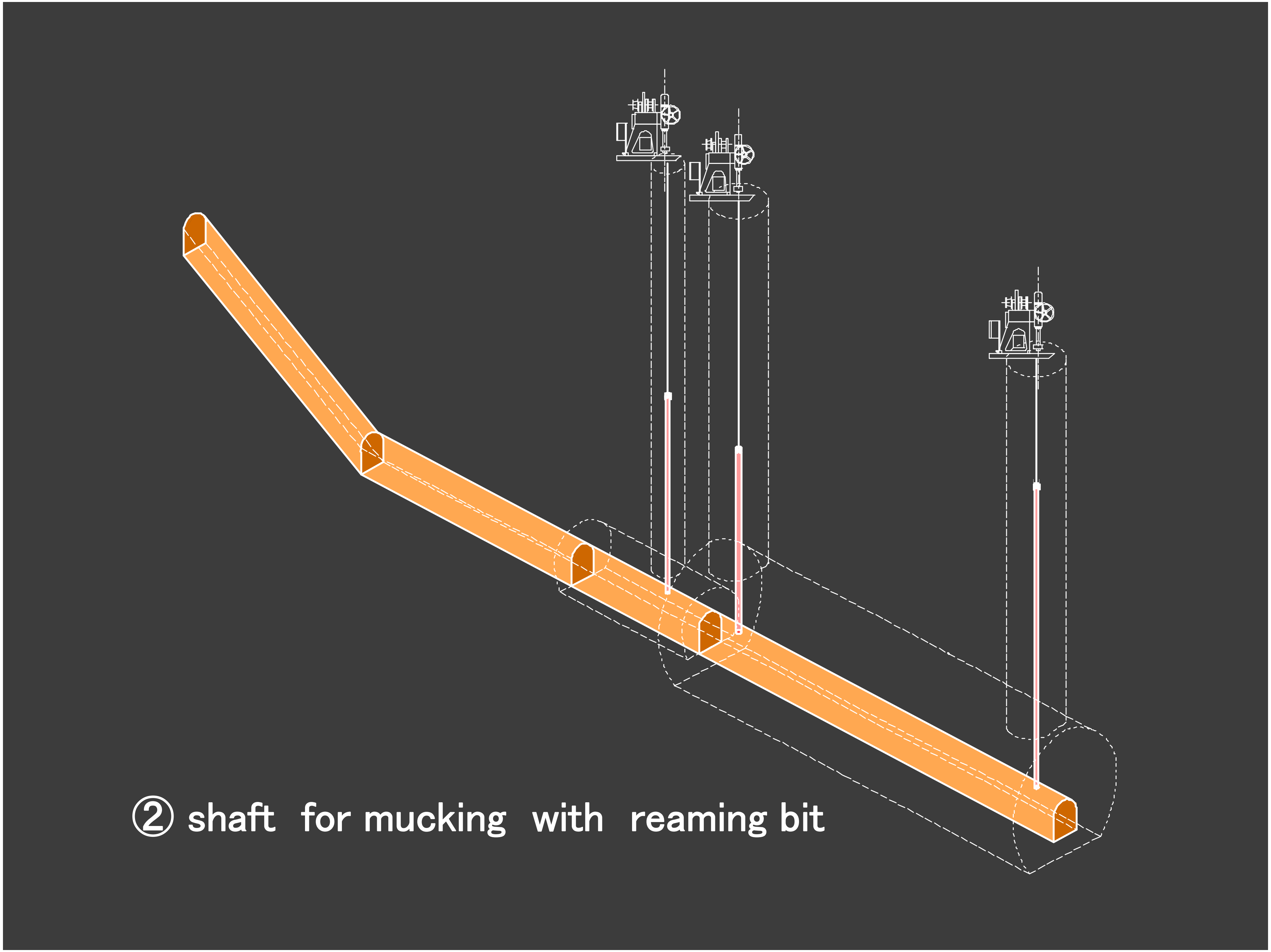


Shaft Construction (Short-step method)

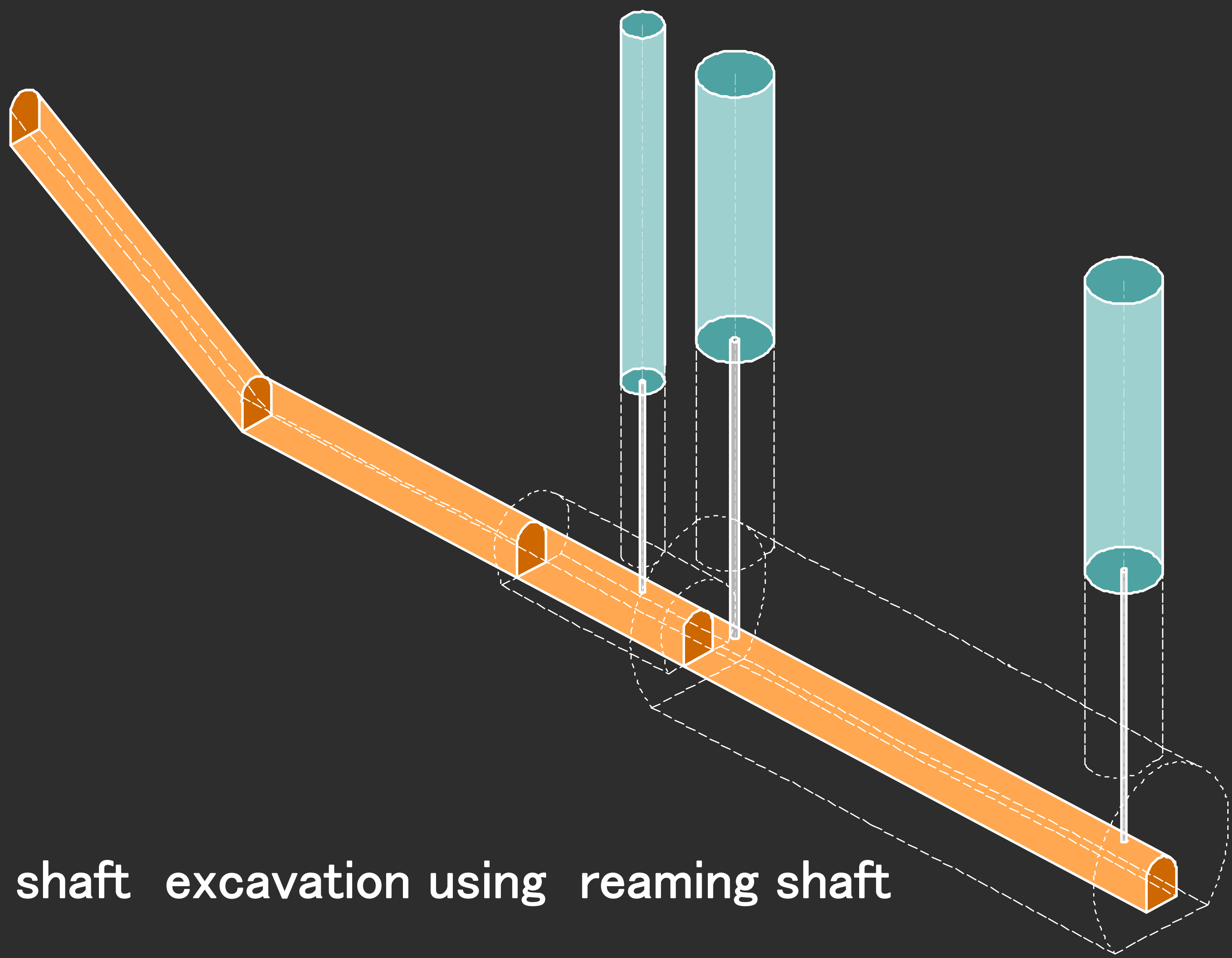


Raise Drilling method for Mucking

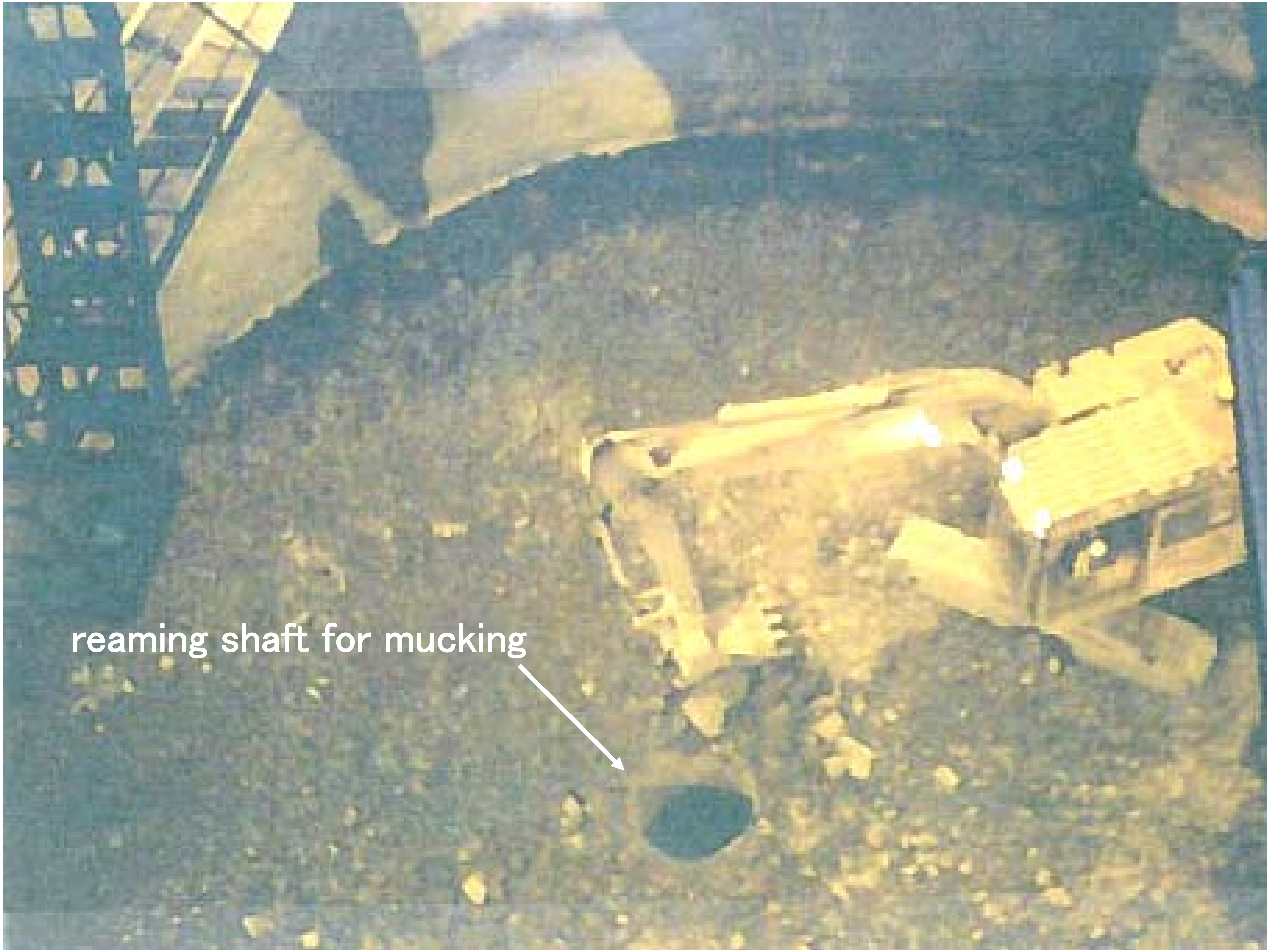

① Tunnel for mucking
①' Boring for Reaming Rod

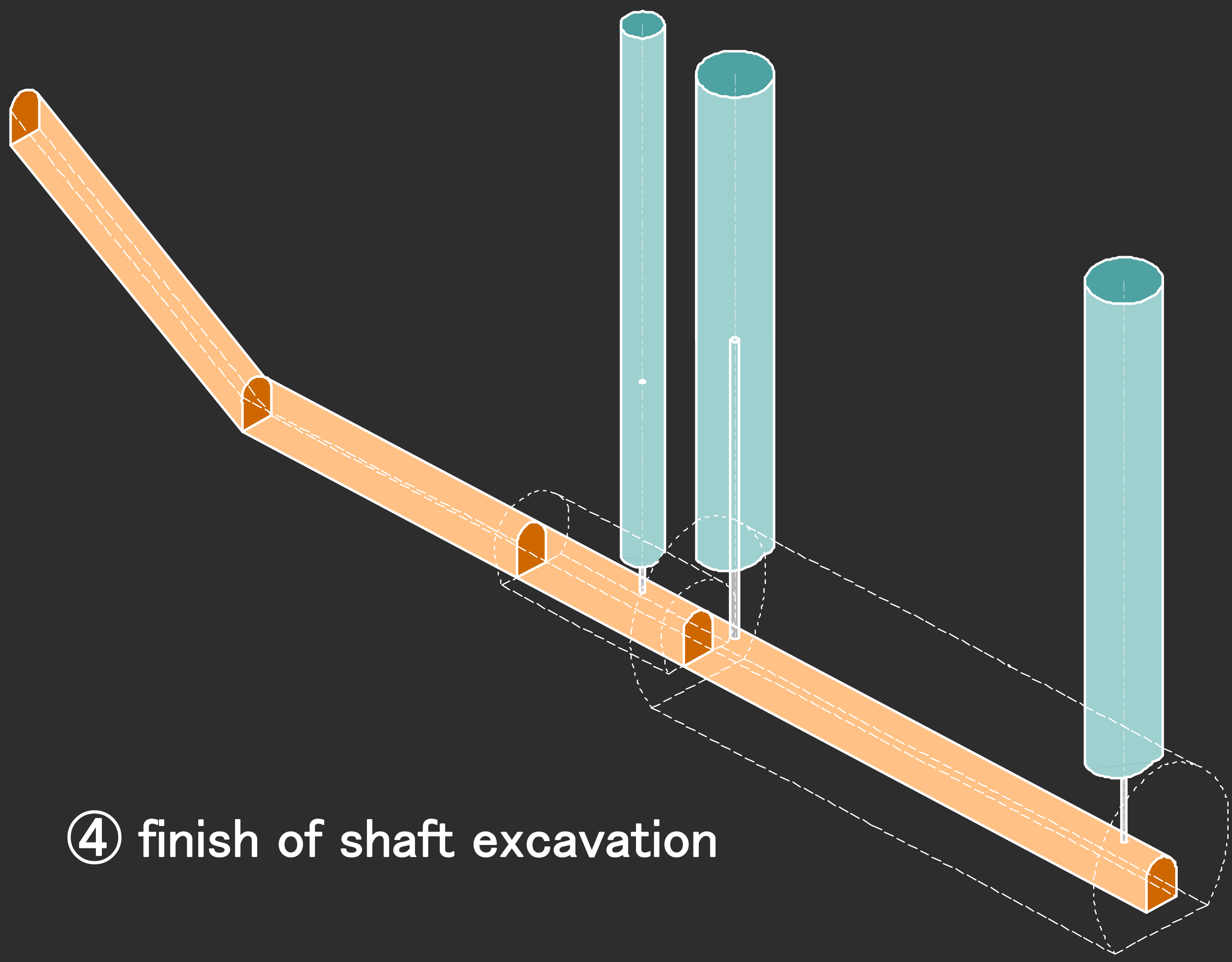

② shaft for mucking with reaming bit

reaming bit

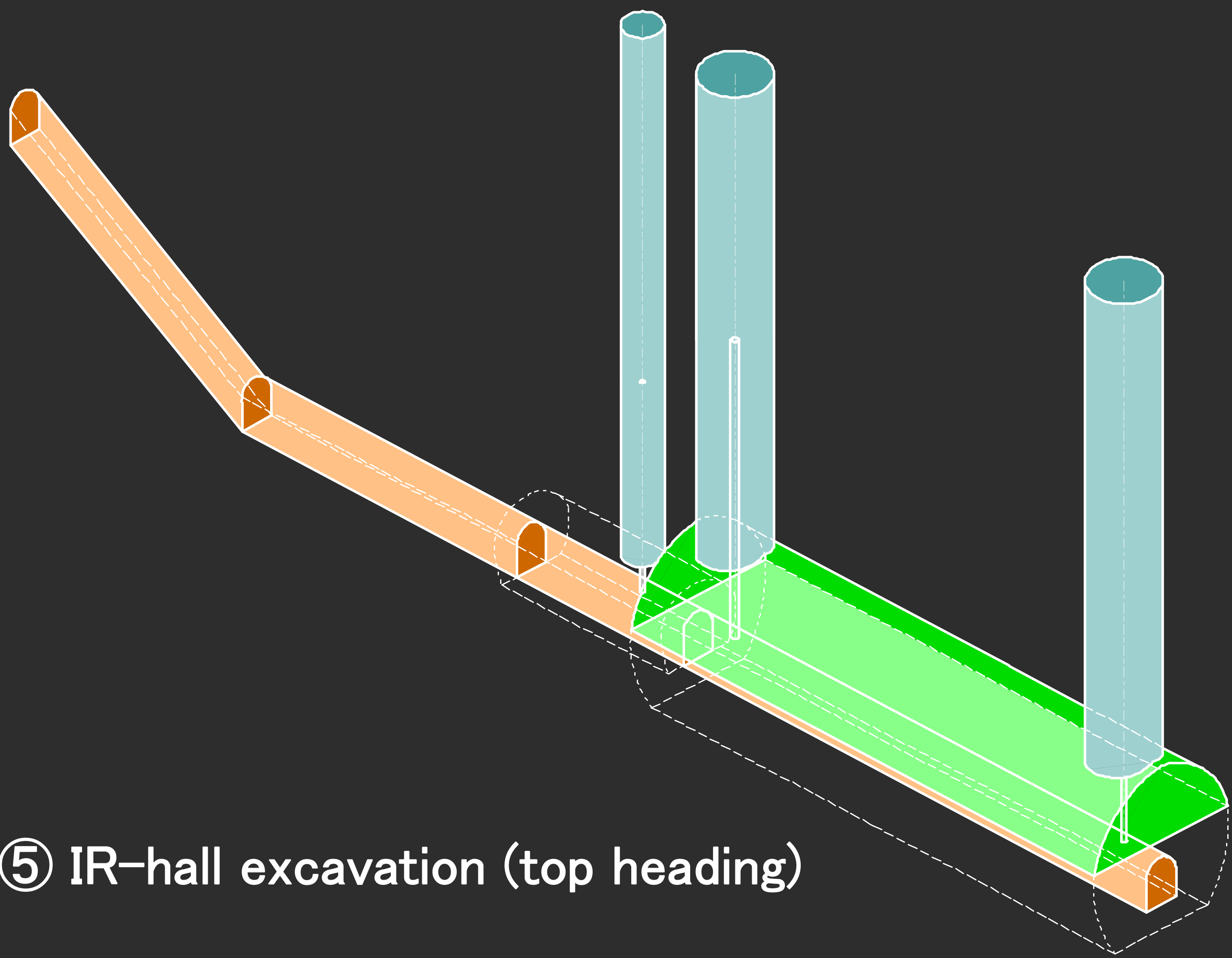


③ shaft excavation using reaming shaft

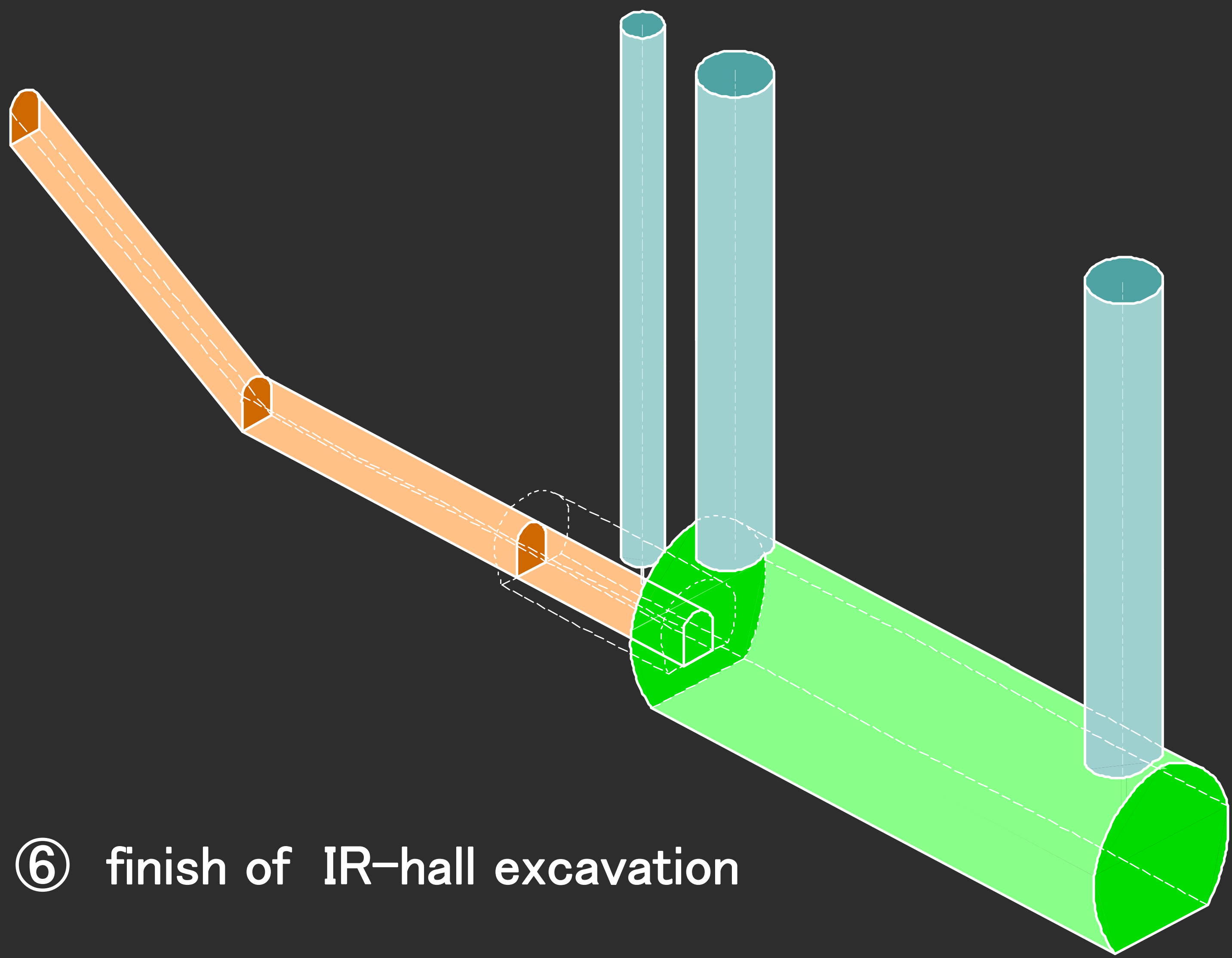

reaming shaft for mucking



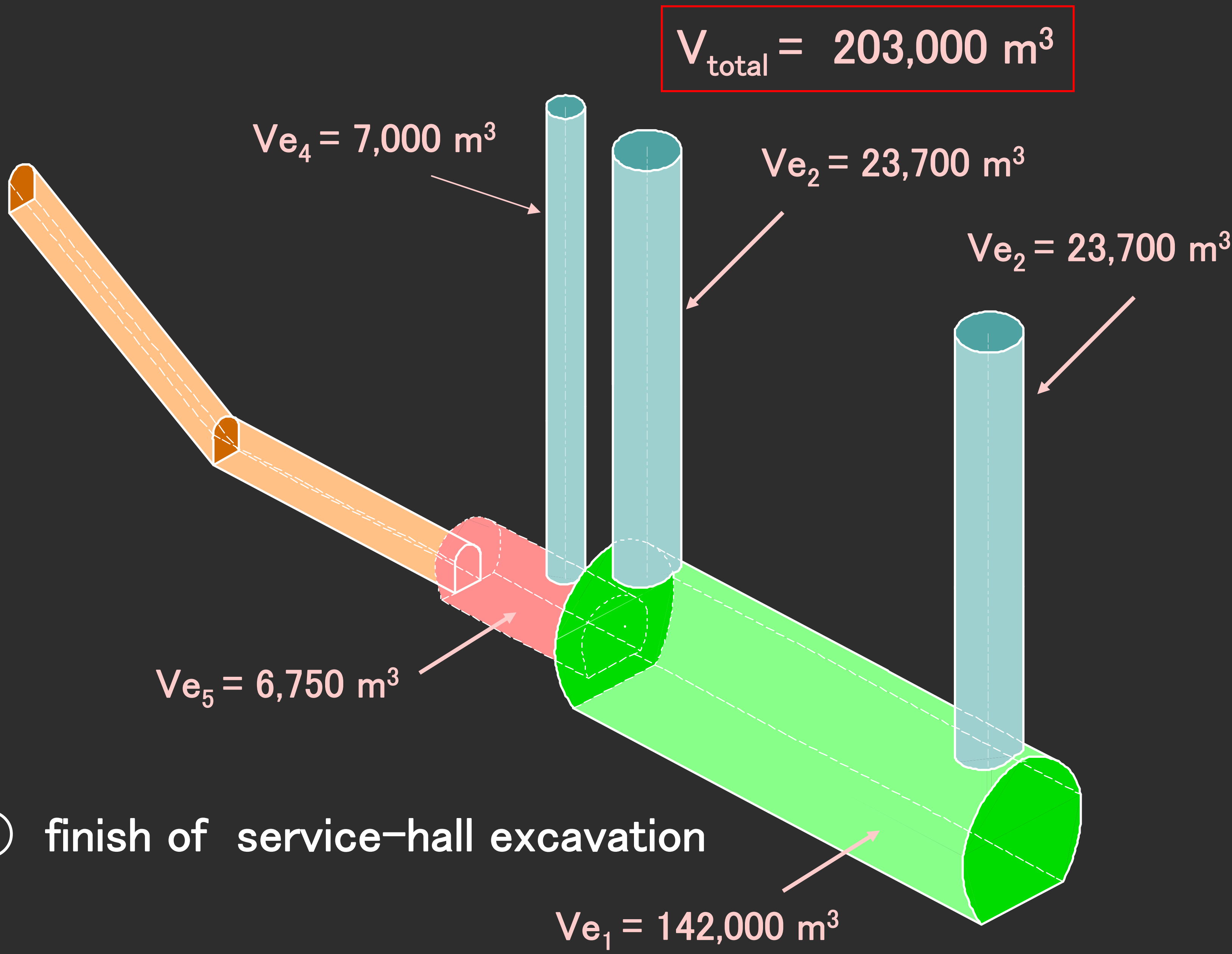
④ finish of shaft excavation



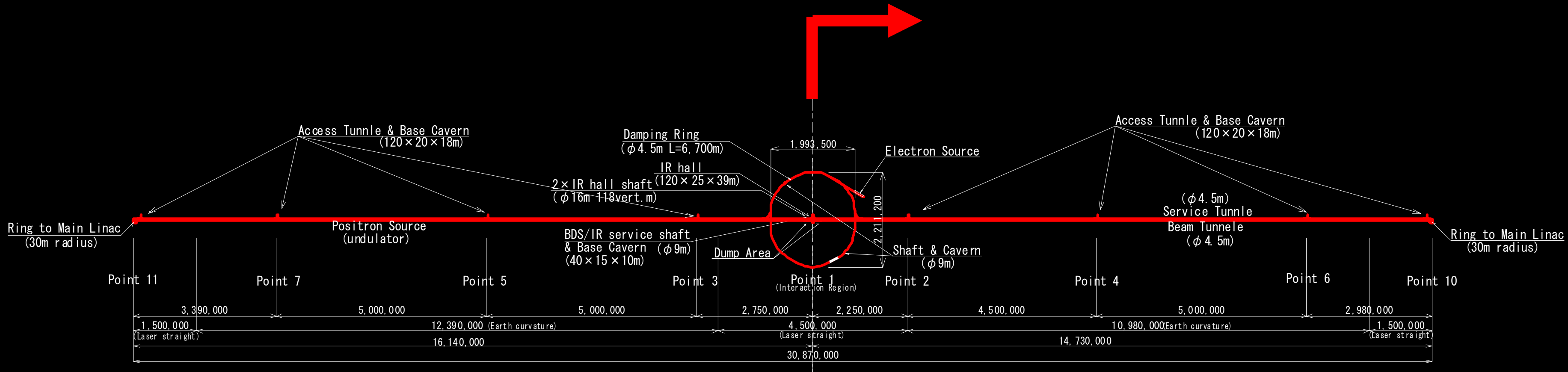
⑤ IR-hall excavation (top heading)



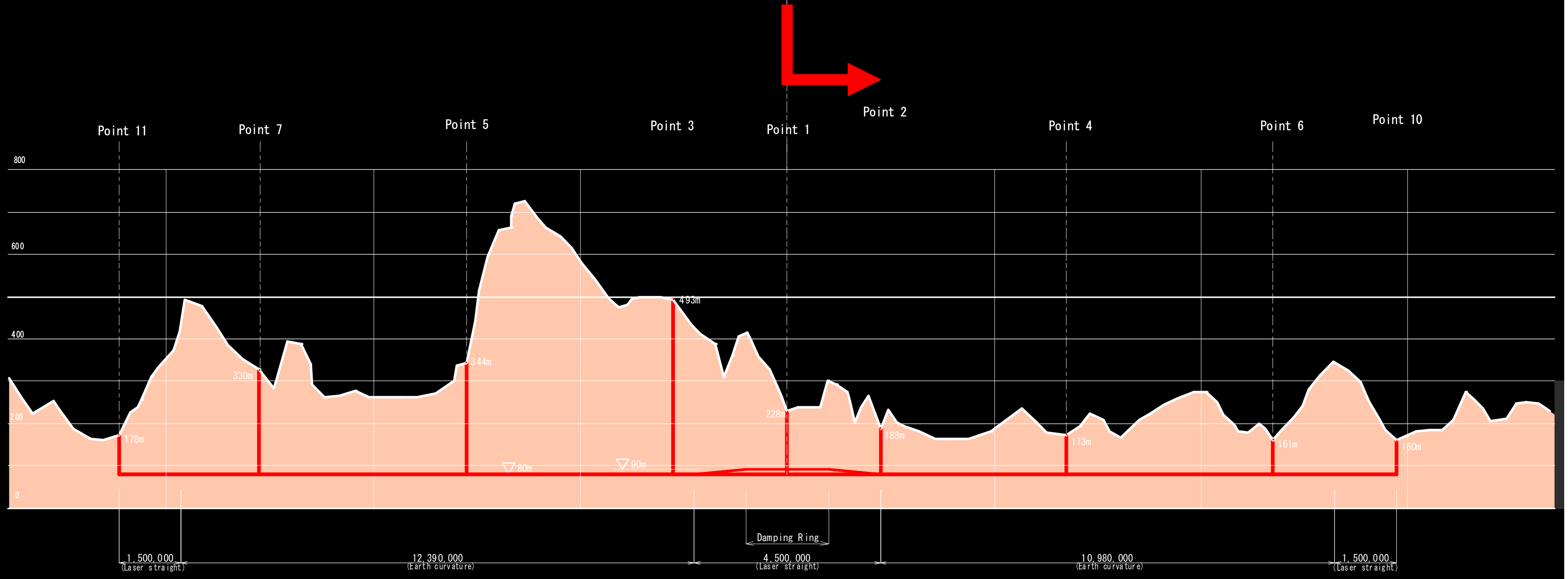
⑥ finish of IR-hall excavation



⑦ finish of service-hall excavation



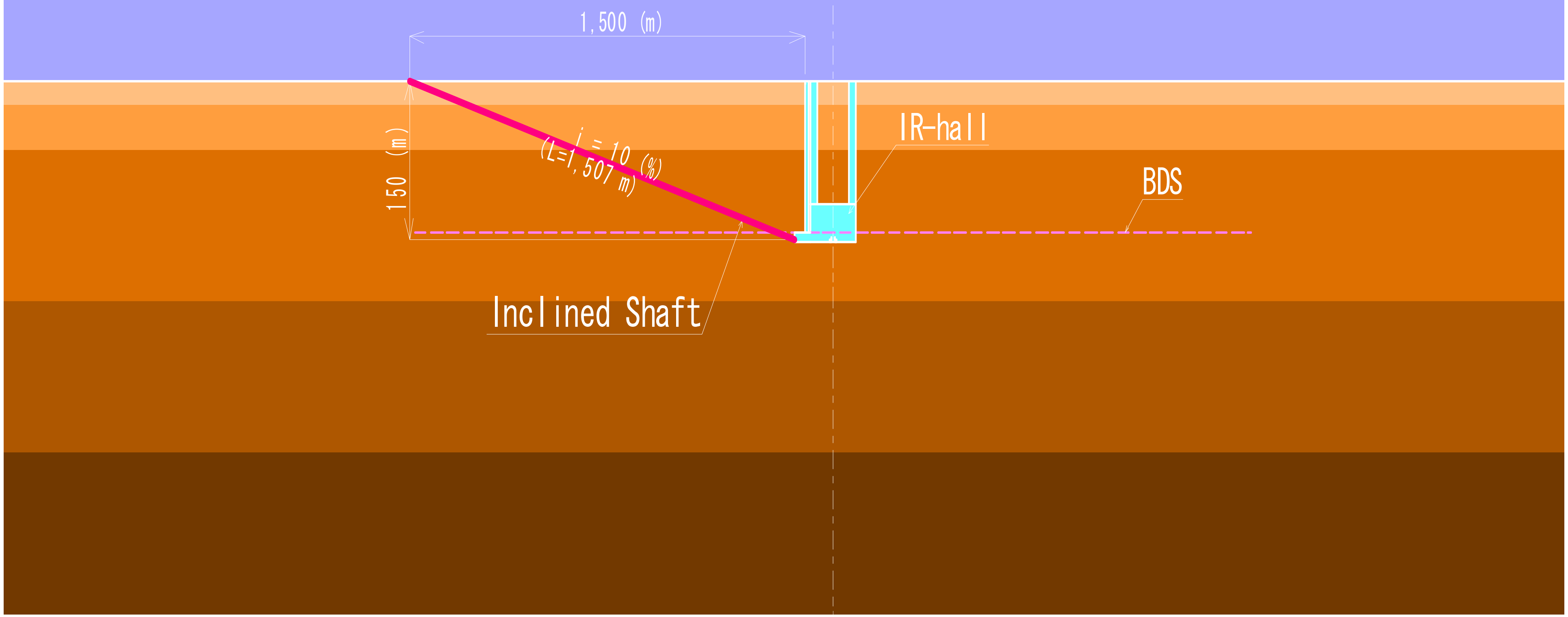
PLAN
(S=1/50,000)



CUT SECTION
(S L=1/50,000 V=1/5,000)

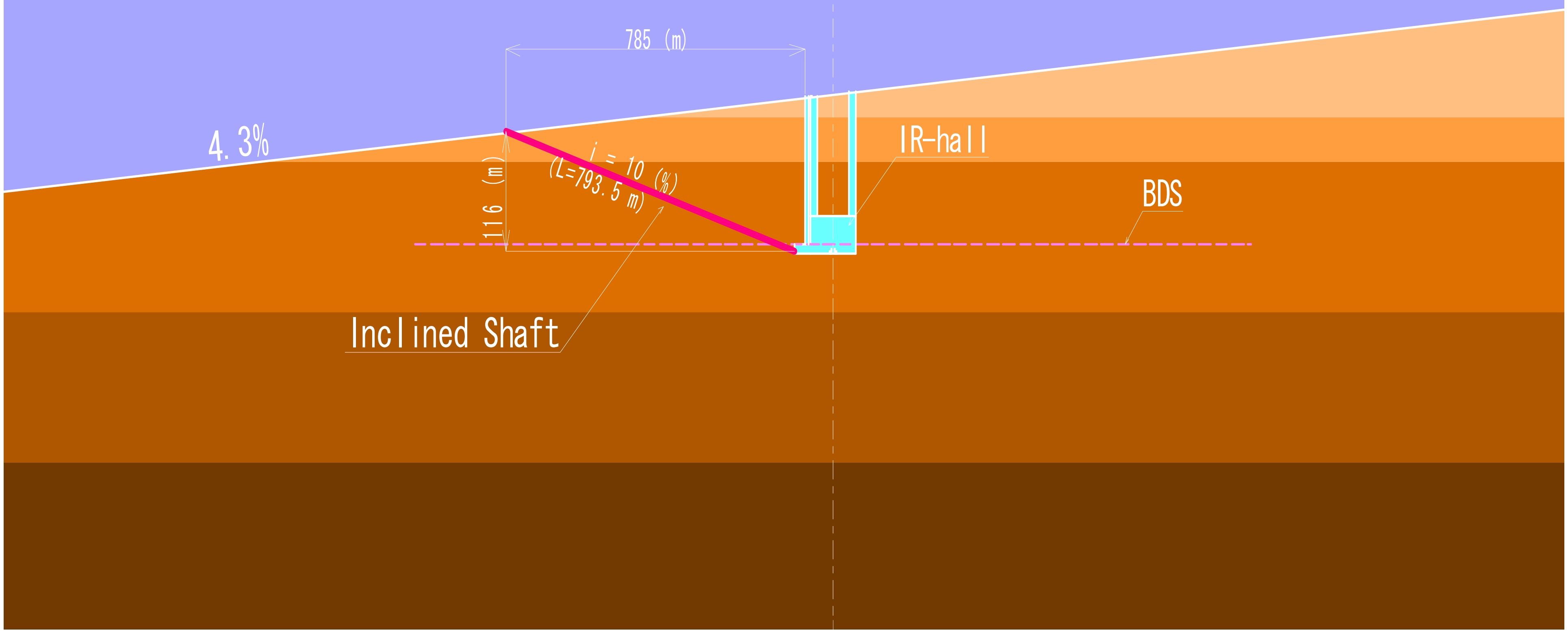
HORIZONTAL CASE

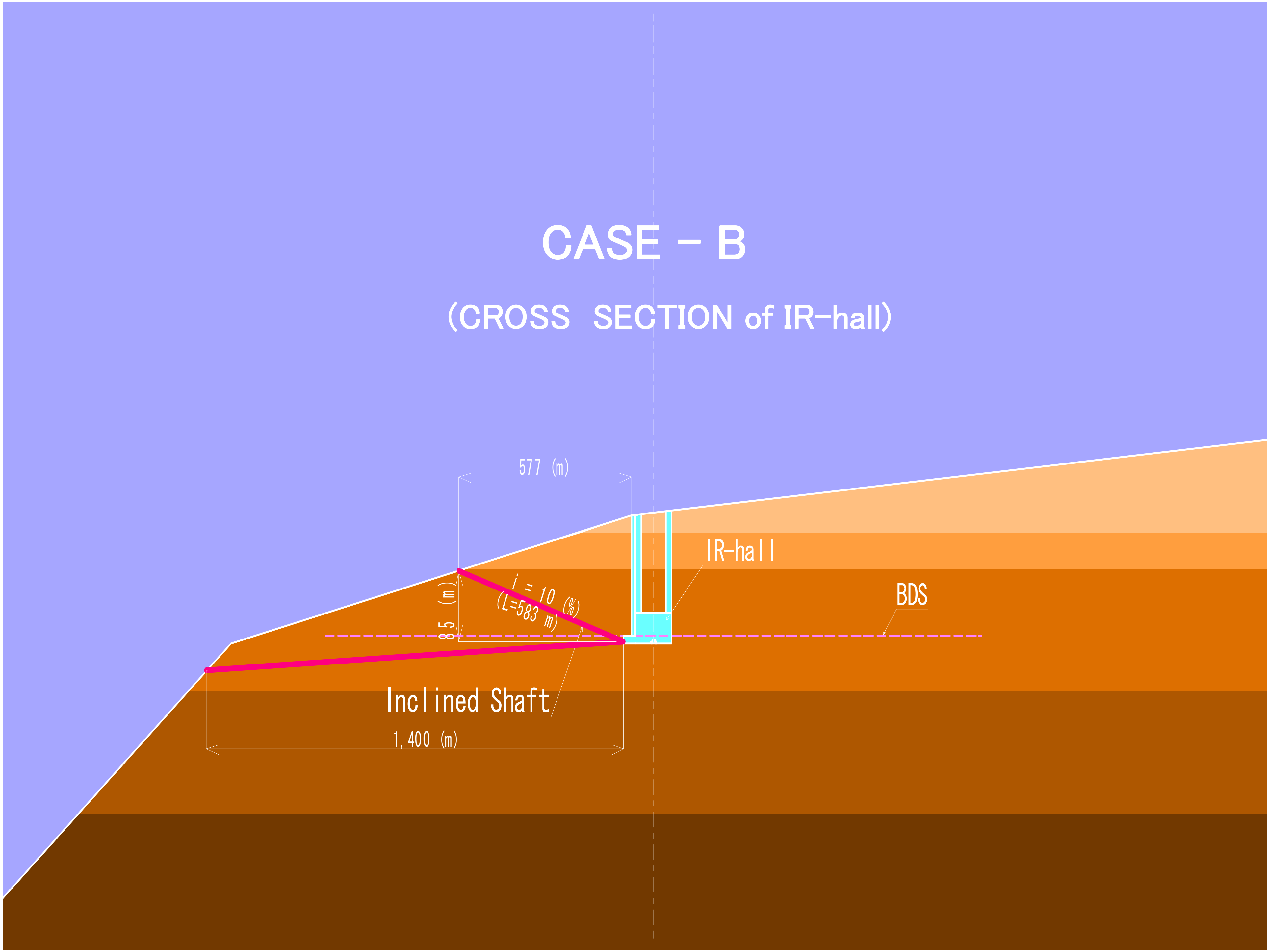
(CROSS SECTION of IR-hall)

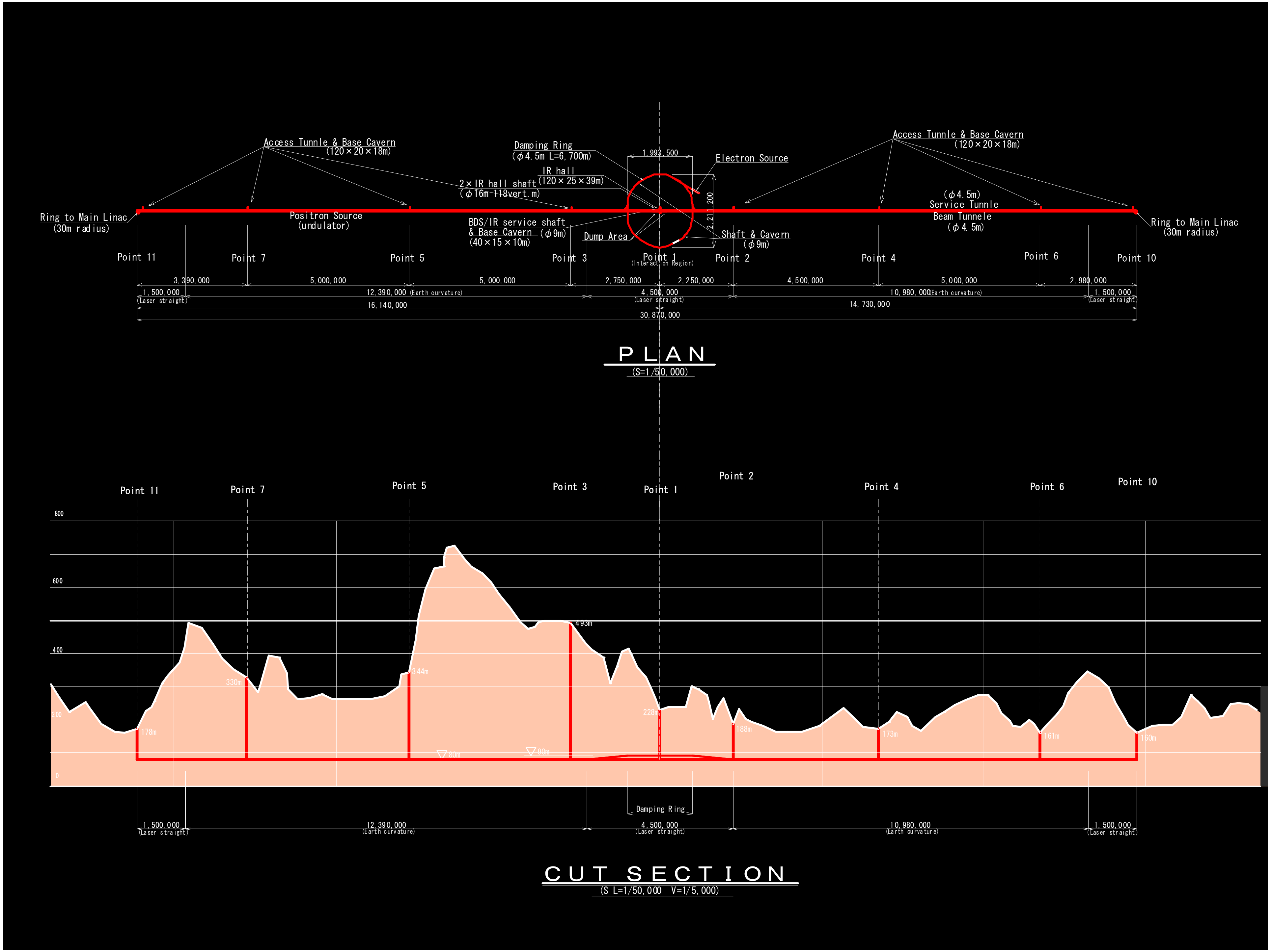


CASE - A

(CROSS SECTION of IR-hall)

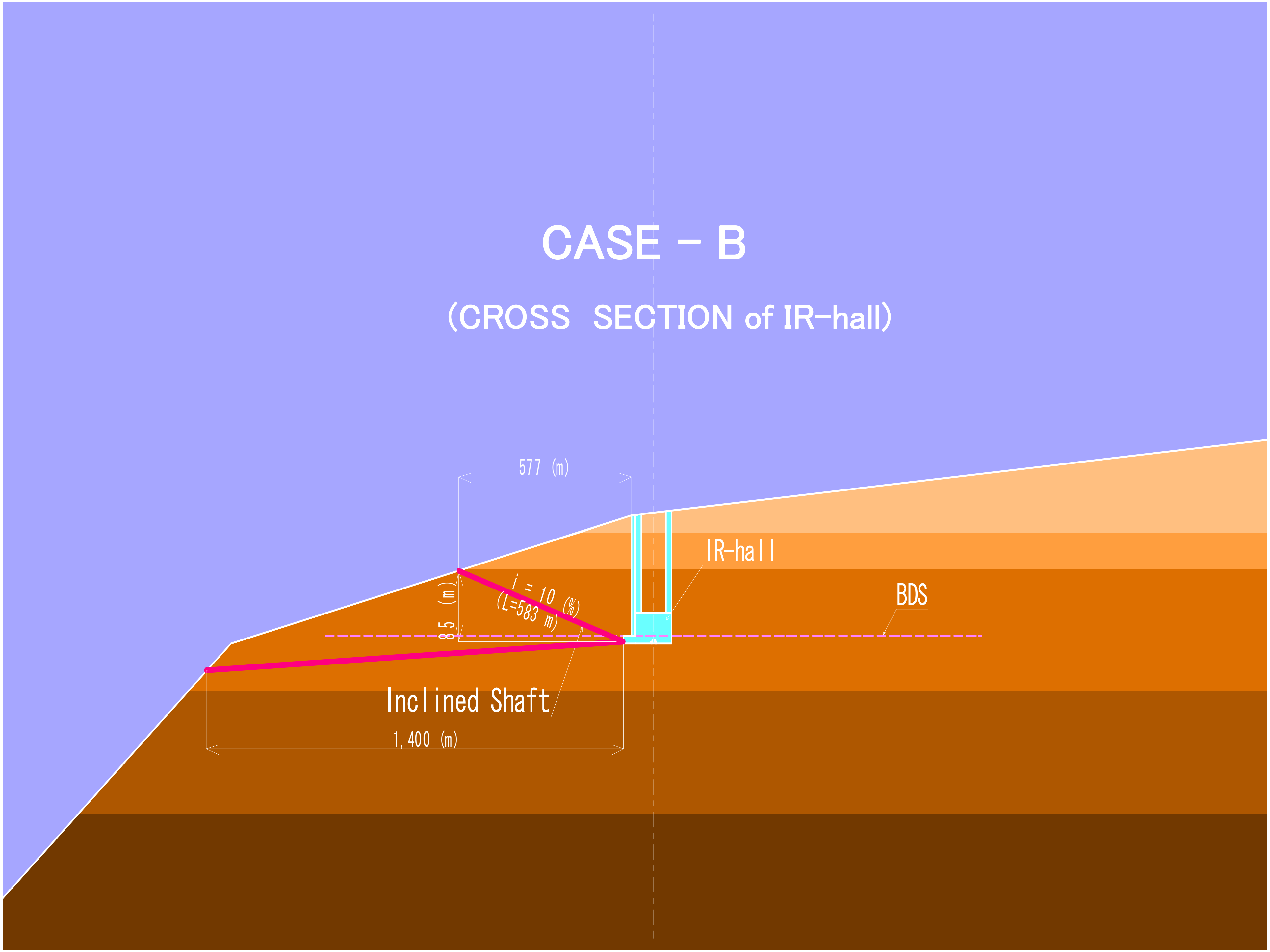



CASE - B
(CROSS SECTION of IR-hall)
577 (m)
IR-hall
BDS
i = 10 (%)
(L=583 m)
85 (m)
Inclined Shaft
1,400 (m)


Access Tunnle & Base Cavern
(120×20×18m)
Damping Ring
(φ4.5m L=6,700m)
IR hall
(120×25×39m)
2×IR hall shaft
(φ16m 118vert.m)
1,993,500
Electron Source
2,211,200
Access Tunnle & Base Cavern
(120×20×18m)
(φ4.5m)
Service Tunnle
Beam Tunnele
(φ4.5m)
Ring to Main Linac
(30m radius)
Positron Source
(undulator)
BDS/IR service shaft
& Base Cavern (φ9m)
(40×15×10m)
Dump Area
Shaft & Cavern
(φ9m)
Ring to Main Linac
(30m radius)
Point 11
Point 7
Point 5
Point 3
Point 1
(Interaction Region)
Point 2
Point 4
Point 6
Point 10
3,390,000
5,000,000
5,000,000
2,750,000
2,250,000
4,500,000
5,000,000
2,980,000
1,500,000
(Laser straight)
12,390,000 (Earth curvature)
4,500,000
(Laser straight)
10,980,000 (Earth curvature)
1,500,000
(Laser straight)
16,140,000
14,730,000
30,870,000
PLAN
(S=1/50,000)
Point 11
Point 7
Point 5
Point 3
Point 1
Point 2
Point 4
Point 6
Point 10
800
600
400
200
0
178m
330m
344m
493m
228m
188m
173m
161m
160m
▽80m
▽90m
Damping Ring
1,500,000
(Laser straight)
12,390,000
(Earth curvature)
4,500,000
(Laser straight)
10,980,000
(Earth curvature)
1,500,000
(Laser straight)
CUT SECTION
(S L=1/50,000 V=1/5,000)

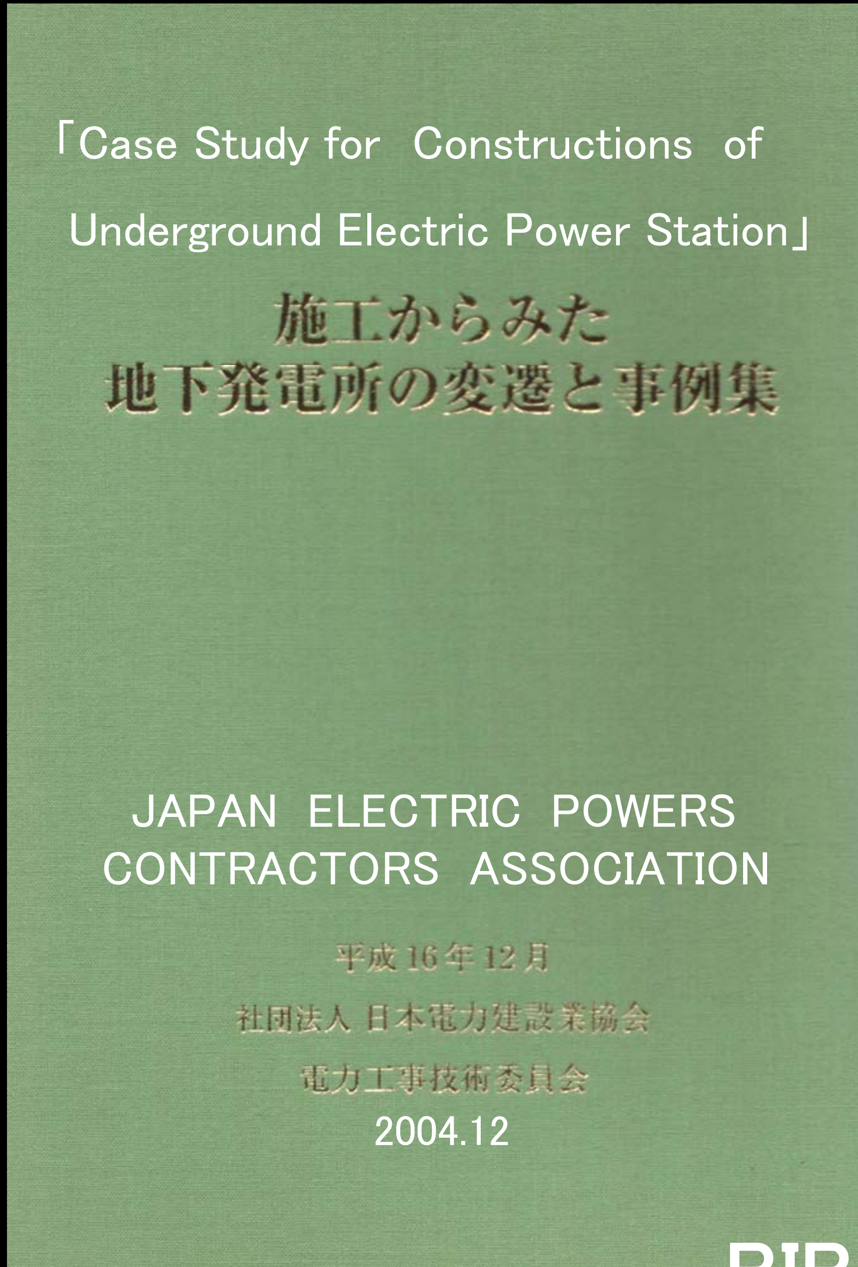
CASE - B

(CROSS SECTION of IR-hall)



CONCLUSION

- It is not difficult to construct the ILC/CF of Civil Constructions in Japan with numerous experiences of same type structure.
- R&D is required to reduce the Cost & Construction Period.
- There are many constructional schemes for cost reduction, contraction of construction period. Please ask us for effective alternative plan at early stage .



BIBLIOGRAPHY

Super-Kamiokande

owner: Kamioka Observatory. ICRR
The university of Tokyo

location: Gifu-prf. Kamioka-town

commencement: Dec. 1991

completion: Jun. 1996

detector dome: B=ϕ40m H=57.7m
V= 69,000 m^2

Super-Kamiokande

over burden： D= 1,000 m

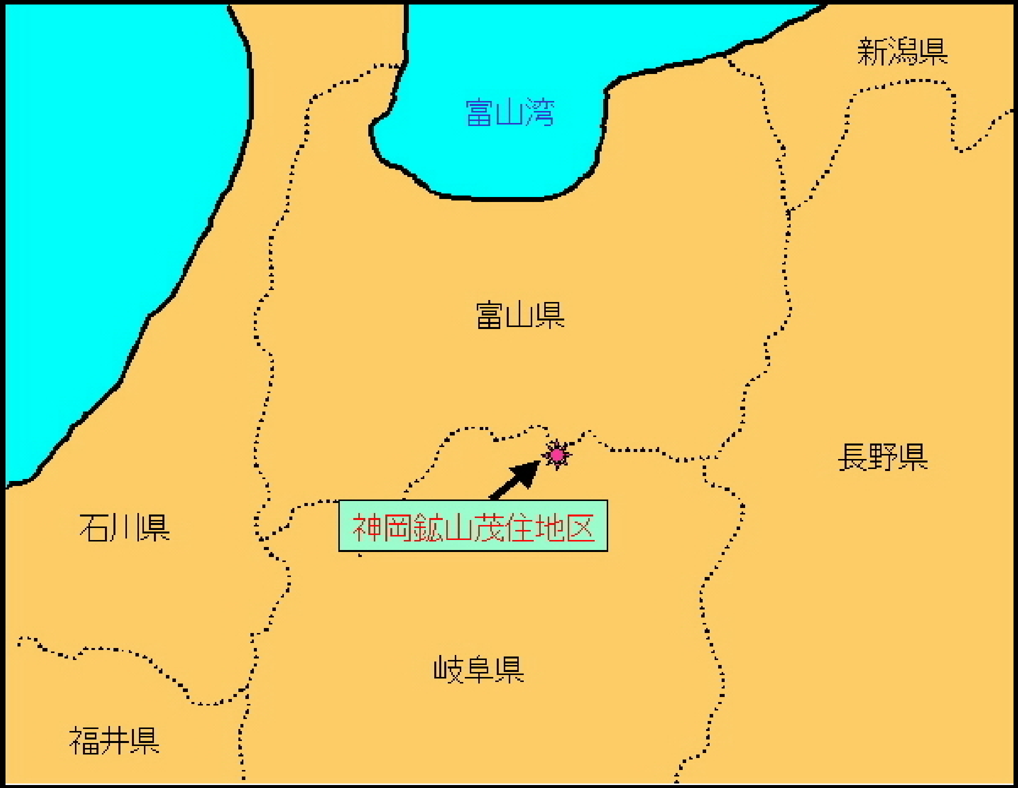
geological structure： Amphibole gneiss

rock classification： A ～ B

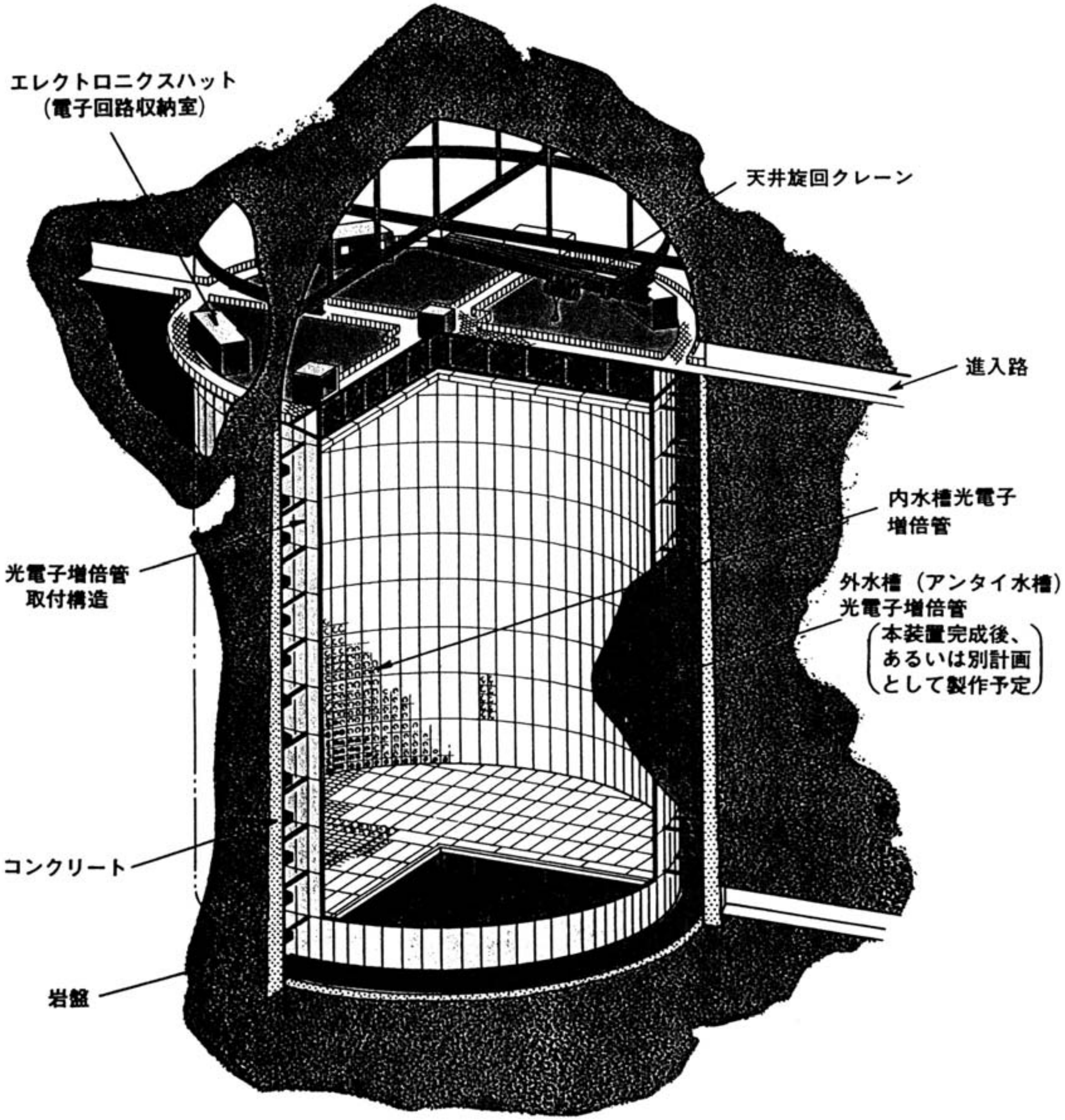
construction methods： Drill and blast (NATM)

tunnel support： Shotcrete + Rock-bolt

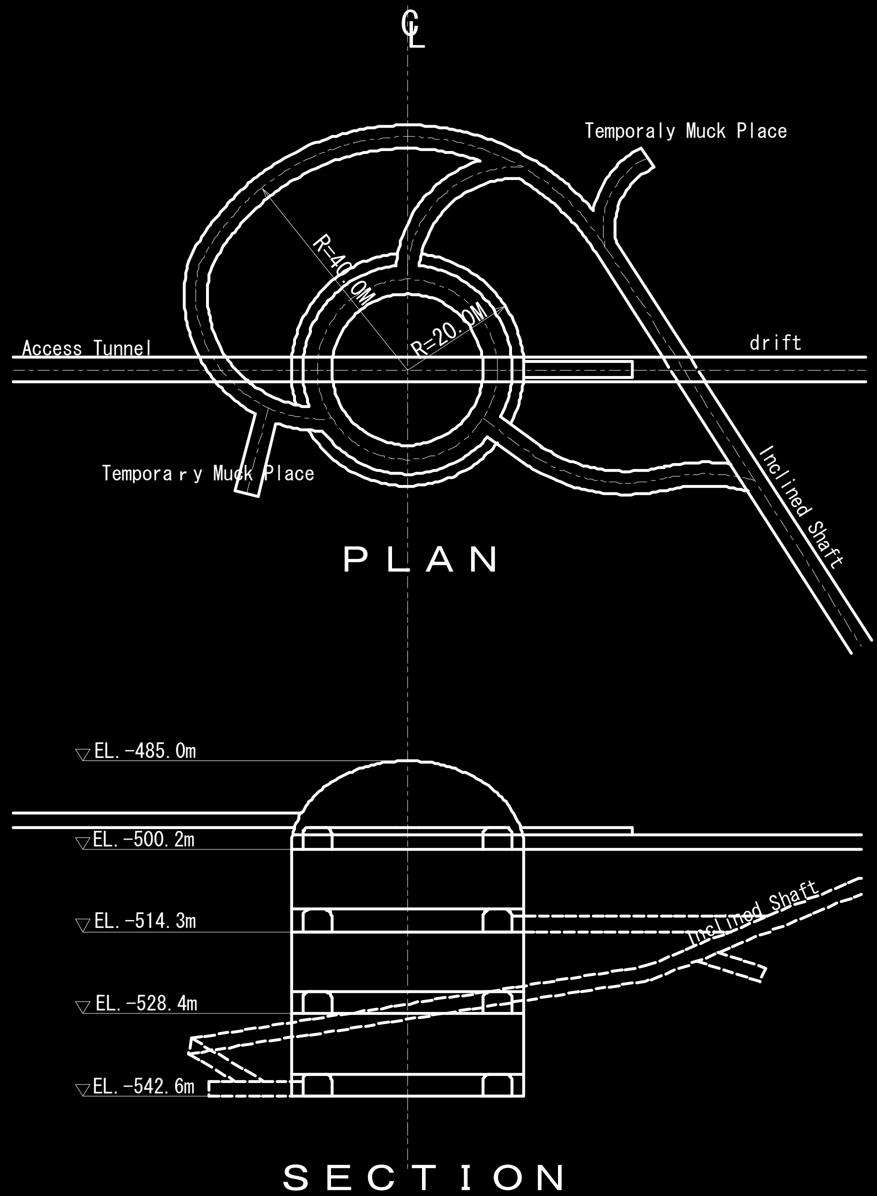
+ Cable-bolt



Lcation

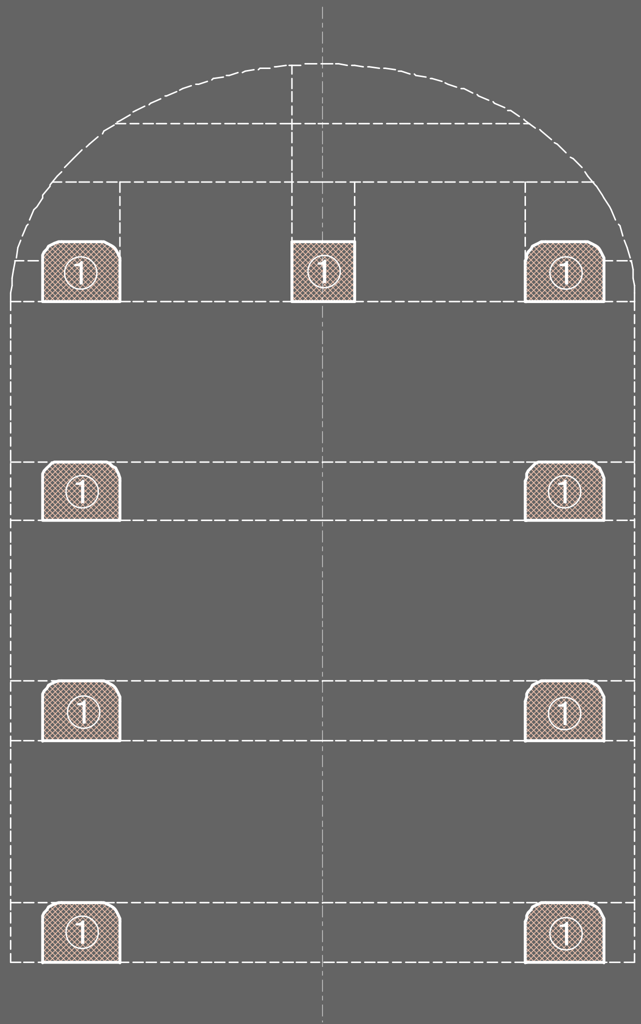


Structural Cut Section

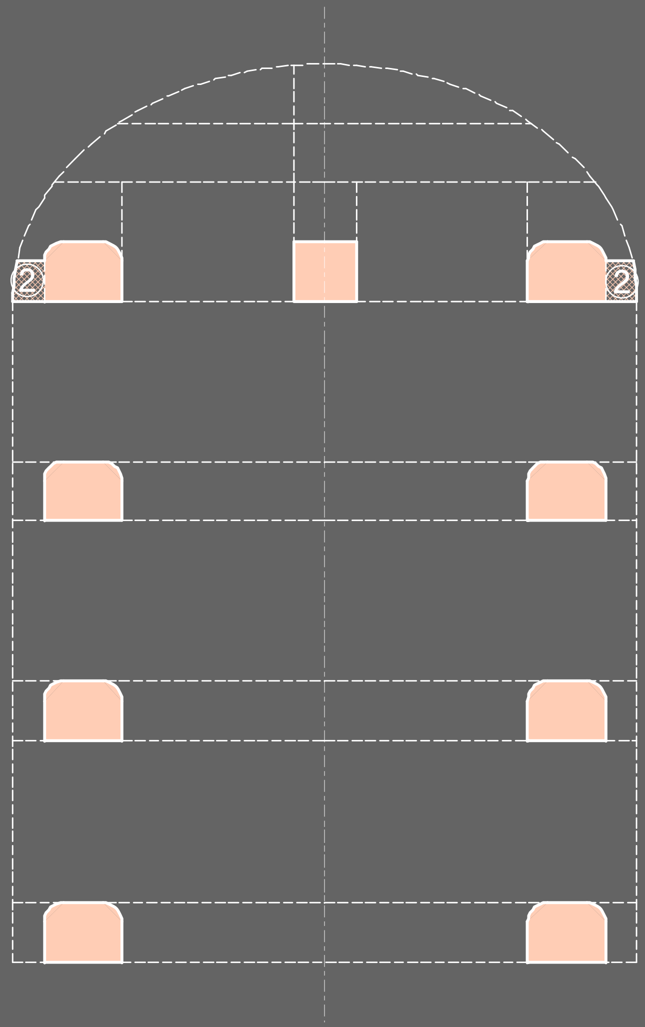


Cavern Structure

STEP-1



STEP-2



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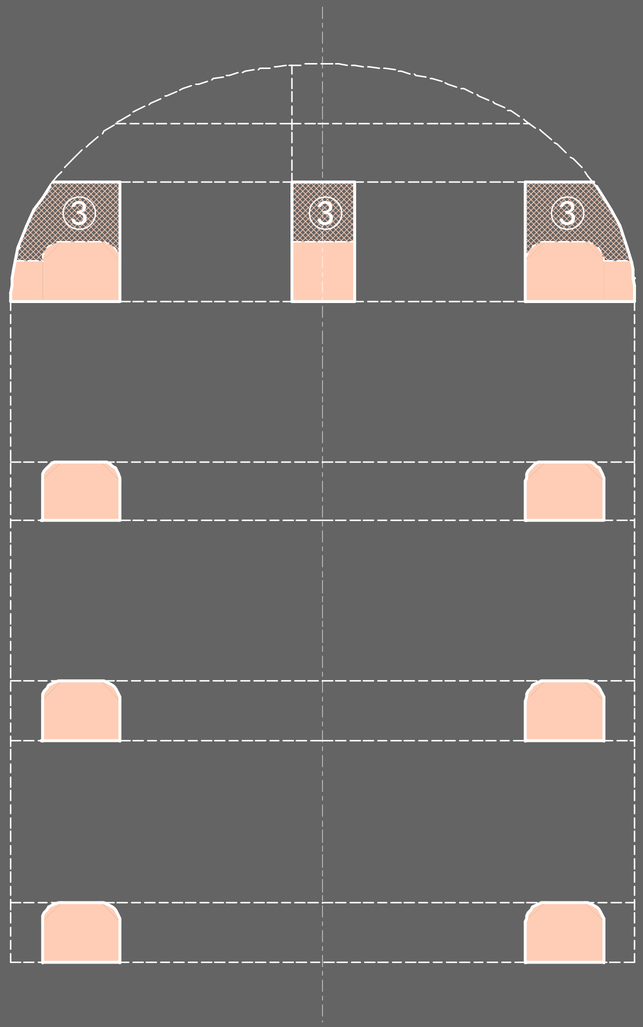

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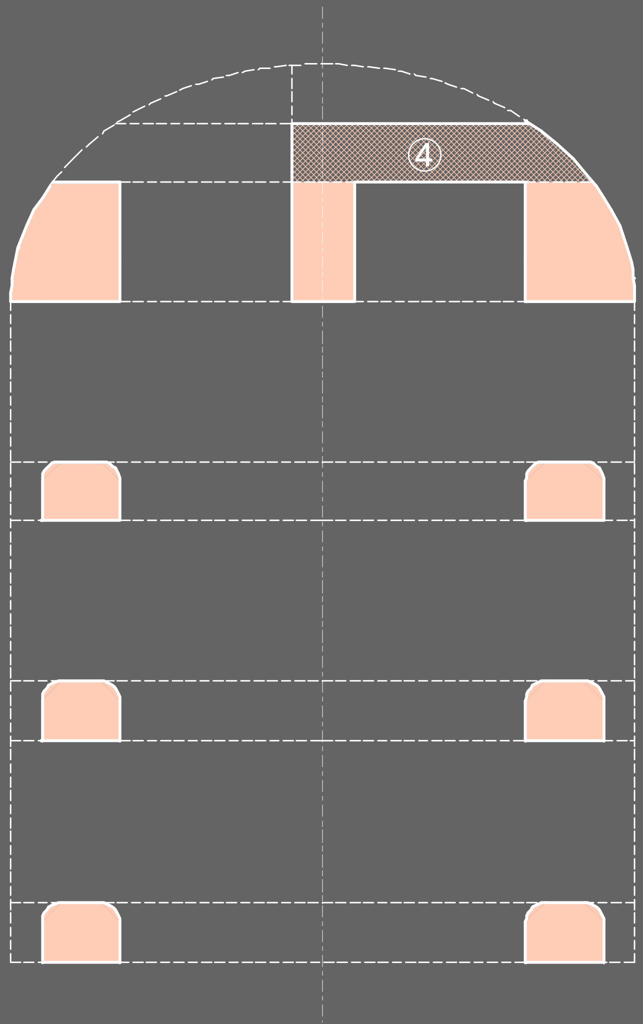

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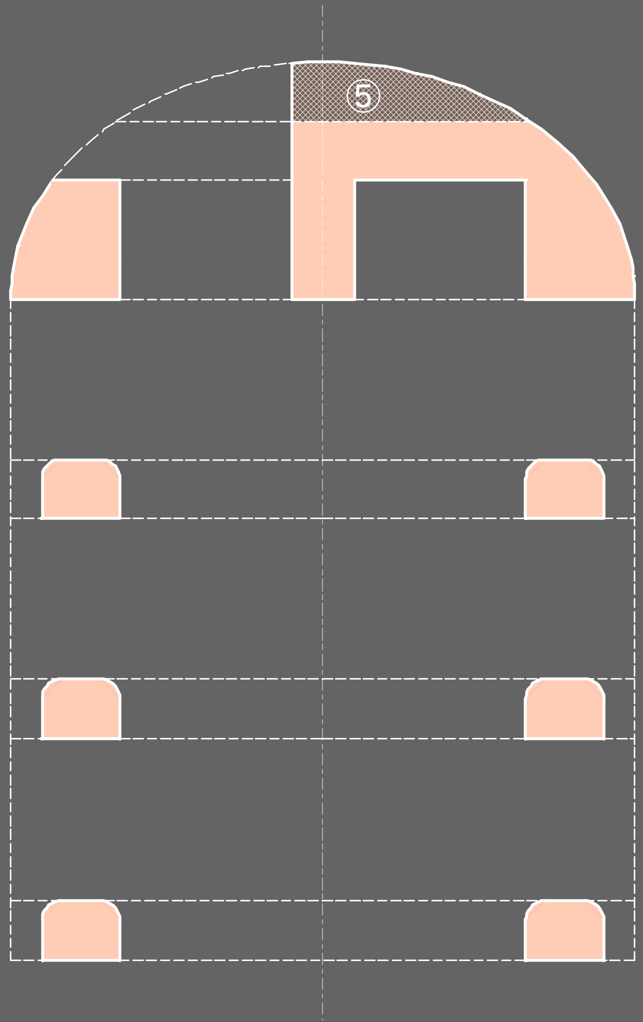

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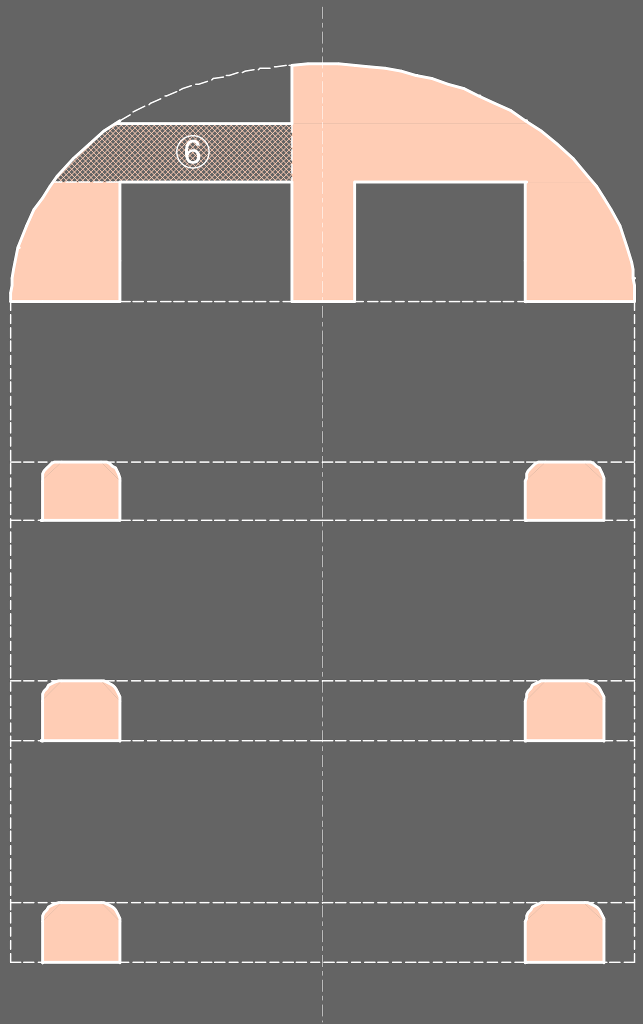

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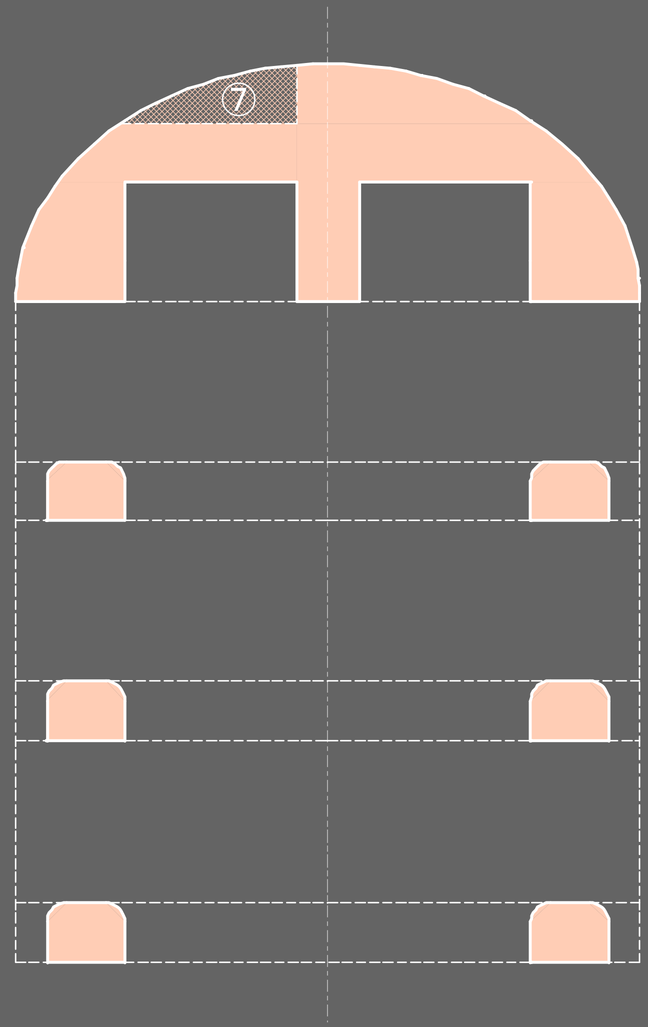

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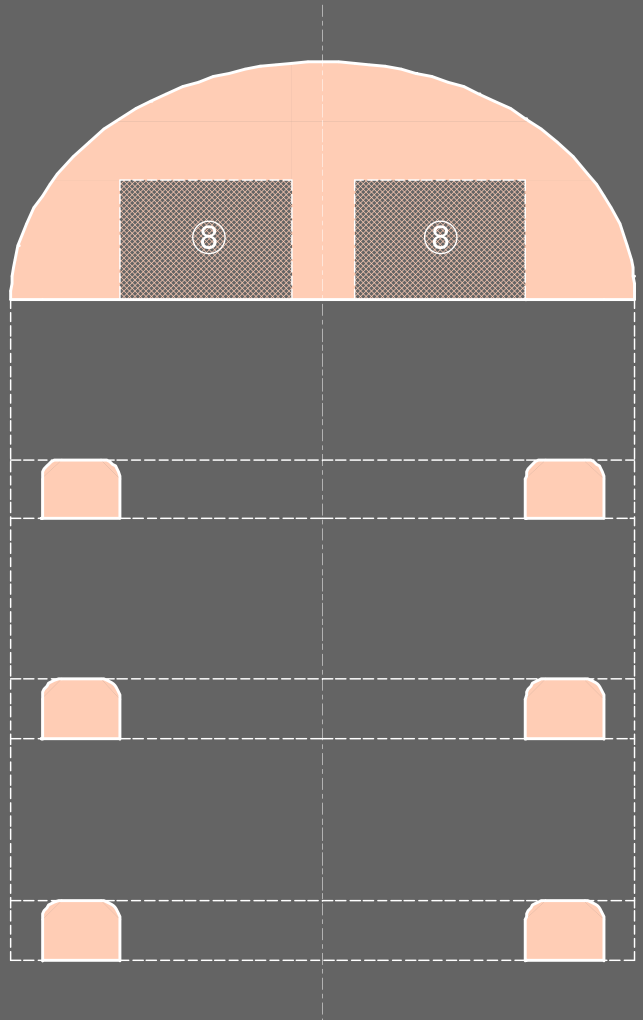
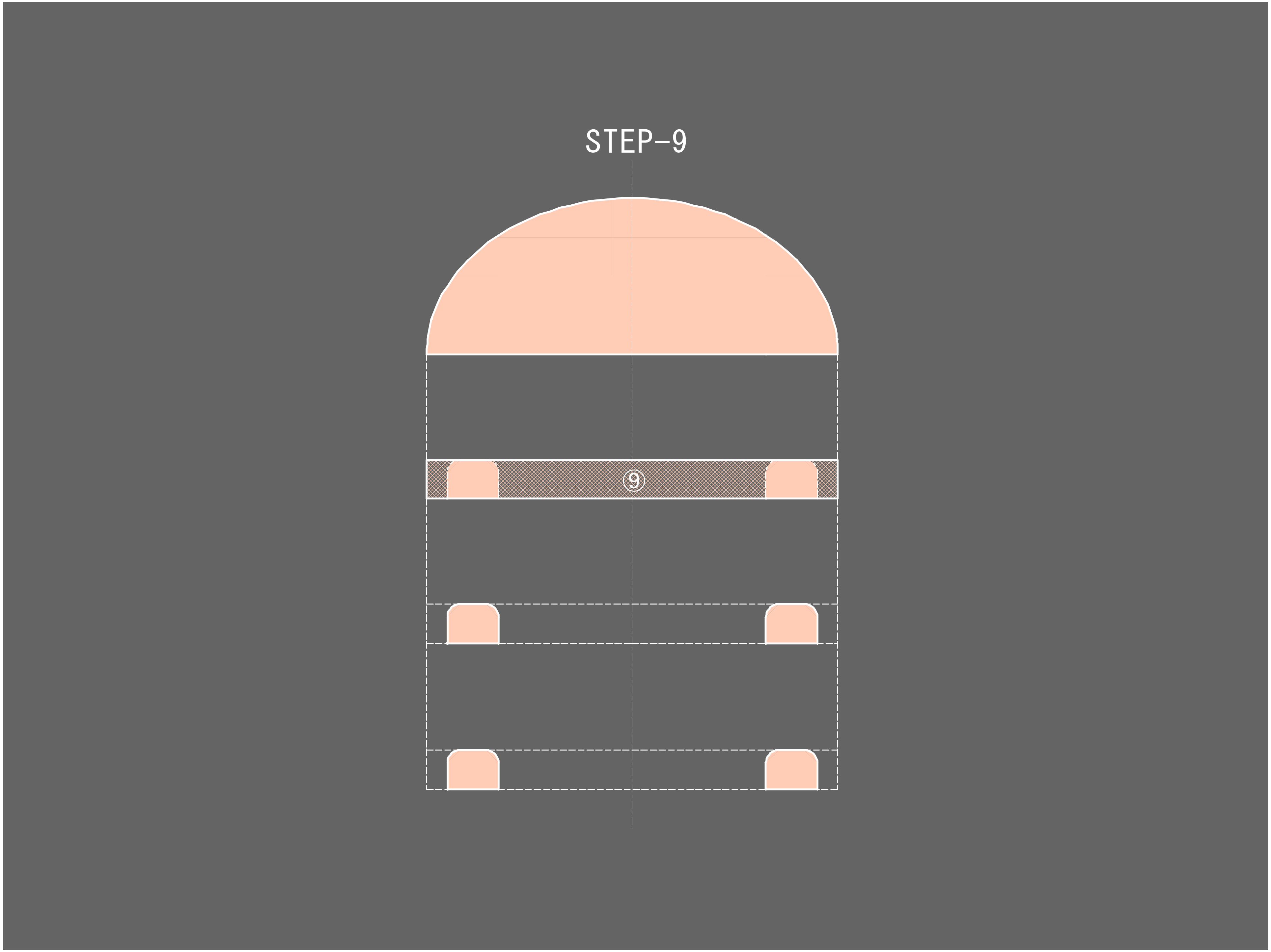
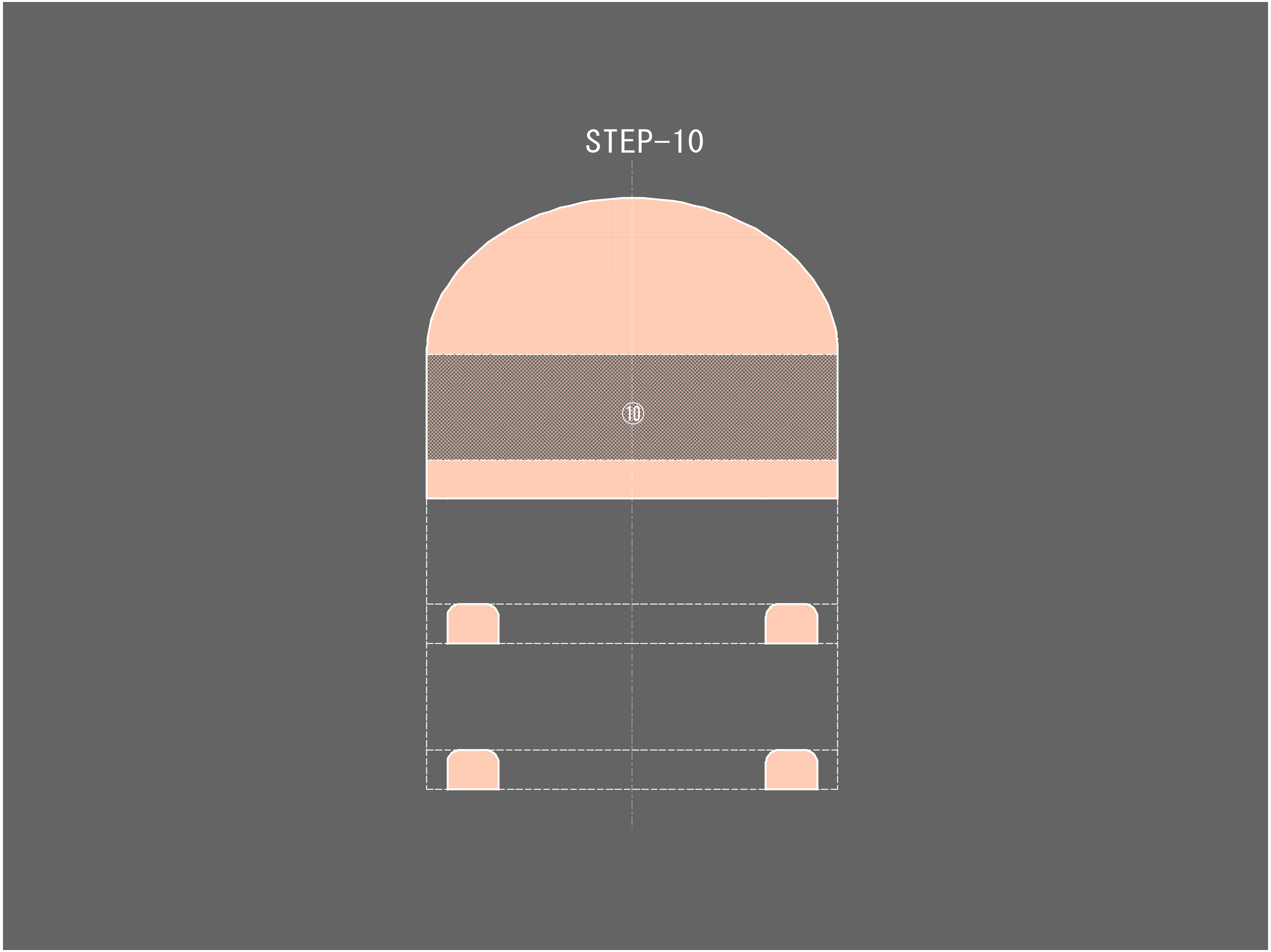



STEP-9
9


STEP-10
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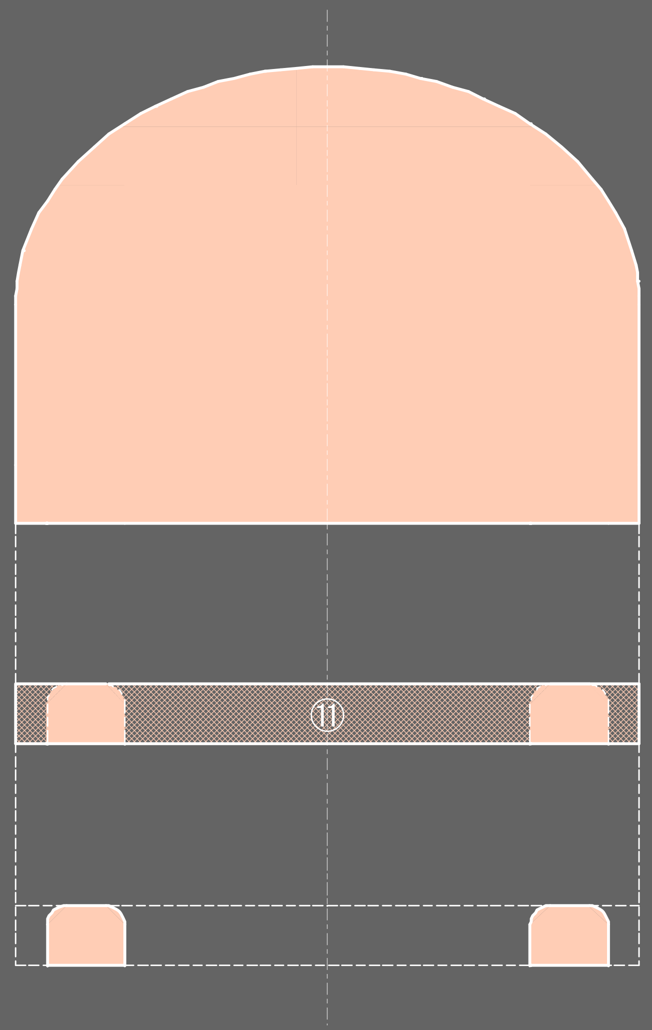
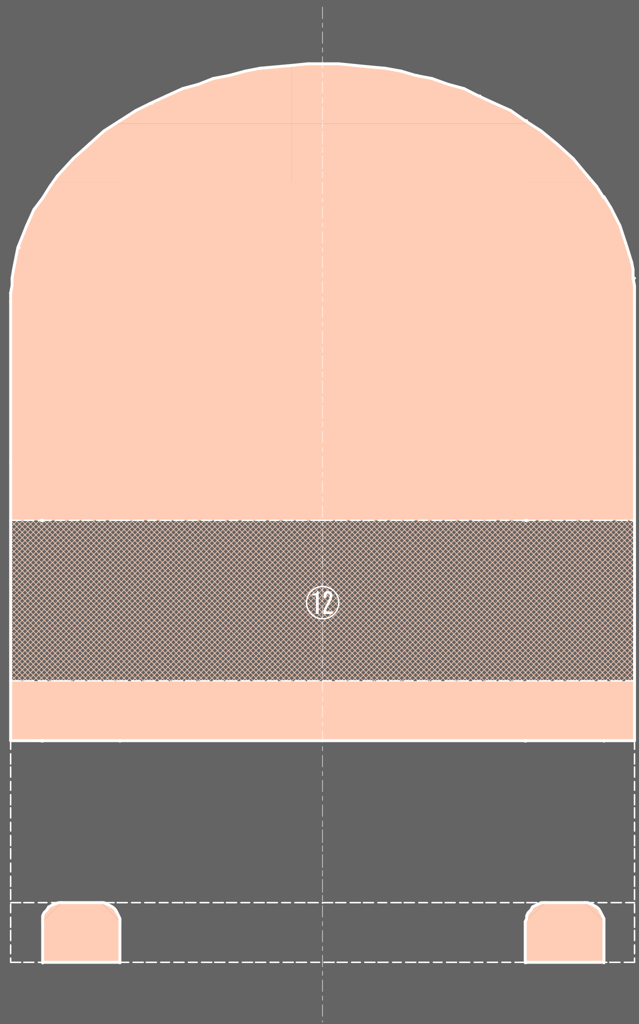
STEP-11



STEP-12



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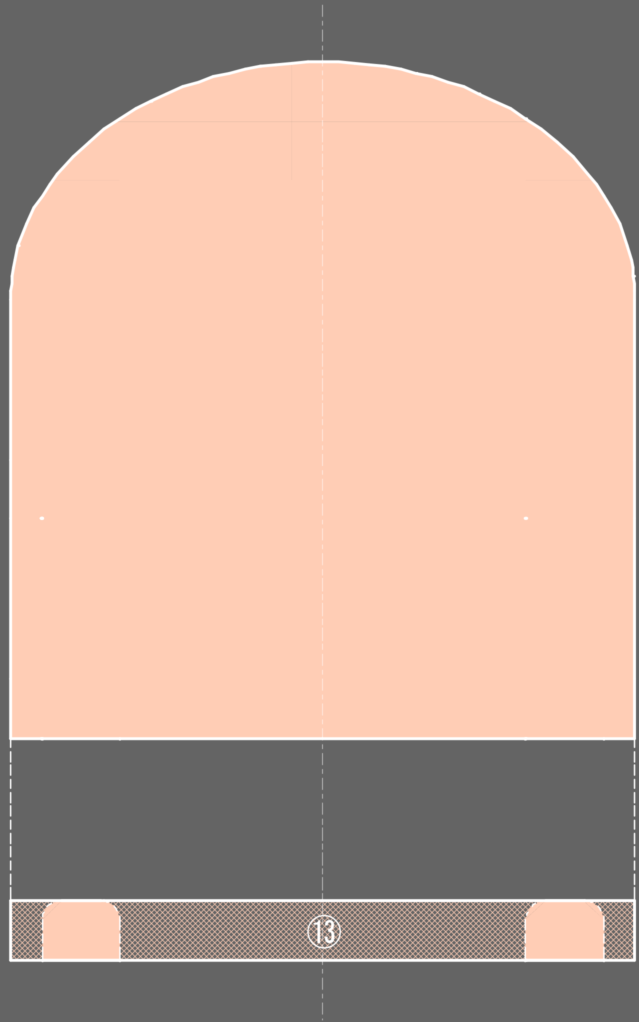

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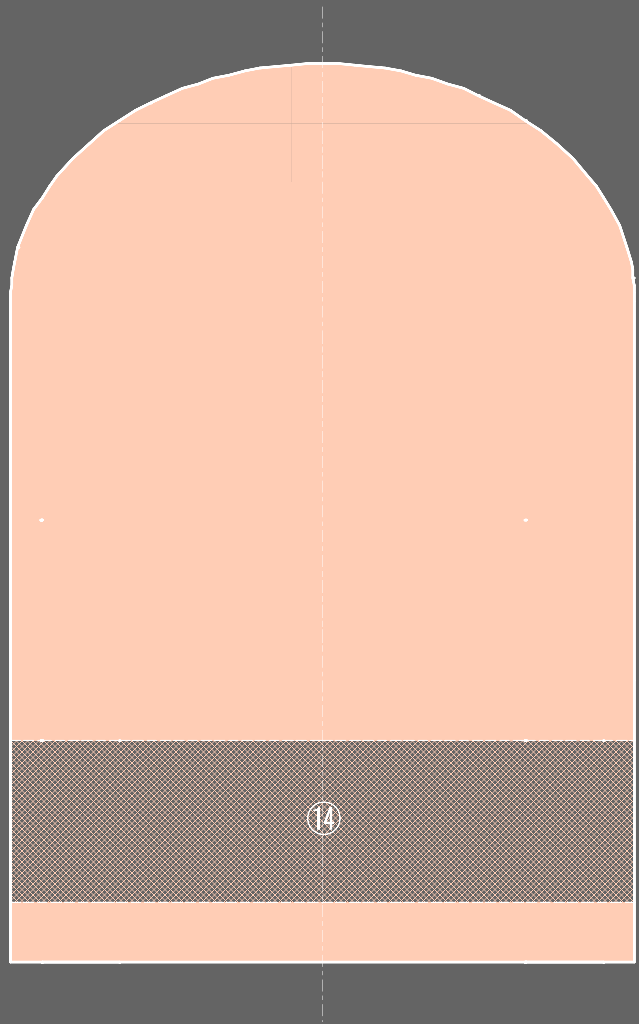
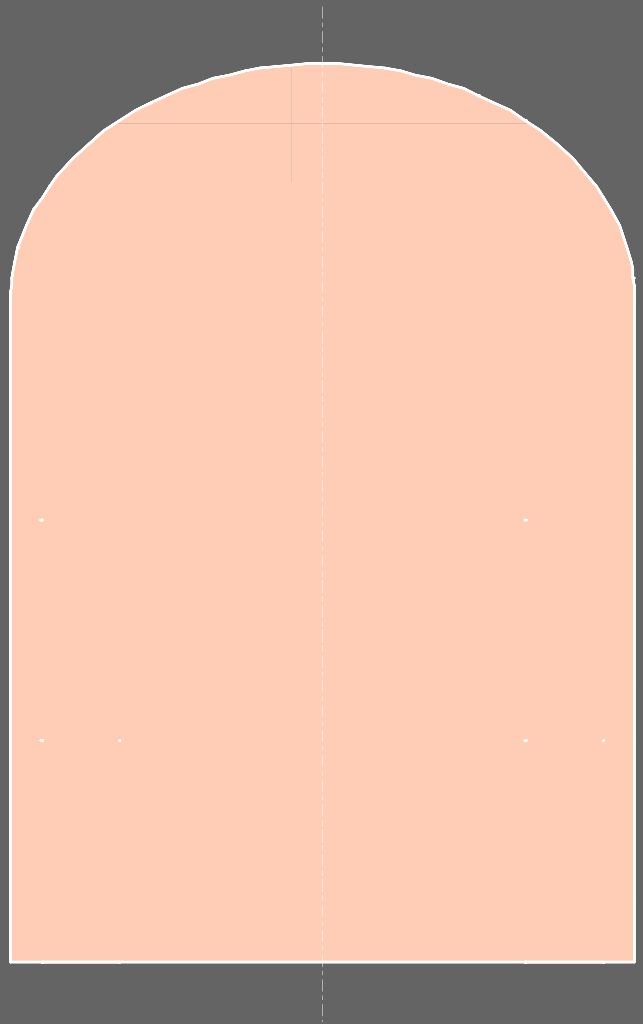


F I N A L

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Super-Kamiokande

BDS layout

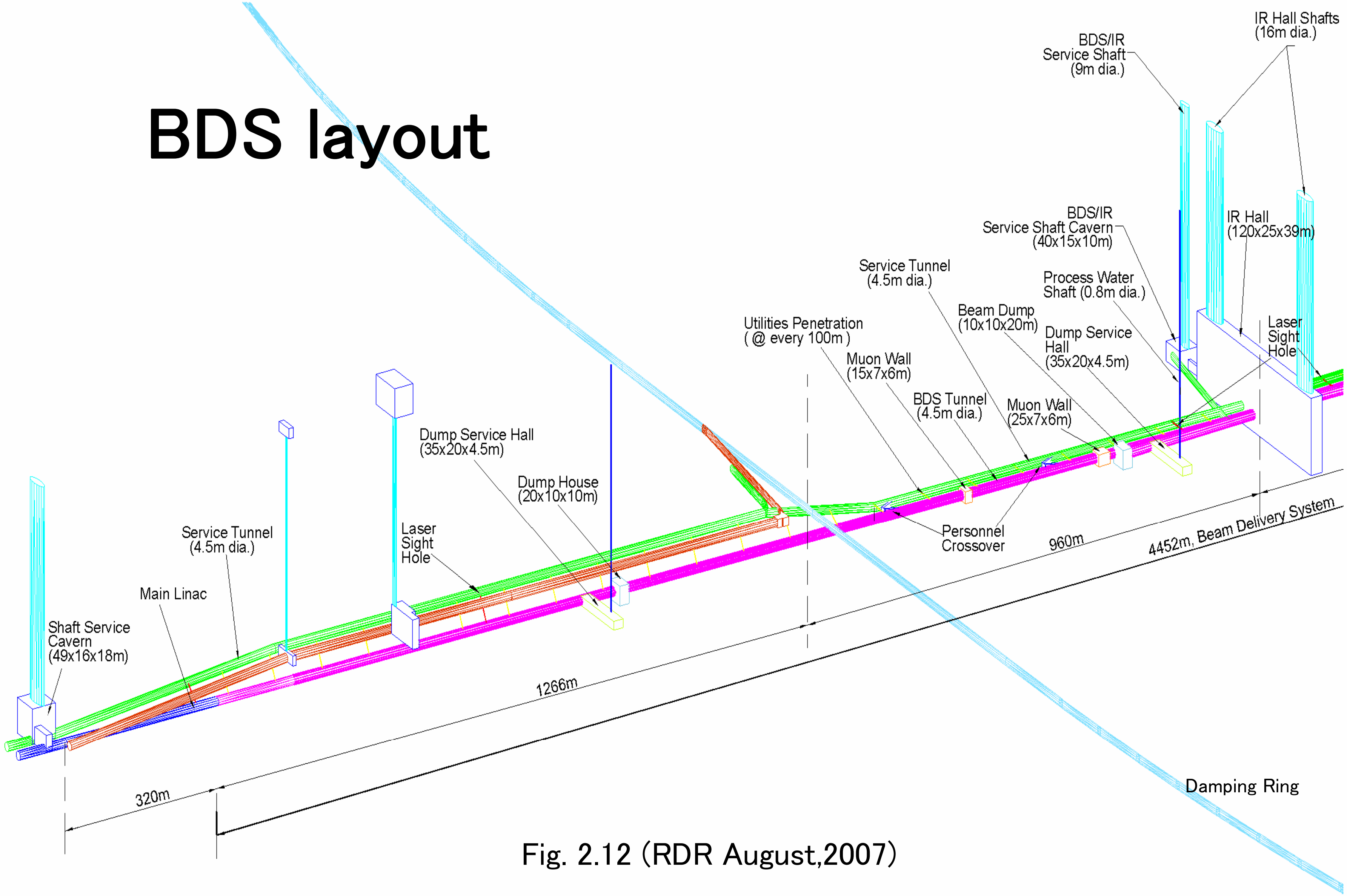

Fig. 2.12 (RDR August,2007)