

CONSOLIDATION OF EMBANKMENT AND SLOPE WITH ANCHORED CONCRETE PLATES

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1. Introduction

Strengthening embankment and slopes into the altered fissured rocks can be performed by their consolidation with reinforced concrete plates, anchored, which are mounted depending digging (performed on stages).

The anchors are constructive elements inserted into a rock in order to take forces from ground on them direction or transversal on it (for the anchors (called "passive") or in order to transmit compression efforts in case of pre-stressed anchors, (called "active"). An anchor consists in three parts: (anchor head, anchor body (tendon) and anchor root). The anchor head is used for anchorage, on the rock surface by a plate. The anchor body joints the head with the root (the anchor root is the interior end, which use for its anchorage into the rock).

Sometimes, is used a combination between long anchors which are tensioned and short passive anchors which sustain a metallic or plastic net which is gunite covered.

Strengthening of existing unstable embankments (fig. 1), by anchoring the shallow mass with ties having them root anchored into the base rock, improve their stability.

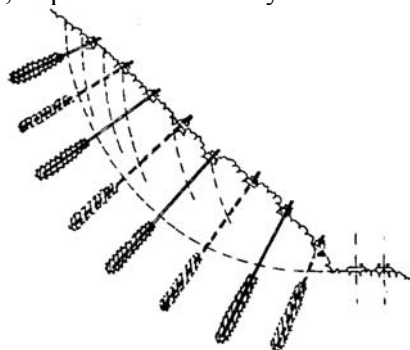


Fig.1. An existing slope stability by anchoring long

2. Execution of works using pre-stressed ties

Tensioned anchorages can be performed with the installation (fig. 2) CMV Drilling K1200 (2.80 width in chain tracks) and injection pump Drake, going through several stages:

- Drilling of holes;
- Performing the anchors;
- Fixing the anchors;
- Tensioning the anchors;
- Injection of drilling.

Rotary drillings are performed under the designed angles, on minimum diameter of 133 mm (with or without tube) function of land.

During drilling, is constantly observing the evacuated detritus and groundwater level, the drilling length should be 5-10 cm bigger than depth on which the anchoring rod is inserted.

The main components of the anchoring rod (fig.3) are:

- steel wire SBP 1 07mm;
- un-perforated PVC tube in the bulb anchorage area, smooth PVC tube to protect the free zone of the anchoring tie;
- steel clamps for contracting the SBP steel wire between two spacers;
- inside and outside PVC tubes for injection;
- PVC tube for inside aeration;
- outside PVC spacers;
- anchorage with head type cone;
- concrete block to maintain effort in anchor;
- blocking cones;
- distribution board, anchor plate;
- sleeve
- metal cover;
- separation shutter of bulb.

The injection of drillings for multistage anchoring ties and their tension (fig. 4, 5) is performed as follows:

- outside injection along whole anchor is performed after tensioning of tie (min. 14 days after inside injection), ascending by the external injection tube;
- inside injection of the tie bulb is performed through the inside injection tube.

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Fig.2. *Drill hole (hole punch)*

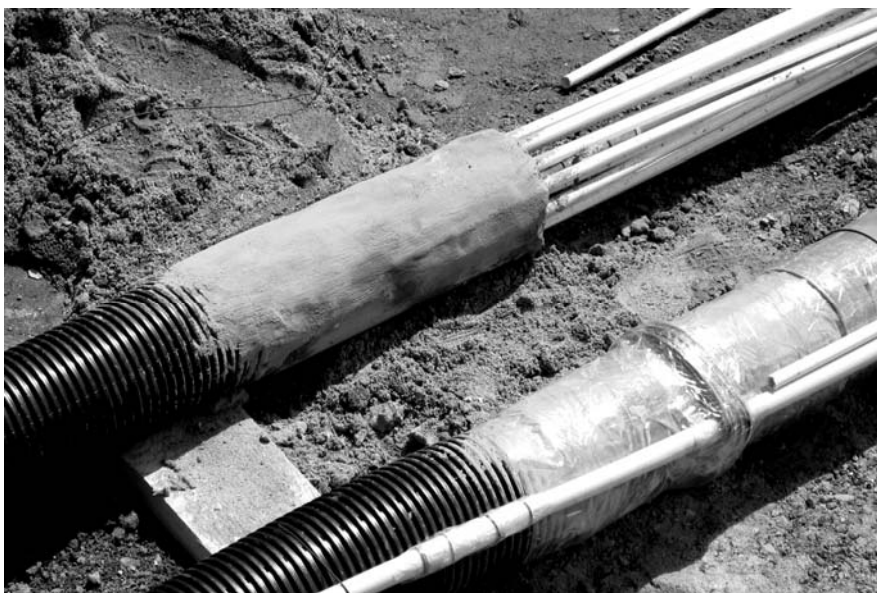


Fig.3. *Making anchors*



Fig.4. *Mounting and fixing bolts*



Fig.5. Tension anchors

3. Comparative costs of slope consolidation works

Version I : Strengthening and protection works with concrete retaining wall						
No.	Code no.	Description of works	UM	Quantity	Unit price (lei)	Total value (lei)
1	E4b	Excavation with scaffolding for the foundation wall	m ³	5610.0	17845	100110.45
2	E4	Excavation for cutting in very hard soil	m ³	3200.0	17845	157104
3	F1	Excavation in hard rock in large spaces without explosives	m ³	1380.0	87.634	120934
4	E5a	Filling with earth taken from cuttings	m ³	1530.0	6.579	10065.87
5	2 C10a	Concrete C12/15 concrete for foundations	m ³	1940.0	399.51	775055.2
6	2B 15b	Concrete C16/20 for elevations	m ³	2940.0	211.60	622112.8
7	2 B 11	Formwork	m ²	2800.0	32.46	90.902
8	2 C 9 b	PC 52 Reinforcement	t	1.6	3076.4	4922.3
9	2B 17a	Rubble stone drain	m ³	1260.0	108.57	136804.5
10	T2	Geotextile	m ²	890.0	17.63	15690.7
11	T1	Weepers	m	360.0	18.49	6656.4
12	C4b	Concrete riprap	m ²	380.0	96.105	36520
13	2 B 28	Steel anchors L = 2m	m	600.0	86	51600
14	2 B 28 b	Fixing anchors 2 "	pcs	300.0	43	12900
15	2 C 9 c	Tied nets	m ²	1800.0	83.85	150930
Total						2192307.7

Ir results: 2192307.7:152 m = 14615.38 lei/ linear m of slope

Version II: Strengthening and protection works with anchored concrete plates and retaining wall						
No.	Code no.	Description of works	UM	Quantity	Unit price (lei)	Total value (lei)
1	E4b	Excavation with scaffolding for the foundation wall	m ³	600.0	17845	10707
2	E4	Excavation for cutting in very hard soil	m ³	1100.0	17845	19629
3	F1	Excavation in hard rock in large spaces without explosives	m ³	470.0	87634	41187
4	E5a	Filling with earth taken from cuttings	m ³	400.0	6.58	2632
5	2 C10a1	Concrete C8/10 for fillings behind plates	m ³	440.0	211.52	93067
6	2 C10a	Concrete C12/15 for foundations	m ³	380.0	399.51	151815
7	2 B 15b	Concrete C16/20 for elevations	m ³	190.0	211.60	40204
8	2 C10a1b	Concrete C20/25 into precast plates	m ³	315.0	211.60	66655
9	2 B 11	Formworks	m ²	1005.0	32.46	32627.3
10	2 C 9 a	OB 37 Reinforcement	t	20.7	2866.25	59331.4
11	2 C 9 b	PC 52 Reinforcement	t	18.4	3076.43	56606.40
12	C4b	Rubble stone drain	m ³	67.0	108.575	7274.5
13	T2	Geotextile	m ²	103.0	17.63	1815.9
14	T1	Weepers	m	50.0	18.49	924.5
15	2 A 5	Concrete riprap	m ²	35.0	22.35	96105
16	2 B 28a	Anchors SBP7 L = 12m	pcs	55.0	3191.1	175511.3
17	2 B 28b	Anchors from SBP7 L = 16m	pcs	165.0	4254.8	702043.15
18	2 B 28c	Anchors from SBP7 L = 18m	pcs	55.0	4786.6	263263
19	2 B 28	Steel anchors L = 2m	m	600.0	86	51600
20	2 B 28 b	Fixing anchors 2 "	pcs	300.0	43	12900
21	2 C 9 c	Tied nets	m ²	1800.0	83.85	150930
Total						1944088

It results: 1944088:150 m = 12960.60 lei/ linear m of slope

4. Conclusions

The solution regarding the partial consolidation with precast anchored plates above presented can be considered optimal from technically and economically point of view, it has a lower cost as follows **12960.6 lei/linear m of slope compared to 14615.38 lei/linear m of slope, which represents a reduction of 11,3% of the costs.**

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