Excavated Bell pile

Kelly bar type Earth Drilling Rig

Bell pile technique

NIPPON SHARYO, LTD

This [Bell pile technique] which is able to increase the end-bearing capacity of the pile by enlarging its bottom sectional area, has come into wide use in Japan This chapter summarizes outline, work process and equipment of [Bell pile technique] by the use of NISSHA ED-series earth drilling rigs equipped with telescopic Kelly bars and BK-series belling buckets.

Transition in bell pile technique

1890	Chicago tech.	Deep drill/bell with man power
1966	London tech.	Casing + Mechanical drill/bell
1984	ACE tech.	Earth drill rig + belling bucket
1986	OMR/B tech.	
1988	ANS tech.	
1989	SSM tech.	
	HND tech.	
	ATOM tech.	
1992	OSSM tech.	
1998	SUN-BEST tech.	

NISSHA

Total Number of units : 50

ED5500……30

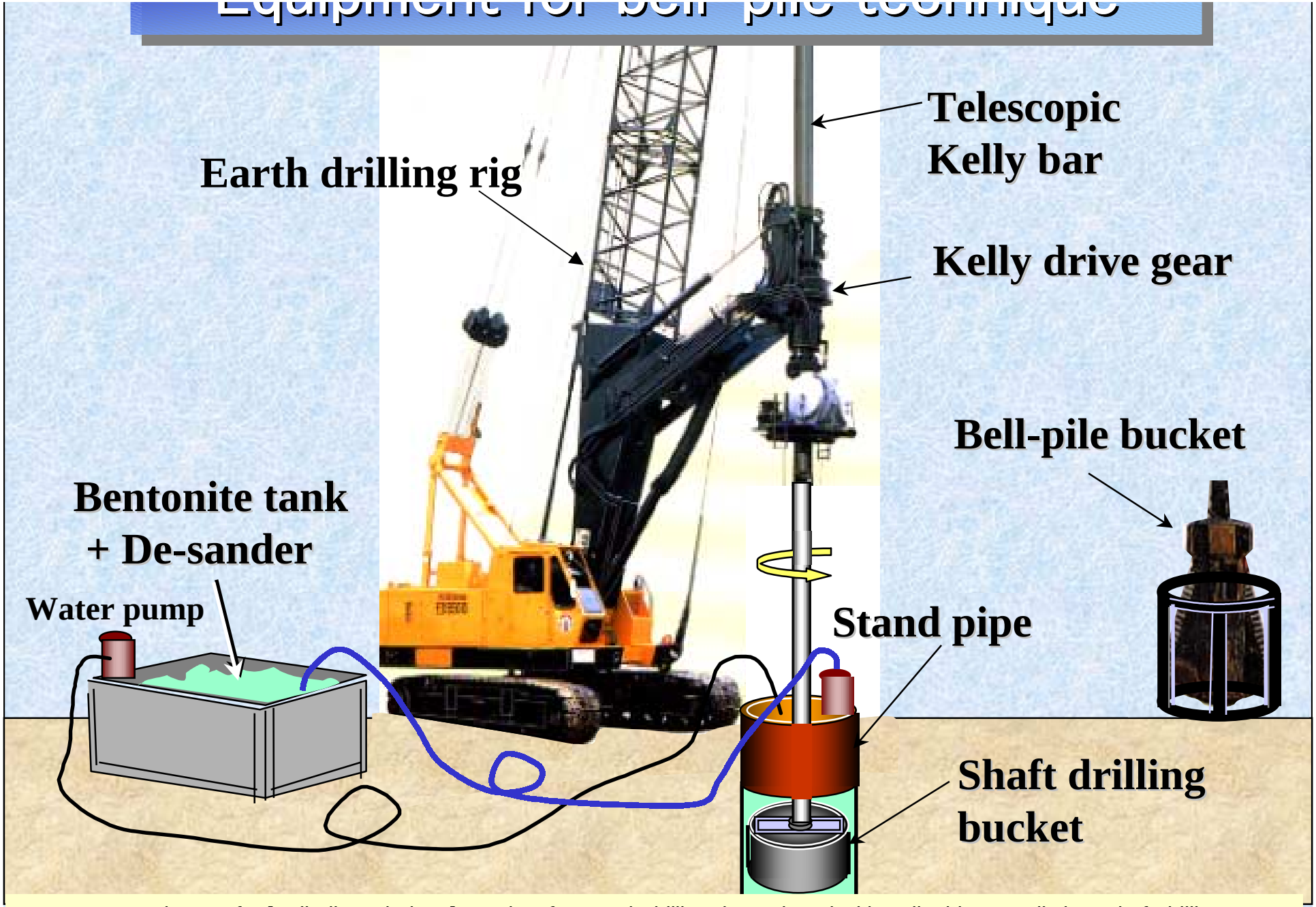
ED6500……20

Technology view and certification approved by Ministry of Construction.

The transition in [Bell pile technique] is as this, starting in 1890 in Chicago and this technique becomes very popular in Japan from 1989 and on for constructing the foundation of medium and high rise buildings.

The population of the equipment to be used for this purpose is supposed to be model NISSHA ED5500-30 units and ED6500-20 units total 50 units from NIPPON SHARYO, and 50-60 units from other manufacturers in Japanese market.

Equipment for bell-pile technique



Necessary equipment for [Bell-pile technique] consist of an earth drilling rig equipped with Kelly drive + Kelly bar, shaft drilling bucket (+ Bell-pile bucket, stand pipe, water pumps + hoses, Bentonite mixer/ de-sander / tank. After drilling the bore hole shaft to the specified depth, replace the shaft drilling bucket with bell-pile bucket to ream the bottom area of the bore hole.

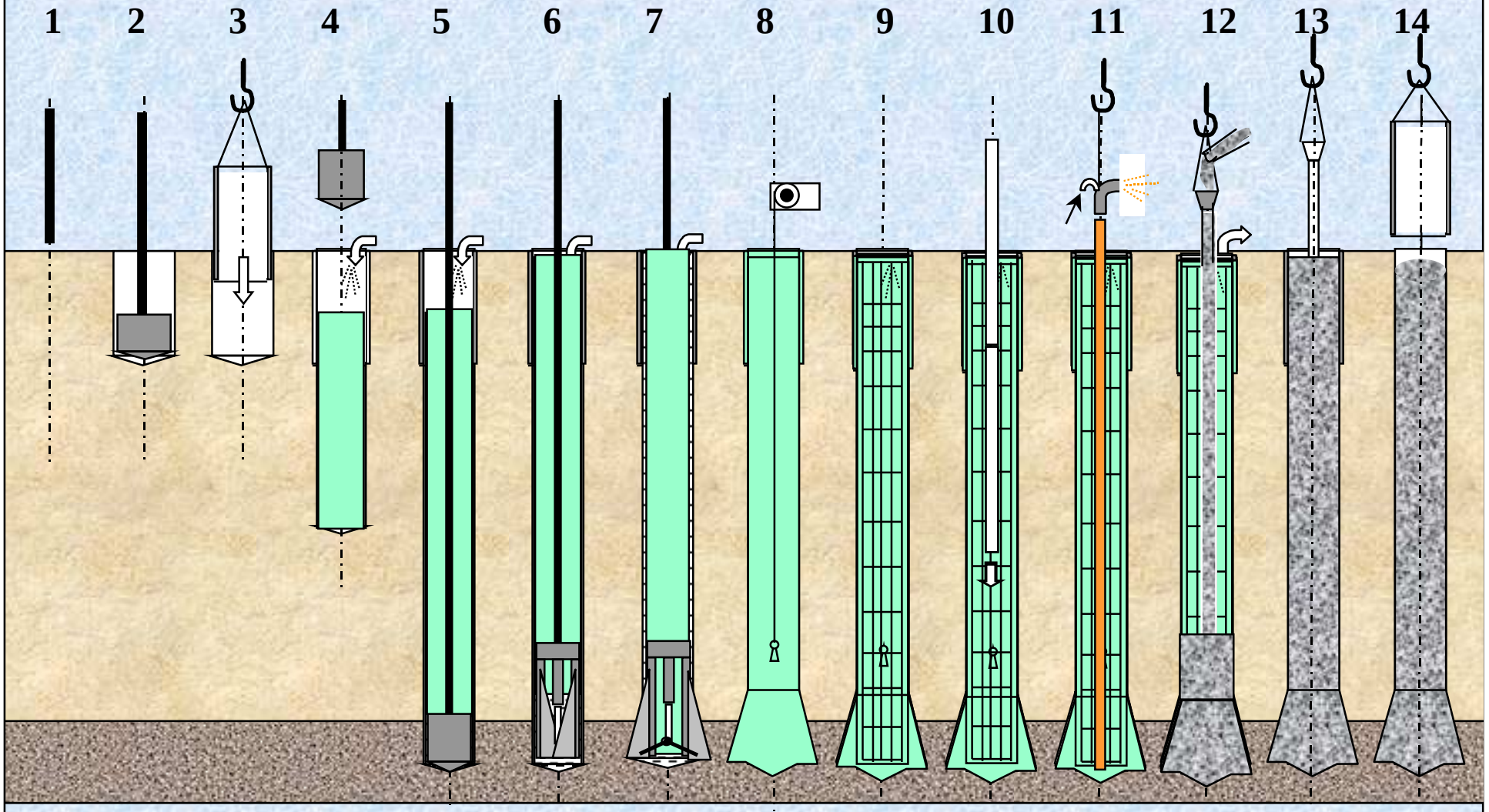
Brief specifications of [NISSHA Earth Boy]

Model of rig	ED5500	ED6200	ED6500
Maximum drilling depth			
without stem rod	**58m**	**62m**	**71m**
with 10m stem rod	**68m**	**-**	**-**
Maximum shaft bore	**2 m**	**3 m**	**3 m**
Maximum bell-pile bore	**3.1m**	**4.1 m**	**4.1 m**
Bucket torque	**6ton-m**	**10.7ton-m**	**13.4/12.2/6.1 ton-m**
Bucket speed (rpm)	**30/15**	**20/10**	**18/10, 18/10, 3/20**
Kelly bar	**Round 4-stage/16.6m**	**Round 5-stage/16.5m**	
Boom lengt	**23m**	**24m**	**26m**
Operating weight	**57.8 t**	**83.5 t**	**116.6 t**

NISSHA offers these three models of Earth Boy series earth drilling rigs equipped with a lattice boom for {Bell-pile technique]. In addition, Model PDH90 is a high power version equipped with a leader which is specially used for constructing bell-piles into comparatively hard stratums.

Typical bored pile work process

in constructing a cast-in-place concrete pile with a bell pile bottom.

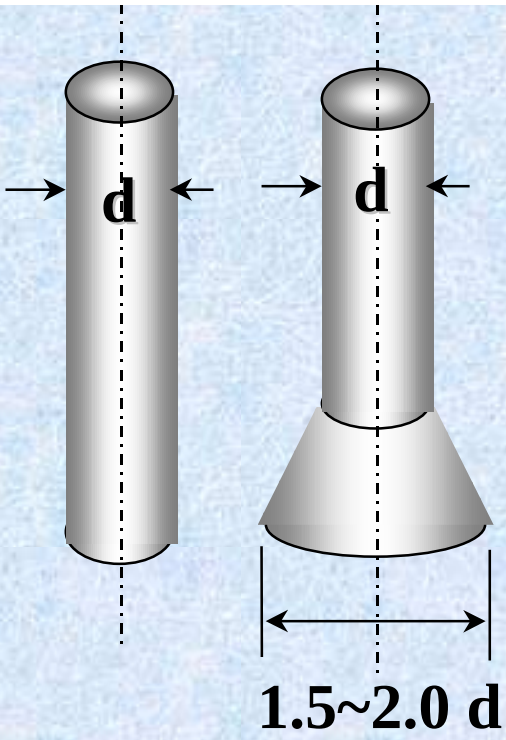


1. Centering 2. Starting drilling 3. Inserting stand pipe 4.Feeding bentonite 5.Drilling till the specified depth 6.Inserting belling bucket 7. Reaming bore hole bottom 8. Measuring depth 9.Setting up iron-reinforcement cage 10. Inserting tremie tube 11. Cleaning slime by an air-lift 12. 13 Concreting 14.Completing cast-in-place concrete pile with belling bottom.

Features of Bell-Pile ①

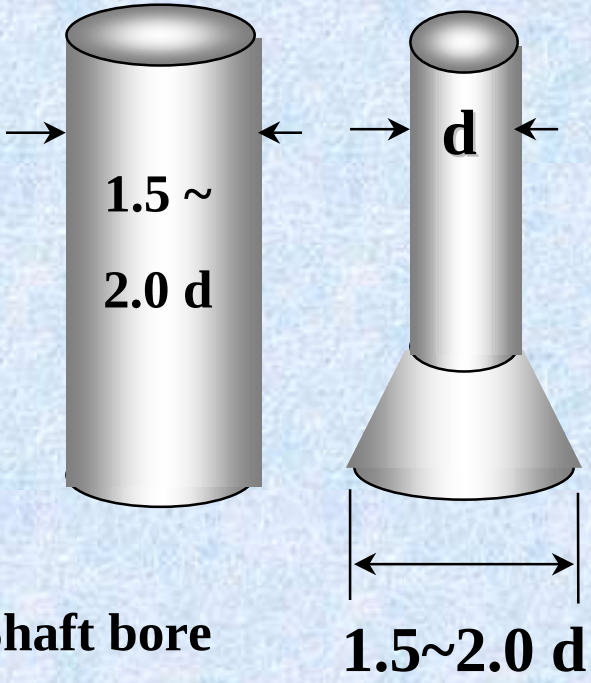
If shaft bore is same….

End bearing capacity is two times and more



If end bearing capacity is same….

Concrete amount is half or less.



Comparison between [Straight pile] and [Bell-pile], if the shaft diameter is the same, then the end bearing area of the bell-pile is twice and more than the one of straight pile. Or if the end bearing area is the same, then the concrete amount to be poured to the bell-pile is half and less than the amount of straight pile.

Jobsites whereby bell-pile is unsuitable

Very soft stratum…… Wall Collapsing

Loosed sandy/gravelly subsoil…… Wall Collapsing

Cobbles having ϕ 10~15cm or larger…. Hard to drill

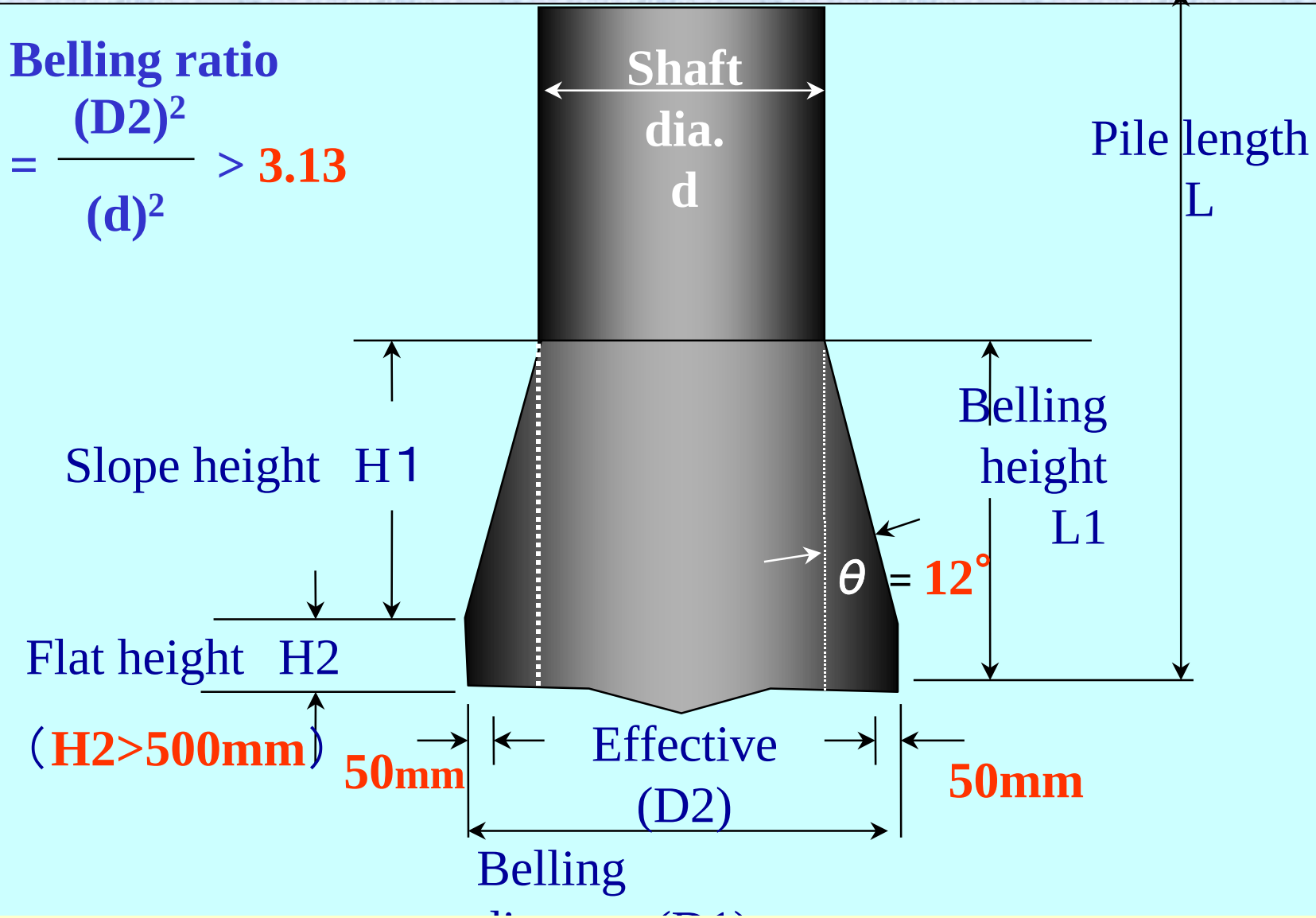
Sloped bearing layer having 30 degrees…Poor vertical and larger accuracy

Pressurized under ground water……Wall collapsing (Pressure : GL + 2m high)

High under ground water current…….. Wall collapsing (Over 3m per min.)

Bearing layer is too hard…….Hard to drill

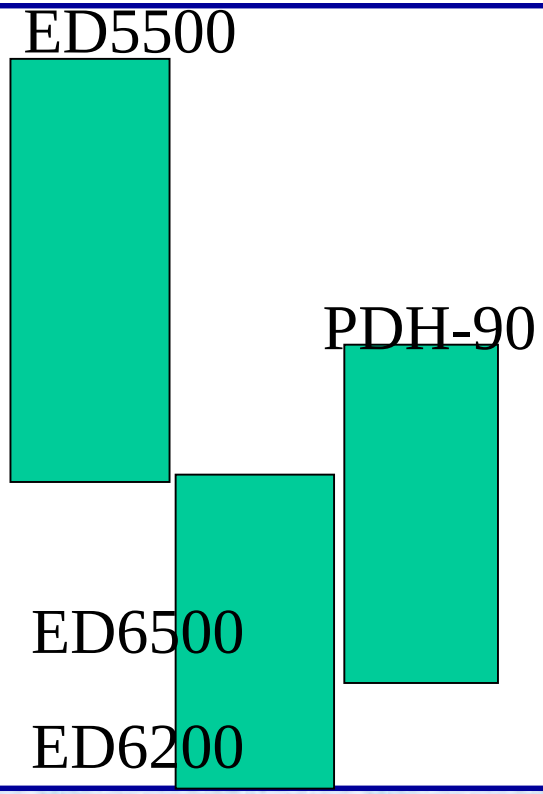
Basic bell-pile shape



Dimensions of belling out are detailed by Ministry of Construction in Japan as shown above. The effective belling out diameter of the bell-pile is actual belling diameter D1 minus 100mm (50 + 50).

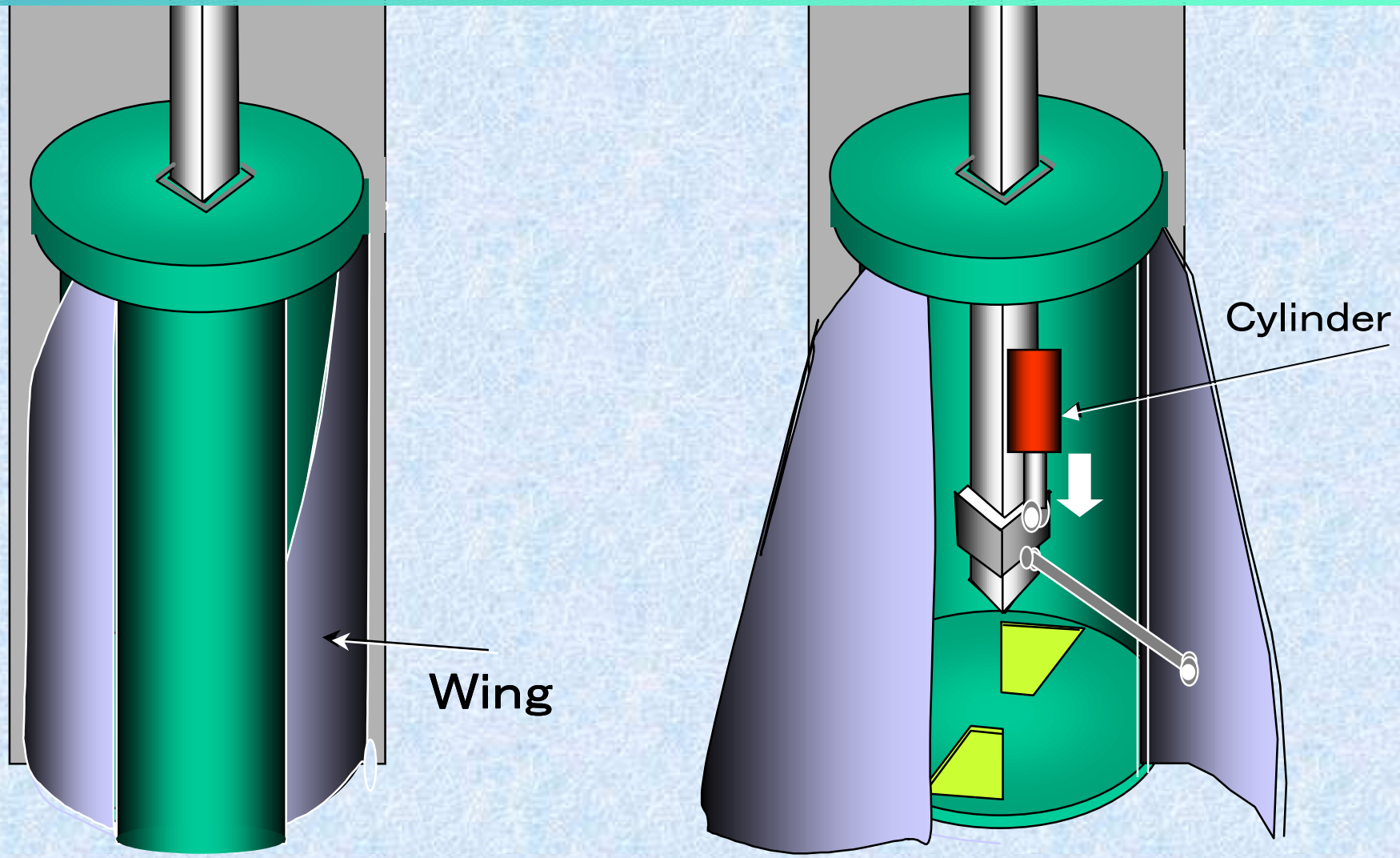
Belling ratio

Type of Bucket	Shaft dia. (d mm)	Bell out dia. (D1 mm)	Capable earth boy
BK-10Ⅱ	1000	1100-1700	
BK-11	1100-1300	1200-1900	
BK-12Ⅱ	1200-1500	1300- 2100	
BK-13	1300-2400	1400-2400	
BK-15Ⅱ	1500-2000	1600-2700	
BK-17	1700-2300	1800-3100	
BK-20	2000-2600	2100-3600	
BK-23	2300-3000	2400-4100	



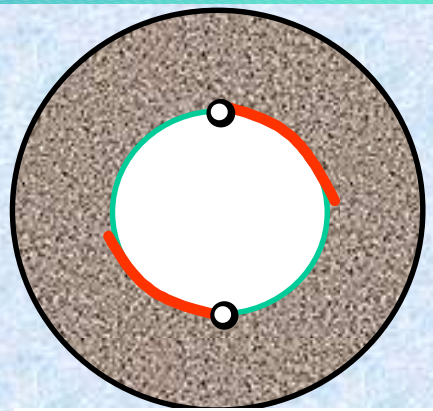
There are 8 models of BK series belling buckets which are equippable to Earth boy series earth drilling rigs depending on their capacity as shown in the table.

Functions and construction of NISSHA BK series belling bucket ①

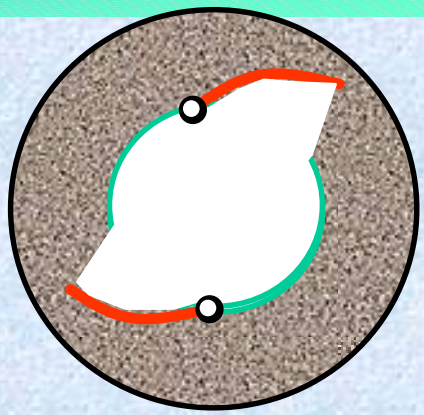


A pair of wings are opened and closed through a sliding rod by a pair of cylinders. An opening ratio of the wing can be detected with a sensor in the cylinder.

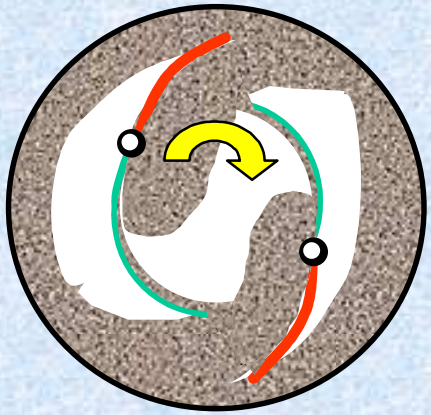
Belling out process



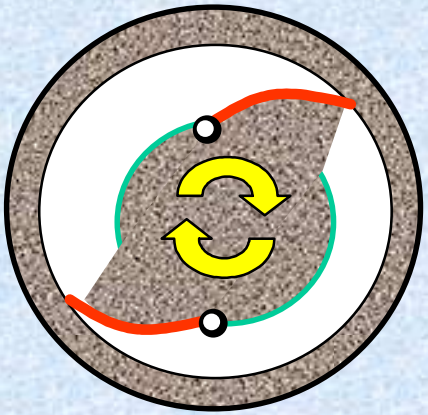
Bucket insertion



Bucket opening



Rotation; drilling



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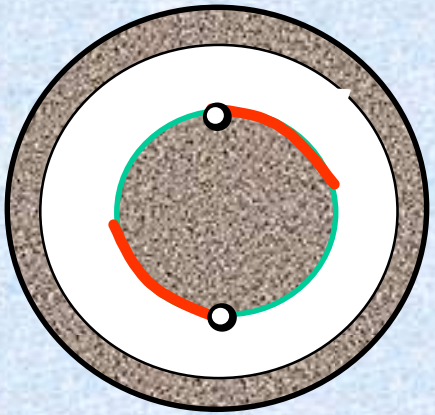
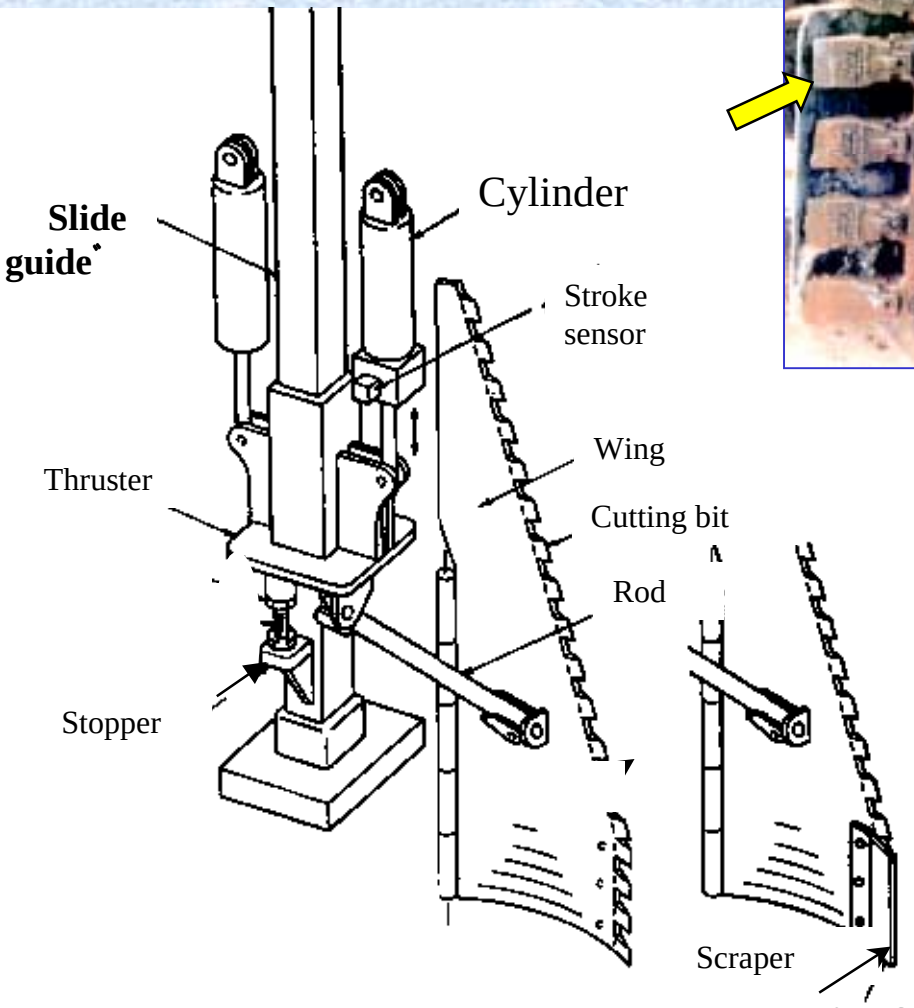


Stop rotation and closing bucket

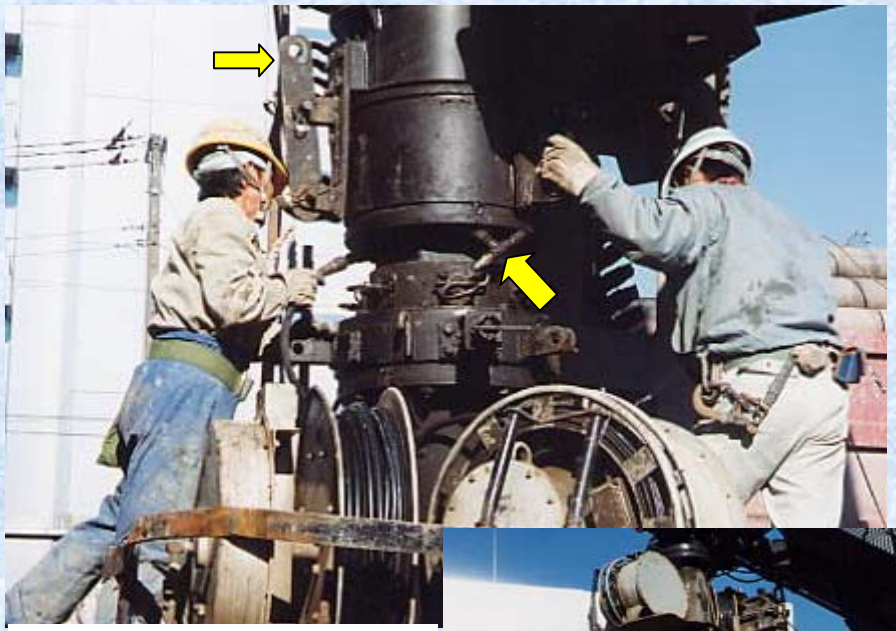
Scraper & Stabilizer

Scraper for cleaning



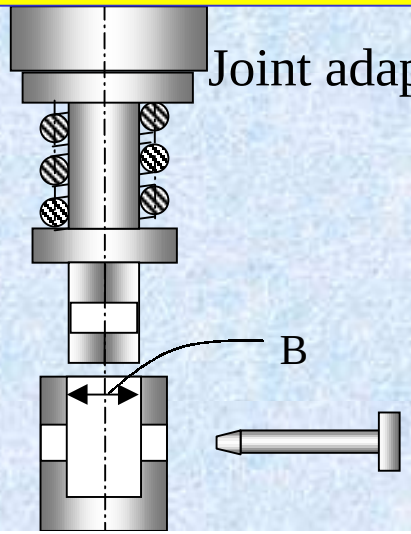
Interchanging of shaft-bell bucket

Belling bucket ↔ Shaft bucket



Hose connection

Rock pin released



	D	Tolerance	R
ED5500（square）	103mm	1.0mm	5mm
DE5500(Round)	142mm	0.5mm	5mm
ED6500 (Round)	142mm	0.5mm	5mm

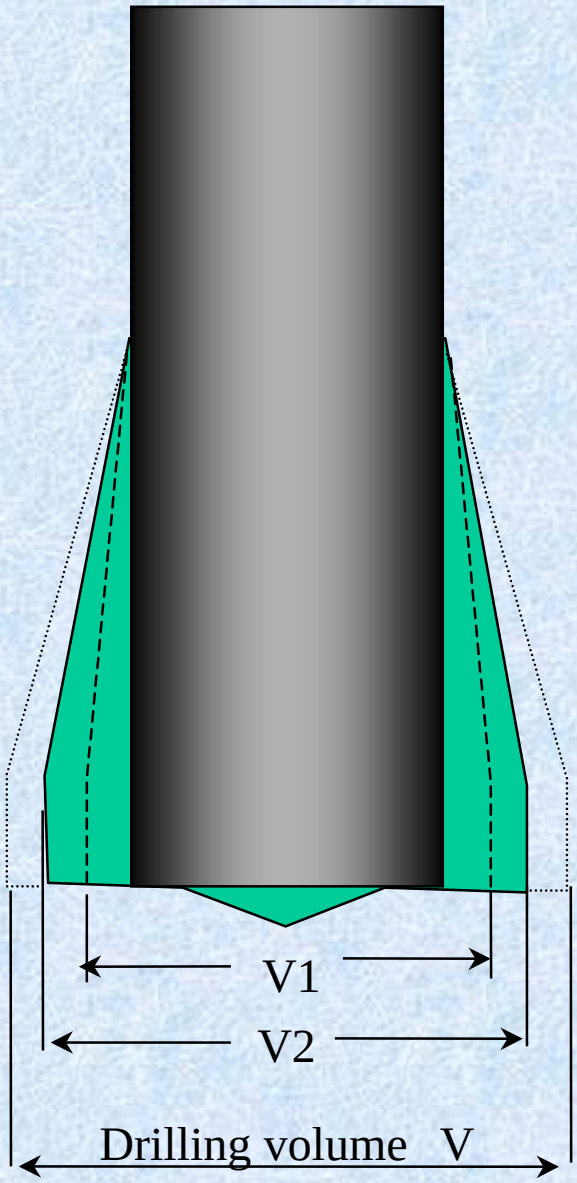
Capacity of belling bucket

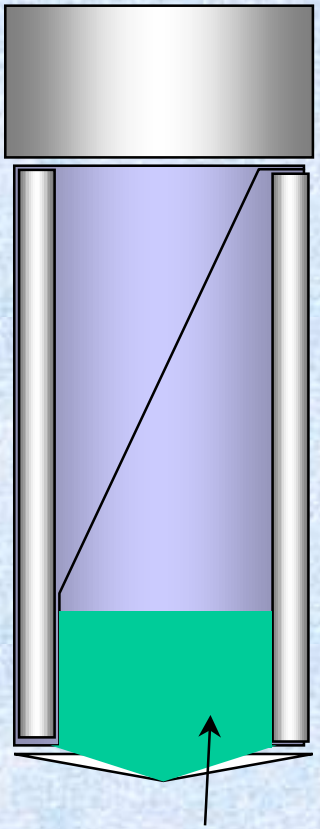
Bucket capacity

VB＞ 1.5 V1

VB＞ 1.5（V2－V1)

1.5 ：Scarifying factor





VB

BK10- 0.17m^3
BK11- 0.20m^3
BK12- 0.26m^3
BK13- 0.32m^3
BK15- 0.45m^3
BK17- 0.60m^3
BK20- 0.90m^3
BK23- 1.20m^3

Bucket capacity VB

Monitor-recorder of bell-pile

1. **Bell-pile sensor**

   Detecting bucket opening ratio

2. **Radio transmitter, batteries**

   Sending data to computer

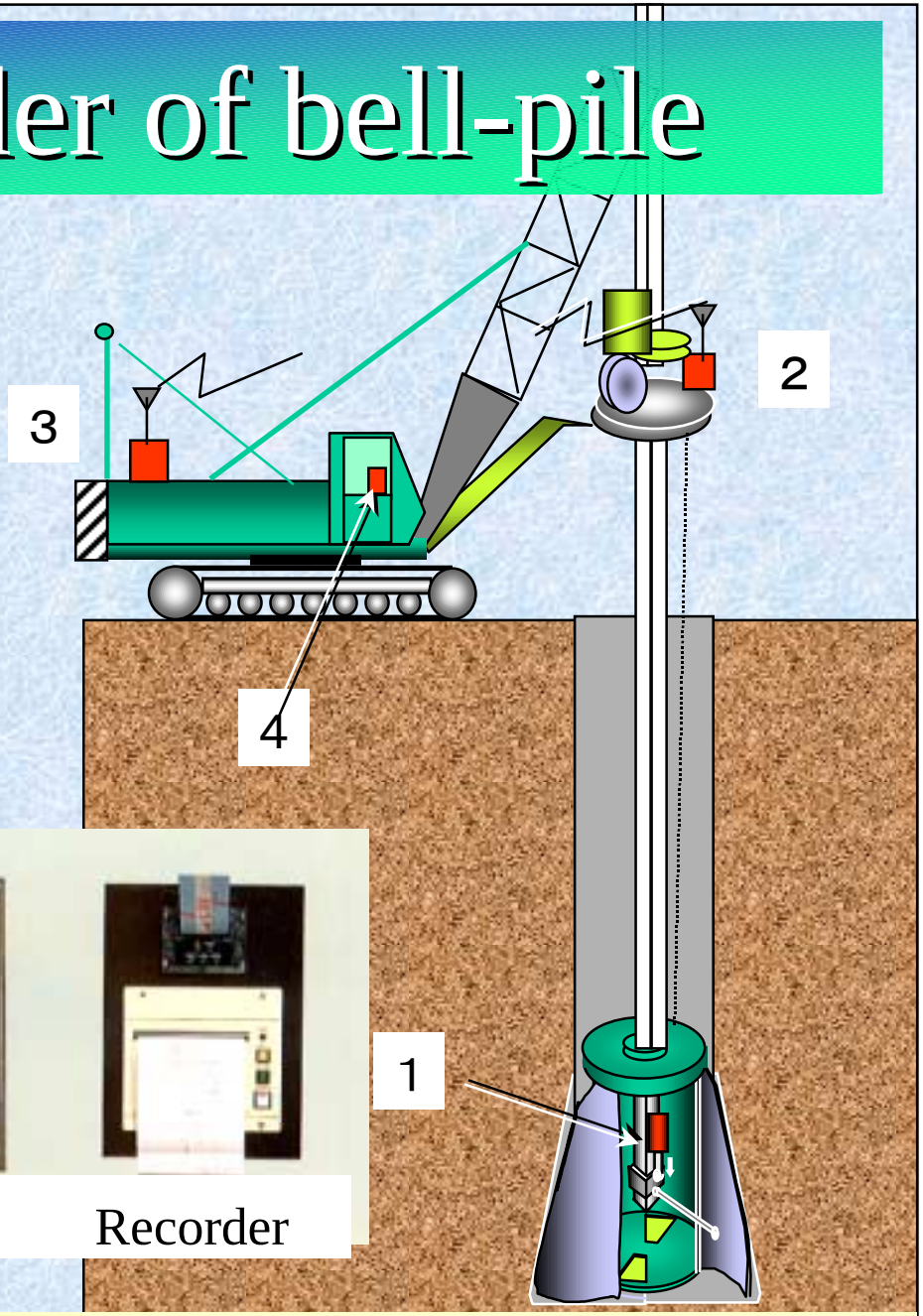
3. **Radio receiver**

4. **Monitor-recorder**

   Bucket opening ratio indication

   Bucket drilling capacity indication

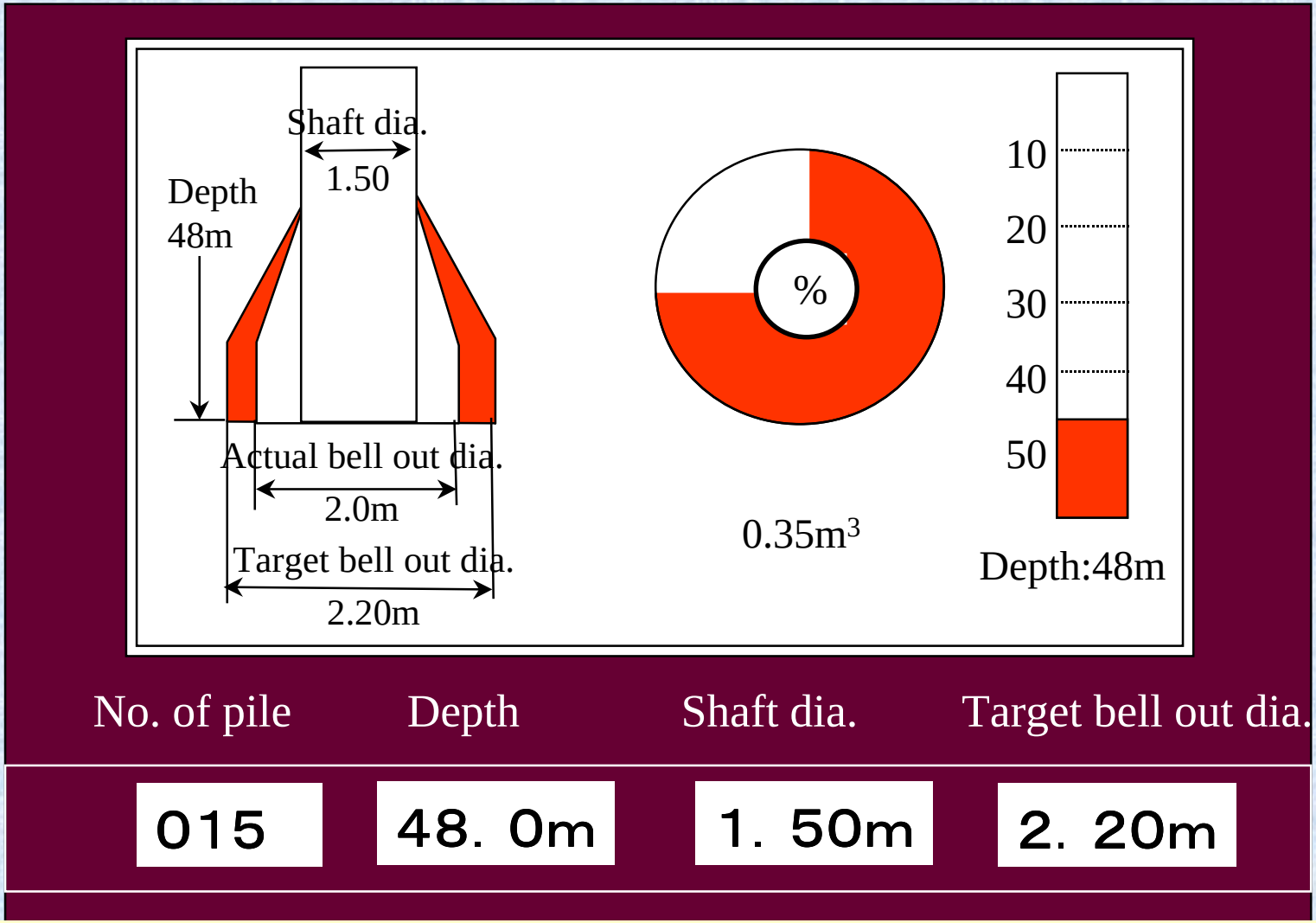
   Drilling depth indication



Monitor Recorder

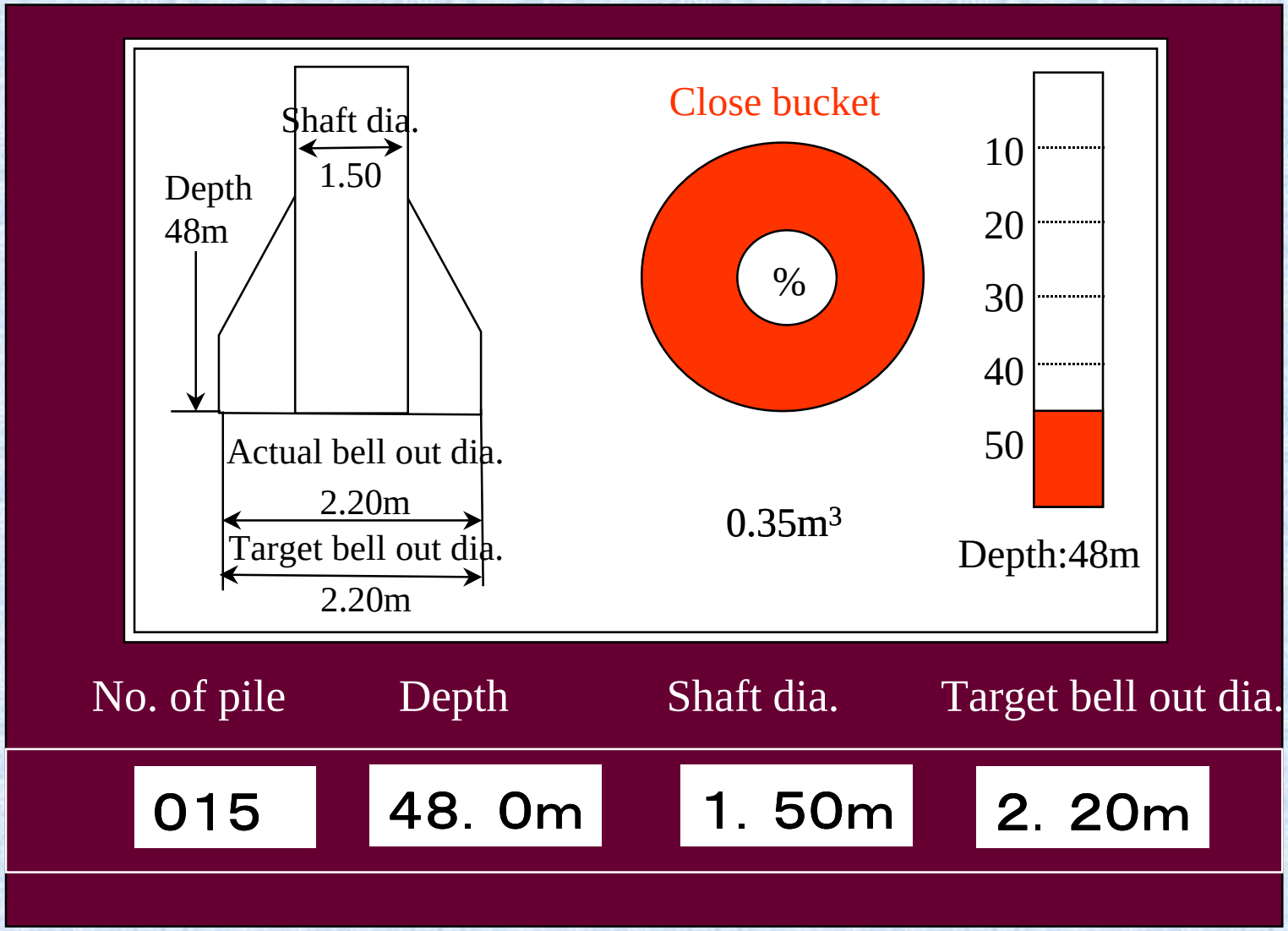
The opening ratio of the belling bucket is detected electrically by the cylinder and its electrical data is transmitted through a radio transmitter to the receiver on the earth drill rig. Bell-pile construction data are monitored and recorded through a monitor and a recorder in the operator's cabin.

Monitor display



The monitor display indicates drilling depth with a bar graph. A circle graph shows the capacity of soil filled in the belling bucket. The left graph shows a cross sectional shape at the bottom of the bore hole, actual belled out diameter and a target bell out diameter are indicated. While the left graph remains a red color shape which indicates the soil to be drilled at the belling out portion.

Monitor display



When the belling bucket is filled up to the specified volume, the circle graph becomes fully red color and voice message sounds [Close bucket]. When the specified bell out shape becomes fully while, then the bell out shape are completed.

Excavated bell-pile for inspection

(Bell pile)

Bucket closed Bucket opened