Transactions of the Korean Nuclear Society Autumn Meeting
Changwon, Korea, December 17-18, 2020

Behavior of Frictional Shallow Anchors subjected to Vertical Loadings in Rock

D. H. Kim [a], S. H. Lee [b]

[a] *Jungang Research Institute of Safety Technology*

[b] *Sangji Univ., Civil Eng. Dept*

[*] *Corresponding author: dhkim2121@daum.net*

Introduction

- Anchors can be used for reinforcement of near slope stability of radioactive waste disposal facilities.

- Full-scale loading tests performed frictional anchors to various lengths at several sites in Korea.

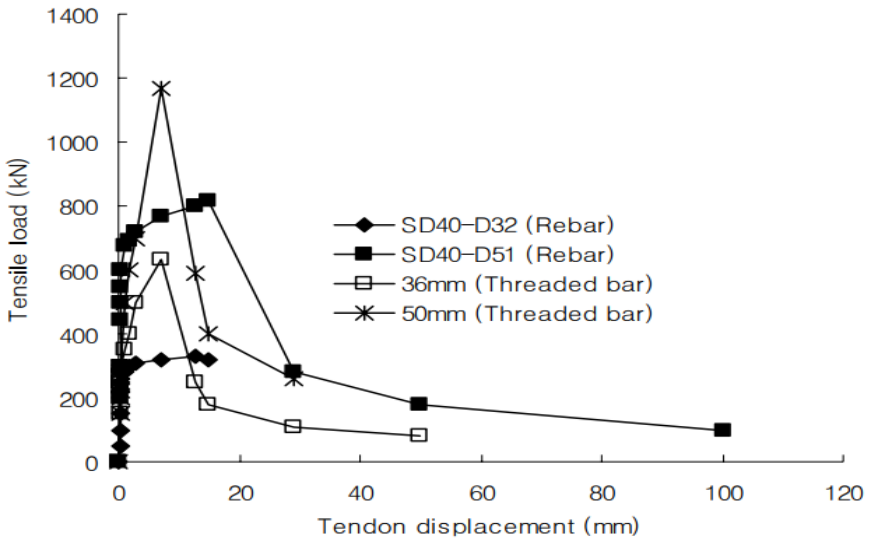
- Laboratory tests were also conducted to investigate the influence of the corrosion protection sheath on the bond strength.

- The main parameters governing the uplift capacity of the rock anchor system were determined.

Laboratory Tests

Table 1. Mechanical properties of anchor and grout types

Anchor types			Yield force (kN)	Compressive strength of grout after 7 days (MPa)
Rebar	SD40-D32	A	305~400	34.3
	SD40-D51	B	770~1011	34.3
Thread bar	36-mm	C	863	34.3
	50-mm	D	1665	34.3



$$\tau = \alpha \cdot f'c \qquad (1)$$

Where, Ultimate bond strength (τ) constant α was found to be 18.5$\pm$ 4 % for the rebar and 21.5$\pm$4 % for the thread bar. Macalloy thread bars have approximately 16 % higher bond strength than the conventional reinforcing bars.

Fig. 1 Load-displacement curves by pullout tests

Full Scale Field Tests (1)

Table 2. Installation of single rock anchors

Depth (m)	Metamorphic rock (Taean)				Sedimentary rock (Changnyong)	Metamorphic rock (Okchun)	Total
	H	M	S	Sub total	M	M	
1.0	2	4	3	9	-	1	10
1.5	1	-	1	2	2	-	4
2.0	3	4	2	9	3	4 (D=32mm)	16
2.5	-	-	2	2	-	2 (D=32mm)	4
2.6	-	1	-	1	-	-	1
3.0	3	3	-	6	4	2 (D=32mm)	12
3.7	-	-	-	-	3	-	3
4.0	1	-	-	1	-	-	1
5.0	-	-	-	-	-	2 (D=32mm)	2
6.0	-	-	-	-	-	1 (D=32mm)	1
Total	10	12	8	30	12	12	54

(H: Highly weathered, M: Moderately weathered, S: Slightly weathered rock)

Table 3. Installation of group rock anchors

No.	Dim. of foundation (m)	Anchor hole		Tendon (each hole) (SD40-D32)	Depth (m)	Location
		Dia. (mm)	No. of Hole			
1	2.5x2.5x1.2	100	8	2	5.0	Okchun
2	2.5x2.5x1.0	100	8	2	5.0	Okchun
3	2.5x2.5x0.8	100	8	2	5.0	Changnyong
4	2.5x2.5x1.0	100	8	2	2.0	Changnyong

bond failures along the interface between grout and rock in the case of very shallow anchor depths of 1~1.5 m in highly weathered

rock-grout bond failure is governed by the rock conditions and the average bond failure is 10~12 % of the unconfined compressive strength of the surrounding rocks.

rock pull-up failures, cracking and heaving on the ground surface were extended radially to a distance equal to the half depth of the anchor

Full Scale Field Tests (2)

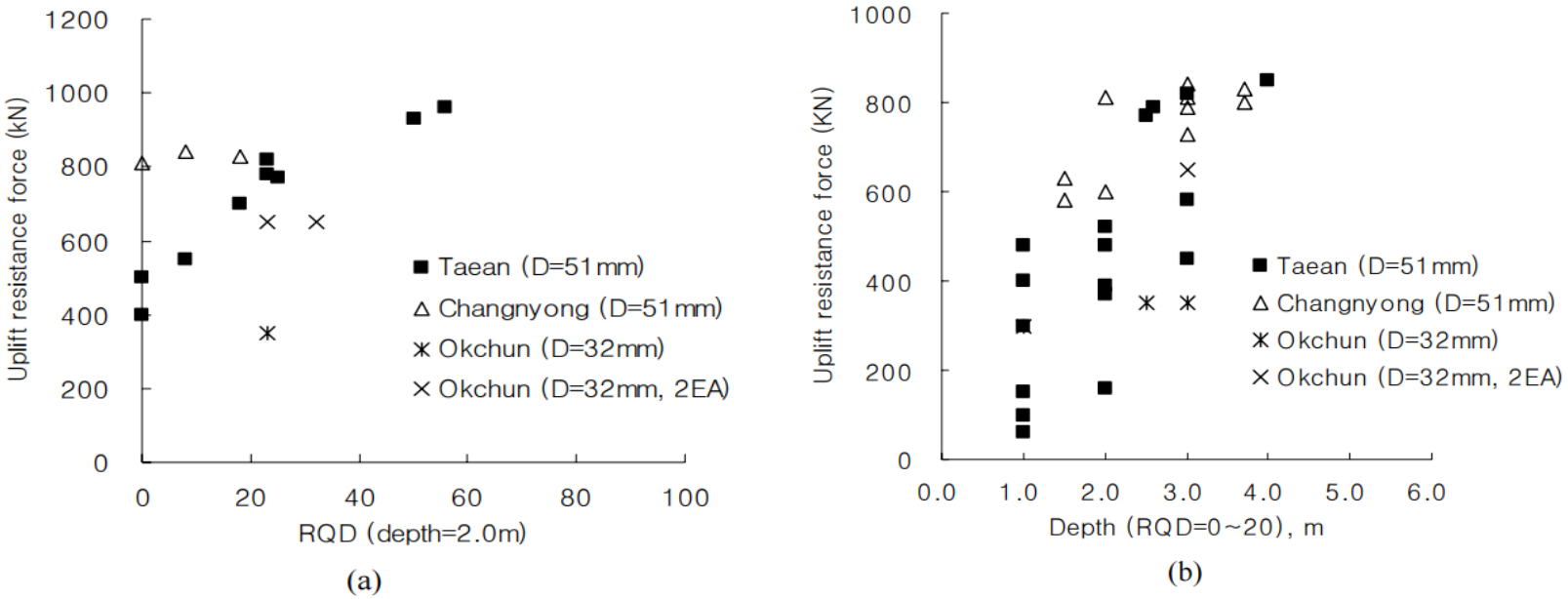


Fig. 2 Uplift resistances vs. embedded length and RQD: (a); (b)

Taean and Changnyong, the uplift resistances measured at the same anchor depth generally increase with RQD

Same RQD also consistently show an increase with fixed depth of the anchor.

rock pull-up failure was estimated to be an inverted cone with the apex at half the embedded depth and having a contained angle of 90° .

Full Scale Field Tests (3)

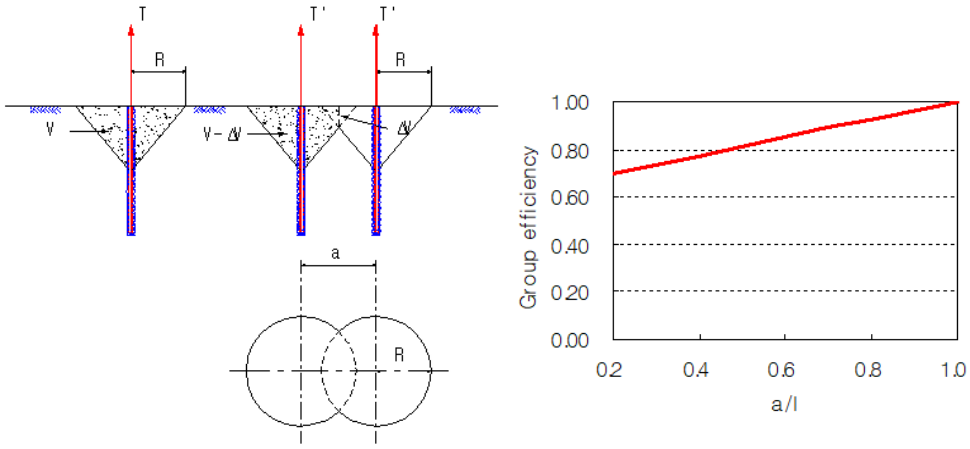


Fig. 3 Group effect of frictional anchor

Efficiency as a function of the ratio a/R, where a is the anchor spacing and R is half of the embedded anchor depth (l). Ratio a/R is greater than 2, the individual anchors in a group have an efficiency of 100 %.

However, it should not be extrapolated below an a/R ratio of 0.4 since group tests were not conducted below this ratio. For the purpose of practical applications, the efficiency (β) of an individual bar in group anchored foundations can be approximated by the following linear equation:

$$\beta = 0.375\,(\frac{a}{l}) + 0.625 \quad for\ 0.2 \le \frac{a}{l} < 1.0 \qquad (2\ a)$$

$$\beta = 1.0 \quad for\ \frac{a}{l} \ge 1.0 \qquad (2\ b)$$

Conclusions

- A review of some recent full-scale and laboratory tests carried out for application in structural foundations was presented.

- From these test results, the uplift capacities and failure modes were evaluated on anchor foundations in various in situ rock masses in several regions in Korea.

- In particular, a number of group anchor tests demonstrated the practical applicability of rock anchor foundations.

- It is believed that the proposed design procedure can be applied to similar anchored structures where pull-out tensile force is considered to be the dominant load.