# Grouted anchors—some construction principles and features

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This short paper gives a brief summary of the construction principles and features of the various types of grouted anchors in use in India and abroad.

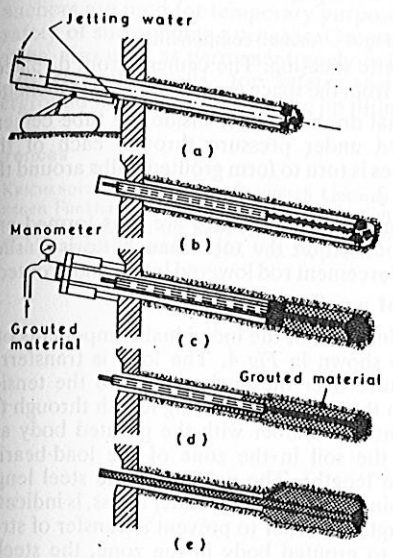


Fig 1 Construction of grouted anchors without packer showing (*a*) insertion of casing pipe (*b*) introduction of tension member (*c*) pulling and grouting of tube (*d*) completed anchor (*e*) final shape of pipe anchor

Grouted anchors, more commonly known as soil anchors are comparatively a recent development in the field of soil engineering. In the case of grouted anchors, the anchor itself and particularly the soil in the zone of action of force is stressed to a considerably greater extent than in the case of the well known tension pile systems.

Grouted soil anchors were constructed for the first in 1958 for the radio broadcasting station at Bayer (Krichnopf, 1959) in Germany. Since then the technology on grouted anchors has advanced both, in the practice and the theory of soil anchors by grouting.

## Basic principles

Depending upon the methods of construction, grouted anchors in soil can be categorised in the following manner.

(*i*) In the most frequent types of construction, pipes of diameter between 60mm and 120mm are inserted into the soil by driving or by any other means like boring, rotation percussion boring, with or without a water jet. The most common type of construction in Germany is by water jet boring, (Jelink, 1970). In this process a jet of water is forced through the borehole which returns back along the outside of the tube creating a space. After attaining the desired depth the tension member is inserted into the boring tube and the grouted hose is connected. A cement slurry is now injected through the tube with a pressure of 5 to 30 atmospheres while the tube is withdrawn in stages and thus, grouted anchor is obtained, *Fig* 1.

(*ii*) The second type of soil anchor is in principle similar to the first type. In this case after reaching the final depth, the borehole is widened by a very strong jet. Cement grout is pumped in through the same tube, as the jet water was earlier, displacing the jet water upwards and the hollow space remaining is filled up with cement grout. In this system, the boring, tube remains in the soil as a tension member, *Fig* 1(*d*).

(*iii*) The third method of construction involves the packer system of grouting *Fig* 2. In this method, with the use of sleeved tubes and packers any zone in a bore hole is grouted. The grouting pressure remains constant till hardening so that the grouted material does not fall during unscrewing of the individual tube pieces, as in the earlier cases.

In the anchor type developed in France, the boring is mostly done without a casing pipe with a thick jet of water or rotating auger. After the bore hole is cleared and com-

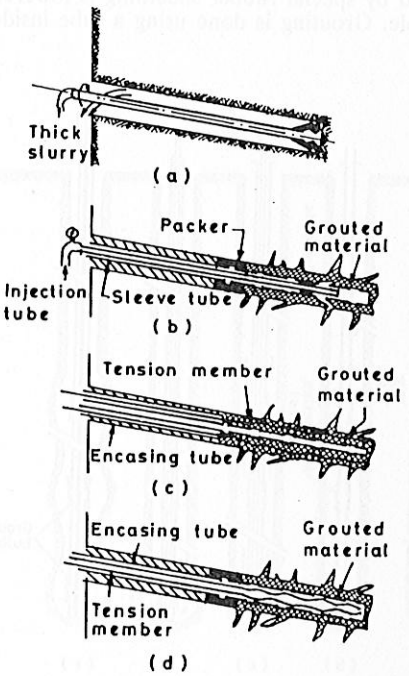


Fig 2 Anchor grouted with packer showing (*a*) boring with rotary chisel (*b*) grouting (*c*) tension member lying outside of injection tube (*d*) tension member lying inside injection tube.

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pletely washed, a sleeved tube is inserted and the zone of soil to be stressed is packed upward using a packer or similar system. Grouting is then done by means of a duplicate packer inserted into the sleeved tube independently *Fig* 2(*b*). This grouting process is repeated several times with thinner and thinner grouts upto a certain saturation pressure.

Non injectable soils can also be blown up and penetrated by the grouting material using higher grouting pressure. The tension members are arranged either around the tube in the beginning itself, or inserted into the tube, after grouting the anchor, and cast. Construction stages of anchors by this method showing different positions of the tension members is shown in *Fig* 2 (*d*).

Tension members placed outside have the advantage that an anchor, which for example, has very low bearing capacity can be subsequently grouted, even after the stressing. In the other case, where the tension members are placed internally, the steel member is better protected against corrosion, by the grouting material in the sleeved tube and by the outer ring of grouting material.

(*iv*) The fourth type of construction is that in which widening of the base in the load bearing stratum is created by special construction methods; *e.g.* by under-reaming with cutters, blasting and jetting with water. Such bulbs at the base or at appropriate depths can considerably increase bearing capacity of anchors, particularly in cohesive soils. In such type of anchors the load is carried by the soil over the widened base. These type of anchors behave in a different way compared to the grouted anchors described earlier in which the load is carried over the skin surface of a thin grouted body.

### Micro piles

An Indian patent No.118640 covers the construction of anchors under the commercial name of micro piles. In principle it is a packer grouting process explained as in (*iii*) above. The basic features of this system are as follows.

A borehole of 75mm to 180mm diameter is drilled by rotation or percussion equipment using bentonite slurry without a casing pipe. A tube manchette having perforated sections covered by special rubber sheathing is lowered into the borehole. Grouting is done using a tube inside

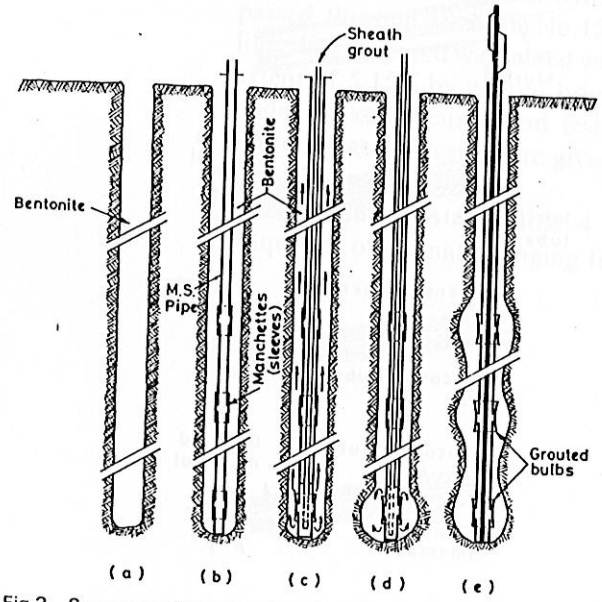


Fig 3 Sequence of construction of micropile showing (*a*) boring with bentonite (*b*) lowering manchette pipe (*c*) sheating grout (*d*) high pressure injection (*e*) completed micropile.

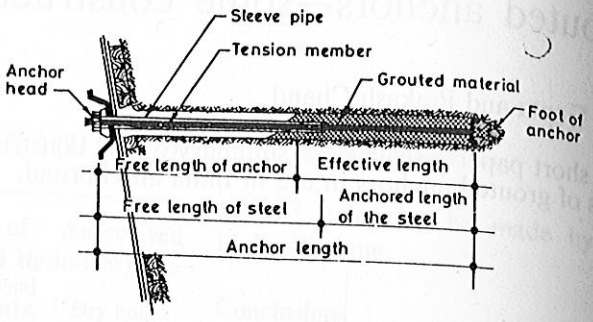


Fig 4 Anchor components

the tube manchette sheating. The cement grout displaces the boring slurry from the space around the tube manchette.

Using a special double packer inside the tube cement grout is pumped under pressure through each of the manchette sleeves is turn to form grouted bulbs around the bore depth, *Fig* 3.

Required number of grout bulbs are thus formed and the residual grout within the tube manchette is washed away and a reinforcement rod lowered into it and grouted.

### Components of a soil anchor

The name and function of the individual components of a soil anchor are shown in *Fig* 4. The load is transferred from the structure over the anchor head to the tension member: and in the zone of anchoring length through the bond of the tension member with the grouted body and from this into the soil in the zone of the load-bearing length (reaction length). The portion of the steel length which can remain freely extended under stress, is indicated as free steel length. In order to prevent a transfer of stress from the steel to grouted body in the zone, the steel is generally led through an encasing tube. The distance between the anchor head and grouted body is called as free anchor length.

*Transference of stress to the grouted body of anchor:* This can be in three ways as shown in *Fig* 5. In type A, the grouted body is strongly connected with the tension members on its entire length. In this case the failure takes place from the top downwards.

In type B, the stress is transferred at the base of the anchor and thus the grouted body is subjected to compression. The pressure tube gives a ring tensile stress also. In type C, more concentrated load is transferred to the toe.

### Requirements of a good soil anchor

(*i*) A soil anchor should fulfill the following requirements, (Jelink, 1970). The load transferred from the structural component to be anchored to the tension member, to the grouted body and to the soil mass should be satisfactory.

(*ii*) The soil anchor should be capable of being checked for its capacity.

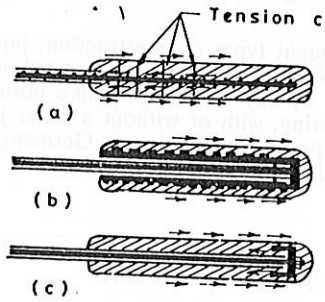


Fig 5 Type of anchors showing stress transfer in the grouted body.

(iii) The soil anchor should be stable. The minimum possible creep effect should take place. Deterioration with time should not occur.

## Advantages of soil anchors

The soil anchors compared to tension pile are much smaller in diameter and therefore light boring machines or simpler methods can be used. Even with the small diameter bore holes large capacities are possible. The most important advantage is that these can be drilled in any direction and need small working spaces. Predominantly the anchors are used for temporary purposes for ensuring the safety of surrounding purposes. Grouted anchors are however, also used as permanent anchors for the protection of retaining walls, for safety against uplift, in underground water tanks, for taking up tilting movements.

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