# Modified High Dispersion Cement with Complex Additives and Filler for Soil Improvement

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## Abstract

**The use of chemical additives has been determined to be an important method for enhancing some properties of cement paste and concrete.**

**These additives include plasticizers or superplasticizers with varieties of inorganic accelerators for hardening, or sometimes some organic agents are also used to enhance the cement properties.**

**Recently, there is an increase in the study and use of complex chemical additives. These additives in combination can enhance each others' basic positive effects.**

**This paper refers to the cement with high dispersion that contains natural mineral filler, which is considered a connective composite material with properties related to the composition, to the proportion of raw materials, to the milling technique, and to the effect resulting from chemical additives and their role in the plasticizing process which is a more complex process. This study targets the use of the modified cement in soil improvement, especially to enhance debilitated soils.**

**Keywords: Mineral filling, hydrolysis process, amino composition, superplasticizer, void structure, Soil Improvement.**

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**Introduction:**

The number of existing studies that include more than one chemical additive and the trial use of the chemical complex additives are increasing and becoming more extensive in different locations.

Often these additives can have many modes of effect on properties of different cement systems. However, the effect of additives on cement paste depends on several factors that may function simultaneously. Some of these factors such as the mineralogical composition and specific composition (i.e. type of material) are involved in the composition of cement. Hence, it is important to assess and compare chemical cement additives with regard to their effects on the properties of cement, including high dispersion mineral filler as cement aggregate. The main target is to improve the properties of cement, cement stone, and concrete by different additives and mineral fillers and to evaluate the positive effects of the combined additives and of the degree of success in filling the pores with products of the hydrolysis process. The modification of cement can take place for optimum soil improvement for the most type of soils.

However, the main applications of this type of soil and cement content improvement are; the enhanced permeability of embedded walls in soil installation (figure1) [8.7] which is also used for clay-certain in accordance with the following compounds shown in table1, and in the cohesion improvement of the lose soil for injected anchors [8.7] (figure2).

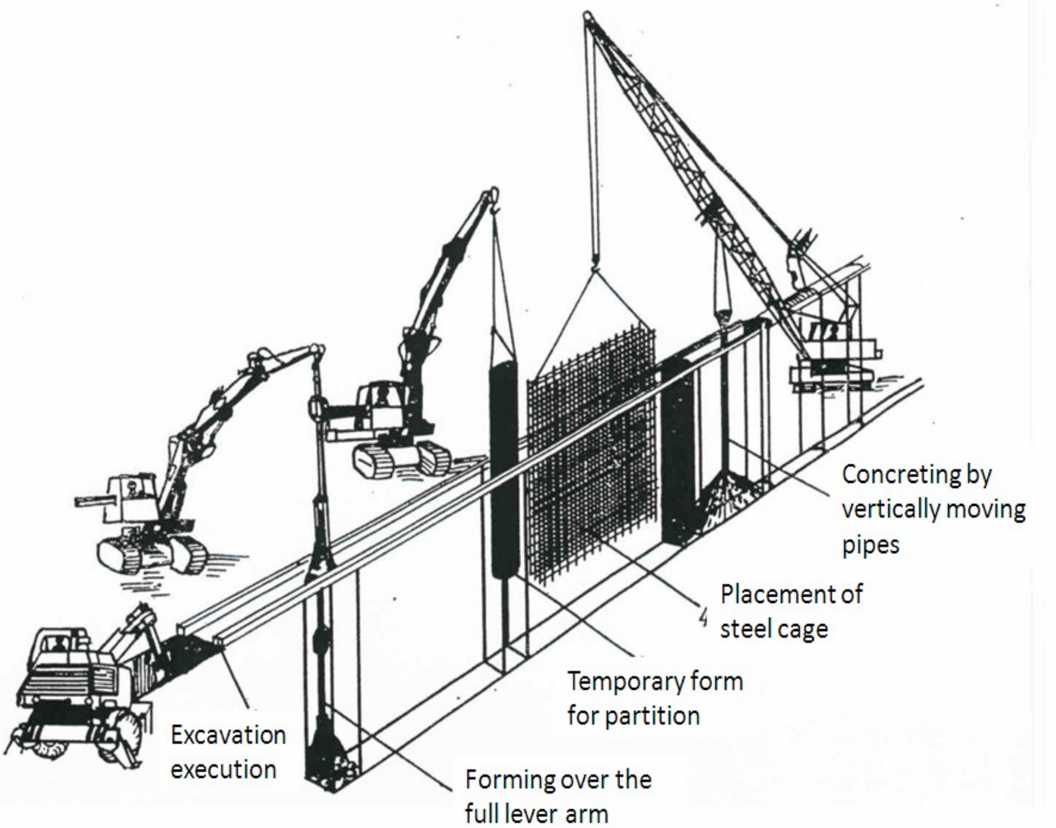



Figure 1:. Illustration for the execution of load bearing walls in soil

**Table1: the strengths of the modified cement based compound used in the soil-curtains for hydraulically insulated structures.**

| Compound | Modified cement with filler [Kg] | Sand [Kg] | Bentonite [Kg] | Water [Kg] | Additives % | Strength [MPa] | |
|---|---|---|---|---|---|---|---|
| 1 | 232 | 680 | 108 | 600 | 1 | 0.23 | .43 |
| 2 | 235 | 680 | 115 | 600 | 0.9 | 0.25 | 0.97 |
| 3 | 262 | 650 | 137 | 600 | 0.85 | 0.32 | 0.82 |
| 4 | 270 | 650 | 130 | 600 | 0.85 | 0.36 | 0.98 |

In this case, the complex additive composition, the improvement of the hydration process, and the mineral filling, in combination, can be optimized for maximum effect.

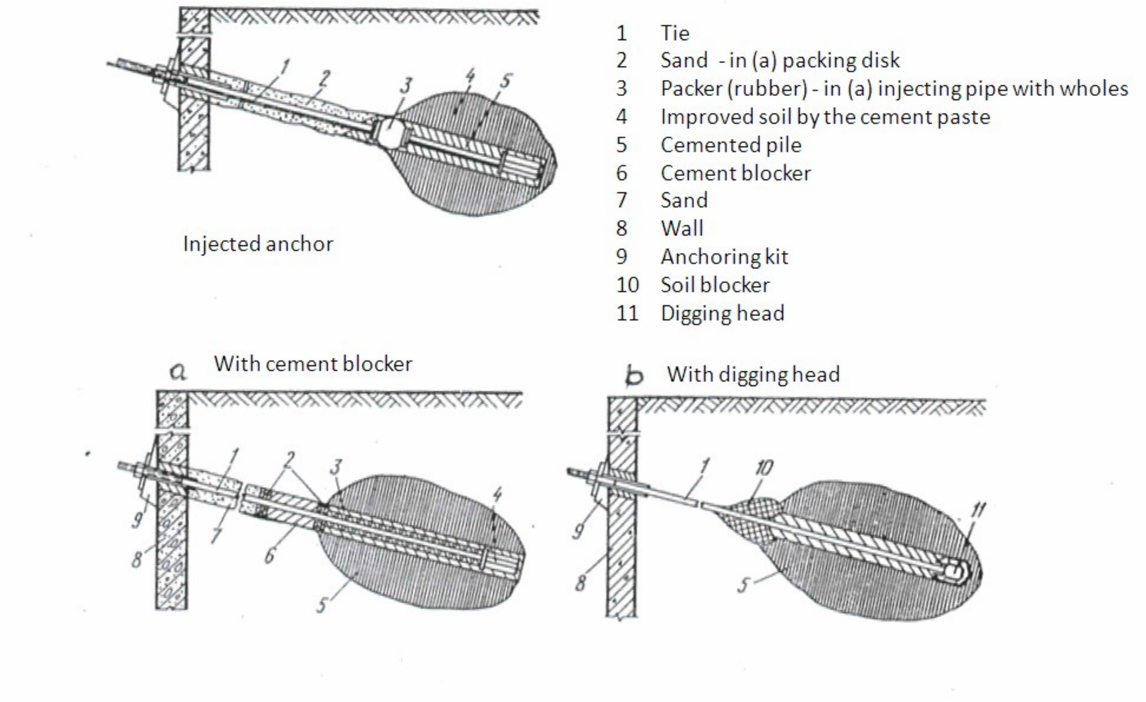



Figure 2: Injected anchors

**<u>Materials and Methods:</u>**

This study is based on high dispersion Portland cement 53% $C_3S$, 6% $C_3A$, 24% $C_3A + C_4AF$,specific surface area 5000cm$^2$/g, the early strength 22-26 MPa, the beginning of setting time is 5h and the end of setting is up to 10h, the water requirement is 19% with 30% natural mineral filler from milling sand [5,7] and traditional chemical additives such as superplasticizer. Other chemical additives are also chosen because they are considered to be waste in some industries, such as waste water from the production of artificial polyurethane caoutchouc, which contains approximately 70% amino composition (AO). This is also the case with the production process waste of enfolding Butyl[1] , Biotin (BI), and also with the chemical complex additive consisting of 1% (BI) and1% Sodium Sulphate (SS).

All of the additives used are soluble in the cement mixing water. The metrical cone is used

[1] Butyl (the hydrocarbon basis has the same structure as Biotin with valence=1)

for this study[7,4,] of the mutation in the kinetics e.g. the influence of the used additives in the plasticizing action in the cement paste. This consists of cement and sand, in the proportion of 1 part cement to 3 parts of sand, which is then slapped into 30 sections.

As a result of laboratory experiments with the above-mentioned composition, and in addition to the readable values of the metrical cone, it can be discerned that the plasticizing effect for additives is different and variant:

1. The Bi residue plasticizing effect is close to the effect of superplasticizer, so-called SM1.
2. The AO (amino composition) has a powerful plasticizing effect that is greater than any of the other additives.
3. The most greatest plasticizing effect is that of the complex additives (Bi+SS).

To evaluate the plasticizing effect for each additive, the following concentrations of additives, which were found to be optimal in proportion of the weight of cement quantity, were used bearing mind the upper bound ratio is 4% except 2% for SM1:

SM1 0.75 ˜ 1.2%; BI 0.75 ˜ 1.6%; AO 3 ˜ 4%; (BI + SS) 0.7 ˜ 1.6%

**Results:**

Applying these optimal additives ratios on the cement paste with the previous composition, the strength of cement stone and its porous structure properties were studied.

**a)** It was determined that the plasticizing additives reduce the amount of mixing water required [3,6], also these additives have an essential effect on the composition and on the structure of new formation in the cement stone (product of hydration) and certainly on the strength and other properties as well.

Therefore, it may be said that the additives can be considered as an agent or technical method with which the void porous structure of cement stone may be modified.

**b)** According to the same ideas and theory from resources [2,5,6], the mechanism of formation for such a structure may be summarized as follows:

In the cement hydration process, the water molecules dissociate and produce proton $H^+$. These protons dissolve and hydrate first the distorted places of the grating in clinker minerals. In this situation the volumes of the hydro phase that touch cement grains are saturated with ions ($Ca^{++}$). Here, the hydrate has hardened phases in the bounds of the initial cement grains.

Perhaps these hydrate phases push for displacement of the volumes that formed as a result of cement grain disappearance that initially formed from, or as a result of, the hydration process.

**c)** The following can be concluded: the formation of the so-called 'internal hardened hydrate' occurs here, and that the internal hydrate plays a fundamental role in the formation of the hardened phase strength shown in the studied volume. This is the volume that was initially occupied by relatively hard cement grains.

The ions ($Ca^{++}$) that formed as a result of hydrolysis of C3S, accompany one another with dissociation of Ca(OH)2. These ions enter into a liquid phase and achieve various concentrations. Here in this situation, formation of the hydrates in the spaces between the grains of hardened cement paste became possible. From the surfaces of the cement grain to the spaces between the grains, a layer of new hydrolysis formation develops that may be titled 'external hydrate'. This has a formation speed which is less than the formation speed of the internal hydrate.

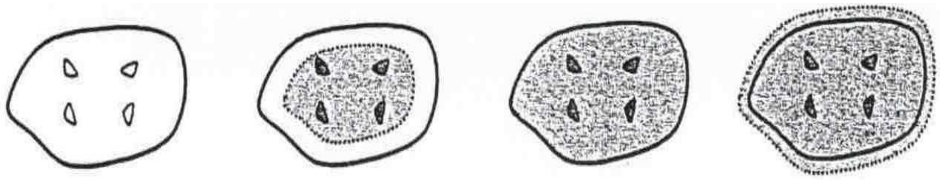
**d)** Therefore, the porous central part of the void between the grains is filled with hydrates of the new formation type, but with less speed and concentration. This creates the long-term porosity and, accordingly, weakness of the cement stone structure[5,6,]. It is clearly the external hydrate that plays the positive role in density and strength of cement stone. This is because the external hydrate has the mobility to fill pores and creates new contact in order to form a homogeneous and unified cement conglomerate.

The use of dilute plasticizer additives organizes and improves the void structure of cement stone because the additives reduce the void volume between grains in the cement paste-stone, because of the development of the external hydrate layer which fills the voids between the grains in the cement stone. According to the facts mentioned above, a comprehensive analysis of the effects of the additives studied in this research on the porosity and thus on the strength of the cement stone has been performed. The results obtained support the underlying assumption with regard to the mechanisms of the formation of porous structure of the cement stone considering the participation of these additives in this process.

**f)** As can be seen in the table, the use of an additive alone, like Bi, has the plasticizing results similar to the SM1 results. However, the use of the (AO) additive that consists of amino composition and the chemical properties with use of the complex additive (Bi+ AO), has not only a superior active surface quality, but in addition reduces the amount of mixing water required (figure 3) [4]. The effect of the comparatively new additives (AO) and (AO+Bi), are superior to that of the commonly used (SM1), addition of superplasticizer.

**g)** The general porosity of cement stone with the presence of the additive Bi, a residue from the production of Butyl, is the same as with the presence of superplasticizer SM1, whereas the additives AO and (AO+Bi) clearly reduces the general porosity because the porosity when SM1 is used is 23% whereas with AO, it is only 16.6% and the porosity with the use of complex additives is only 13.2%. By adjustment of the use of these additives AO, Bi+SS, cause a decrease in the indexed medium dimension of pores for cement stone.

**Figure 3:**




This index has been set by kinetic water absorption (figure 3) [4], which assures that there will be filler with crystalohydrate production indirectly to each pore and that moreover, there is less new pore structural formation for cement stone and with less general dimension and volume of pores.

Table shows the improvment of hardened cement strength values with AO and Bi+SS complex additives in comparison with the hardened cement strength value with only the SM1 additive.

**h)** The extent of hydration was set according to reference [1] and from the register table it can be discerned that the use of one additive, such as SM1 or Bi or AO alone, does not significanly affect the hydration, which in turn indicates bond improvement, not from the hydration step, but from the improvement in void structure. In addition, improvement of hydration with the complex additive Bi + SS occurred because of the presence of ($Na_2SO_4$) in this additive, which accelerates the hydration of calcium silicate. This is confirmed by the high value of 0.85 in the table.

**Table 2: Properties of high dispersion modified cement**

| Additives | Cement paste normal thickness (%) | Content of chemical additives (%) | Diffuse (ran) of standard cone (mm) | Indexed medium dimension of pores | General porosity (%) | Pressure strength (28 days) | | Used coefficient for adhesive properties of cement | Extent of hydration (%) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | % | MPa | | |
| Bi+SS | 17.8 | 1.1 | 159 | 1.04 | 13.2 | 147 | 61 | 0.85 | 69.5 |
| AO | 18.4 | 3.1 | 151 | 1.61 | 16.6 | 124 | 50.7 | 0.66 | 61 |
| Bi | 21 | 1.1 | 135 | 2.57 | 22.2 | 103 | 43.1 | 0.64 | 60 |
| SM1 | 21 | 0.85 | 137 | 2.9 | 23 | 100 | 42 | 0.59 | 61.7 |
| | | | | | | | | | |
| Ao+Bi | 19 | 1.3 | 160.5 | 1.18 | 13.1 | 118 | 48.3 | 0.71 | 69 |

**<u>Conclusion and Recommendation:</u>**

The comparative analysis of the effect of chemical additives on high dispersion filling cement has been carried out and the effect of each additive alone has been observed:

1- The possibility of replacement of the superplasticizer (SM1) with Bi (residue from the butyl production process).

2- Replacement of (SM1) by AO (Amino Composition) for improving the cement stone strength by up to 24%.

3- When using the complex additive (Bi + SS) at a proportion of 1:1, (BI=1, SS=1), which appears to be optimal, increasing the strength by more than 45%.

4- It is recommended to use this cement with additives for filling up soil grottos and for improvement of roads and buildings at a lesser cost, due to the cement consisting of mineral filling with additives that are considered industrial waste.

5- The use of this industrial waste in the concrete production technology is expected to result in significant reduction in cost.

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