Use of Innovative Shotcrete-Tube Technology in Excavation Mechanism Instead of Bentonite Clay Cycling

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***Abstract*—Nowadays excavations are mostly performed with bentonite clay cycling which is so inappropriate in economical and timing issues of projects.In this method introduced, all unwanted machinery and constructions are limited and replaced by a simple tube and nozzle designed for shotcreting and restraining the drilled walls, which provides its stability against falling down and also waterproofing bore walls against water streaks, drilled through.In this experimental work, a new device is designed and some tests were accomplished in soils with different properties and all advantages and disadvantages of this brand new method are informed.**

***Index Terms*—Excavation, shotcrete, soil stability, pileimplementation.**

I. Introduction

The routine procedure in drilling performance in weak and wet soils is the bentonite clay usage which protects the walls fallen and prevents water entrance by layers made of, called cake [1].

But Bentonite cycling had many defections which directed us using a new method with bentonite advantages and limiting its defections.

Bentonite cycling defections:

1) In case using bentonite clay with high density, Bentonite causes thickness increment in walls and friction reduction.
2) In case using pits for concrete piles, the bentonite remained on steel reinforcement cages prevents proper engaging between steel and concrete used.
3) The sand separating process for a pit with 1(m) diameter and 30(m) depth gets 30 to 45 minutes of whole project timing.
4) 1nun-stop suction or injection cycles to exit old bentonite and, new bentonite entry.
5) In soils with high falling risks bentonite clay doesn't have the common efficiency which it replaces with casing pipes in upper parts.

Designed device introduction

This device is made up of 2 important parts:

- Shotcrete rotator nuzzle
- Dentate tube

1) Shot Crete rotator nuzzle

The shotcrete nuzzle is designed to have a rotary motion so it makes a uniform concrete surface through walls. Also a water jet nuzzle is placed beside shotcrete nuzzle to supply water needs of shotcrete shout through walls.

2) Dentate tube

For concrete stability on walls and providing charisma time for concrete shout through walls, a dentate rubber tube with Anti-adhesion properties was designed to reduce concrete rebound and insure concrete charisma timing needs.

The mechanism of this tube is based on suction and pumping air as shown in Fig. 1.

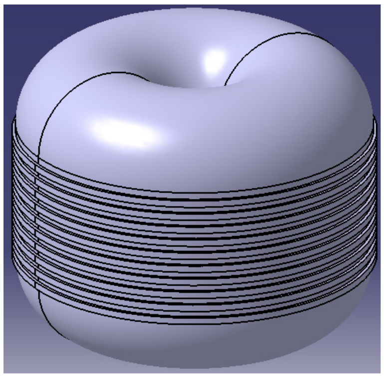

Fig. 1. Plastic air tube

Another reason for using dentate tube, is the friction increment between main concrete used for piles and walls.

The dimensions of this designed tube with shotcrete nuzzle are shown in Fig. 2 (a)

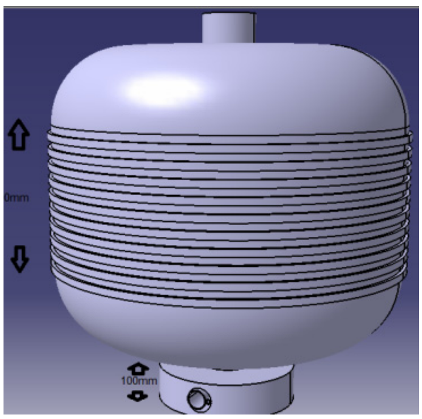

Fig. 2 (a). Tube and shotcrete nuzzle

This tube has no movement connection with auger drilling parts so it has a separated monitoring system.

II. Designed Device Procedure

Bucket and shotcrete-tube device should work in harmonious, so all devices would be matched and work together.

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The shotcrete nuzzle has the same rotation rate speed and is sticking to bucket shaft, but tube part has a separated mechanism and has no movement connections to bucket shaft due to Leadscrew used in tube's inner section.

Cooperation procedure

By devices startup, drilling bucket starts the excavation and descends through soil layers.

The upper soil parts would be restrained by bucket walls, and right after the point bucket passes soil's surface, shotcrete pump and water jet stars being shout through pit walls to make a regulated shotcrete surface.

After 30 to 40 (cm) of shotcreting upper parts, the dentate tube's pump starts to blow up the tube till it reaches the shotcrete surface to hold it and provide its early charisma timing. After reaching the proper stability on walls the tube releases the pressed air content so the tube gets its early distance with walls to continue its functions.

The whole completed device with its dimensions is shown in Fig. 2 (b).

III. Experimental Program

The main idea of this experimental work is based on shotcrete usage possibility in pits with high falling risks and observing results of the major shotcrete surface properties, which the shotcrete mixture is written for [2].

It was decided to use 3 different soil-made standing walls with minimum 3% water content to simulate the worst instability conditions instead of real conditions in major digging projects[3], [4].

The standing walls had 65cm height and 35cm depth as shown in Fig. 3.

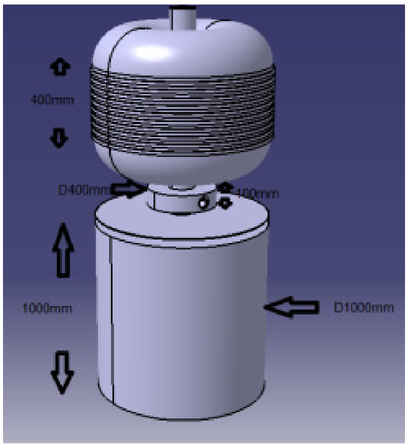
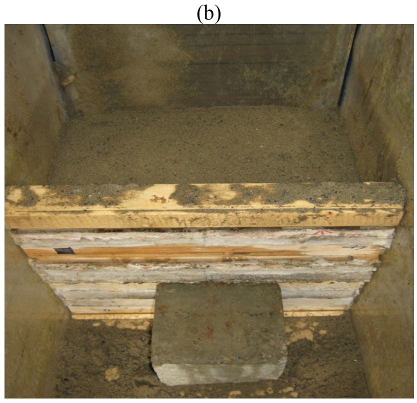


Fig. 2. (b) Final device

(a)

(b)



(c)

Fig. 3. (a, b, c) Soil-made standing walls format

All 3 soils are known as unreliable textures which have made many problems in different excavation projects [4]. These 3 different soils were made and classified accordant to world reference base for soil resources as shown in Table I

TABLE I (a): Samples Physical Properties

sample	sand%	silt%	clay%	Texture	Permeability k(mm/sec)
wall 1	87.1	4.3	8.6	loamy sand	0.0097
wall 2	35.5	20.8	43.7	Clay	0.00031
Wall3	72.9	13	14.1	sandy loam	0.0064

sand 63-4000 μm
silt 2-63 μm
clay < 2 μm

TABLE I (b): Samples Chemical Properties

sample	TiO_2	Al_2O_3	Fe_2O_3	MnO
	%			
wall 1	8.7	19.3	44.1	0.3
wall 2	2.5	12.8	11.3	0.2
wall 3	5.1	13.4	32.7	0.3

The shotcrete mixture proportion was written for this particular experiment with special ingredients such as cement based waterproof and epoxy powders to result wanted properties of shotcrete such as pastiness and waterproofing. To accelerate the charisma timing it would be more proper using type III Portland cement as used in this experiment.

The main idea of using epoxy powder in concrete mixture is the stone-made layers through drilling wells, which have less pastiness with common concrete mixes versus other soil textures.

The specific shotcrete mix proportion is shown at Table II

TABLE II: SHOTCRETE PROPORTION

portland III cement	fine.agg <4.75 mm	course.agg 4.75-20 mm	w/c ratio	waterproof powder wp-60	epoxy powder A-321
Kg/m3					
365	570	1190	0.19	7.3	5.47

It was decided to use aggregates with less dimensions instead of common aggregates, due to small shotcrete nuzzle and more pastiness which fine aggregates show, against course ones.

The shotcrete process was done in 5 steps by removing 5cm of upper wood shields and shotcreting removed area and so on to simulate real digging conditions.

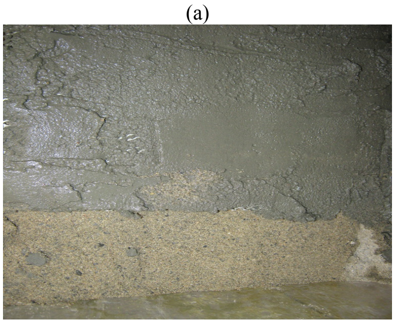
Waterproofing test

For this test, all 3 soil-made walls were irrigated by 10lits of water during the shotcrete pumping, to examine shotcrete mixture efficiency.

IV. RESULTS

The second wall with clay texture had the most rebound percentage of shotcrete, shown in Fig. 5.

(a)



(b)shotcreting upper parts

Fig. 4. (a, b) Shotcrete walls

But it wouldn't cause serious problems in real digging process by bucket protection shield presence, considered in designing set.

In waterproofing test the major volume of water was drained from edging parts of the surface which proves mixture waterproofing efficiency during shotcrete process.

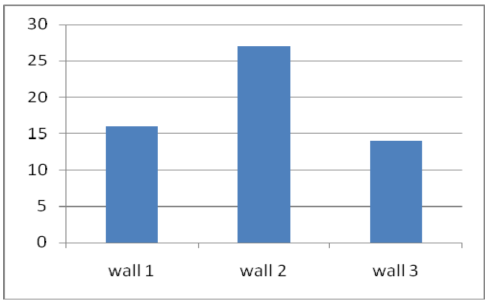
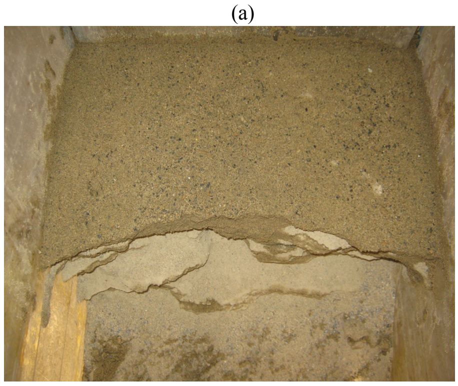


Fig. 5. Approximate shotcrete rebound percentage

(a)



(b)

Fig. 6. (a, b) Different soil-made walls instability

The soil-made standing walls were so unstable without outer shotcrete shields as shown in Fig. 6.

V. CONCLUSIONS

Due to high costs of bentonite clay cycling in excavations, the introduced mechanism and mixtures seem to be more efficiency which includes many device and structure limitations such as sand separating systems and bentonite pools which requires enormous areas to be placed [5].

Also many bentonite presence defections specially, in pile implementations should be limited as the designed device and its procedure is planed for.

Another important reason which makes this mechanism more executive, is its proper usage in fine soils with high collapsing risks and places with water streak layers due to device and mixture's special properties [6].

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