Evaluation of Geotechnical and Qualitative Properties of Fine Grained Construction Materials on North and Northeast of Mashhad City

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Abstract
Fine grained materials often consist of clayey and silty soils. They can be used as construction materials and primitive matter to produce brick and adobe. Brick kilns are developed on north and northeast of Mashhad due to spread of fine grained soils in this region. Therefore it is important to evaluate the quality of construction materials in such places. This paper deals with the qualitative investigation and engineering classification of soils on northern part of Mashhad city. Thus sampling was done and different tests were carried out. Also, dispersion potential in this region was investigated.

Keywords: *Construction material, Clayey and silty soil, Dispersive soil, Mashhad city*

1 Introduction
Evaluation of geotechnical properties of soils, especially fine grained soils, is so important in different projects. In engineering geology, construction materials are defined as earthy or rocky materials which are exploited in order to be used in different civil projects. Fine grained materials which include clay and silt, usually deposit on plains and places with low hydraulic power (Ghobadi, 1385). According to different studies on alluvial sediments of Mashhad city, a large amount of these sediments are fine grained. The abundance of these sediments increases toward northern and northeastern parts of the city (Yousefi et al., 1386). Many authors have studied about fine grained soils and related phenomena. Hashemi Tabatabaei and Aghaei Araei (1387) compared the effect of quick and hydrated lime on geotechnical properties of fine grained soils. Also, the same authors (1386) had an approach on treatment of fine grained soils using different quantities of lime. Yousefi et al. (1386) studied on clay minerals of Mashhad city basin based on Atterberg limits. Moreover, Sadr Karimi (1383) evaluated the influence of dielectrophoresis process on clay minerals. Also, different authors such as Tsolis-Katagas and Papoulis (2004), Erguler and Ulusay (2003), Thomas et al. (2000), Sidharan and Prakash (1998) and Sivapullaiah et al. (1987), studied about different characteristics of clay minerals, fine grained soils and different factors which affect them.

2 General Geology of Mashhad Plain
The study area is a part of Mashhad plain. This plain is located on northeast of Iran, between longitudes 58° 20′ and 60° 08′ E and latitudes 35° 40′ and 36° 03′ N (figure 1). There are two different mountain ranges in this plain; Hezar Masjed Mountain on north and Binalood Mountain on south. Northern and southern boundaries of this plain are faulted and depressed. Mashhad city is located on southern part of this plain, in foot of Binalood Mountain. Binalood

Mountain had been formed by early Symerian orogeny (Aghanabati, 1383). It had passed several stages of granitization and metamorphism during Hercynian and early Symerian orogenies. Binalood commonly consist of metamorphosed conglomerate, shale and sandstone accompanied by phyllisch, ophiolite and granitic and granodioritic masses (Alavi, 1991). A new erosional cycle has started from the latter parts of Tertiary and beginnings of Quaternary, contemporary of the last phases of Alpine orogeny. The resulted sediments have formed new plains. Mashhad city has been developed on young alluvial sediments of Mashhad plain. The maximum alluvial sediments thickness in the region is about 250 ^{m} whereas the average thickness is about 120 ^{m}. These sediments are results of Kashaf Rud river activity and seasonal floods of local rivers. Kashaf Rud is the most important physiographic feature in Mashhad plain with about 300 ^{Km} length and an almost E-W trend that originates from Hezar Masjed and Binalood mountains. Mashhad city is located on southern part of Kashaf Rud river so it seems that the rivers originated from upstream (i.e. Binalood) have played a more important role in forming Mashhad city basin. Totally, in Mashhad plain, from south and southwest toward northeast, the soil grain size decreases and the soil alkalinity increases (Yousefi et al., 1386).

3 Evaluation of geotechnical properties of fine grained materials

In order to provide geotechnical data, 12 samples were collected (figure 2) and different tests were carried out. The main purpose of this research is supplying fine grained materials for making adobe. In order to evaluate the geotechnical properties of samples, different tests such as sieve analysis, hydrometer, Atterberg limits, pinhole test and double hydrometer test were carried out. Table 1 indicates Atterberg limits and the soil types based on the Unified Soil Classification System.

3-1 Identification of dispersive soils

Dispersive soils are a particular type of soil in which the clay fraction erodes in presence of water by the deflocculating process. This occurs when the interparticle forces of repulsion exceed those attractions so the clay particles are detached and spread into suspension. If it is raining and the water is flowing, as in a crack in an adobe, the detached clay particles are carried away. Dispersive soils are found in arid and semi-arid areas. Bell and Maud (1995) reported occurrence of this type of soil in the areas of South Africa with less than 850 ^{mm} annual precipitation. The Mashhad plain is characterized by a semi-arid climate with low rain fall of about 255 mm/year and evaporation rate of about 2400mm/year. Sherard et al. (1977) reported that dispersive soil could be formed anywhere in the arid, semi-arid. Benito et al.(1993) and Faulknera et al.(2003) found that in dispersive marls in southeast Spain, fresh material is often much more dispersive than surface samples, which suggests leaching or exchange of surface sodium on badland surface through time. Dispersive soils can not be identified by conventional index tests such as particle size distribution, Atterberg limits and compaction characteristics. Four common laboratory tests which identify dispersive soils are the crumb test, chemistry test, double hydrometer or Soil Conservation Service (SCS) and pinhole erosion test. In this study, double hydrometer and pinhole erosion test were carried out on samples collected from the study area.

3-1-1 Double hydrometer test

The double hydrometer test or Soil Conservation Service (SCS) dispersive test is the first method has been used to identify dispersive soils (Decker & Dunnigan, 1977). In this method, the particle size distribution is first measured using the standard hydrometer test, in which the sample is dispersed in the hydrometer bath with strong mechanical agitation and a chemical dispersant agent. A second hydrometer test is made without strong mechanical agitation and without a chemical dispersant agent. The later shows less colloidal particles than the former and the difference is a measure tendency of the clay to disperse naturally. By definition, percent dispersion is the ratio of clay size particles (0.005mm) in the two tests. The double hydrometer test results are presented in table2 that is based on types of dispersion in table 3. Table 2 shows that 6 samples behave as dispersive soil.

3-1-2 Pinhole test

The pinhole erosion test is also one of the most reliable tests for identifying dispersive soils. The pinhole test provides qualitative information on dispersivity of soil particles. In conducting the test, distilled water under a low hydraulic head is caused to flow through a tiny hole in the soil specimen. For dispersive soils, the flow emerging from the soil samples is cloudy and the hole rapidly enlarges. For non- dispersive soils, the flow is clear and the hole does not enlarge. Two limitations of the pinhole erosion test for identifying dispersive soils have been observed. Undisturbed soil sample of high sensitivity may be classified as dispersive from the pinhole erosion test. Apparently, the natural structure of the soil is destroyed by punching the pinhole in undisturbed soil specimen and reaction analogous to dispersion is obtained in the pinhole erosion test. Soils with high sodium (>80%) and low total dissolved soils (<0.4meg/l) in the soil pore water may show non-dispersive in the pinhole erosion test, while the soil may exhibit dispersive performance in the field. This may occur because a decrease in the concentration gradient between the soil pore water and eroding fluid results in a decrease in the erosion rate for soils. A total of 12 pinhole tests were carried out on the selected specimens. The results of pinhole tests are presented in table 4. As this table shows, 6 samples out of 12 behave like dispersive soils.

4 Conclusions

North and northeast of Mashhad city, the study area, is covered by fine grained soils including silt and clay. In this paper, two out of four common test methods were carried out to study the dispersivity of soil in the study area. This study was initial part of a main aim which is finding a proper mine for exploiting fine grained construction materials in order to make adobes for reconstructing a historical zone. The initial results are as follows: 1) Six out of twelve samples show dispersivity based on pinhole tests. 2) The same samples indicate dispersivity based on double hydrometer tests. Five samples show intermediate dispersivity and one sample shows high dispersivity. Finally, it is suggested to collect more samples and to carry out more and different tests in this regard. The chemical tests are highly recommended.

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Table 1-Types of tested soils based on USCS and their Atterberg limits

Sample	1	1*	2	3	4	5	6	7	8	9	10	11
Soil type	CL	ML	SM	ML	CL	ML	ML	CL-ML	ML	CL-ML	ML	CL
LL	27.7	.	.	21.9	25.5	.	.	23.1	33.1	22.1	.	24.2
PL	19.4	.	.	19.1	16.5	.	.	18.3	25.6	17.6	.	15.9
PI	8.3	N.PI	N.PI	2.8	9	N.PI	N.PI	4.8	7.5	4.5	N.PI	8.3

Table2-The results of double hydrometer tests

Sample	Dispersion%	Dispersion type	Sample	Dispersion%	Dispersion type
1	11.2	Non-dispersive	6	34.3	Intermediate
1*	35.5	Intermediate	7	40.2	Intermediate
2	18.8	Non-dispersive	8	12.9	Non-dispersive
3	5.1	Non-dispersive	9	31.3	Intermediate
4	4.9	Non-dispersive	10	53.6	Potentially high
5	31.4	Intermediate	11	15.2	Non-dispersive

Table 3- The types of dispersion

Dispersion%	Dispersion type
0-30	Non-dispersive
30-50	Intermediate
50-75	Potentially high dispersive
>75	Completely dispersive

Table 4-The results of pinhole tests

sample number	pinhole test results	sample number	pinhole test results
1	non- dispersive	6	dispersive
1*	dispersive	7	dispersive
2	non- dispersive	8	non-dispersive
3	non- dispersive	9	dispersive
4	non- dispersive	10	dispersive
5	dispersive	11	non-dispersive

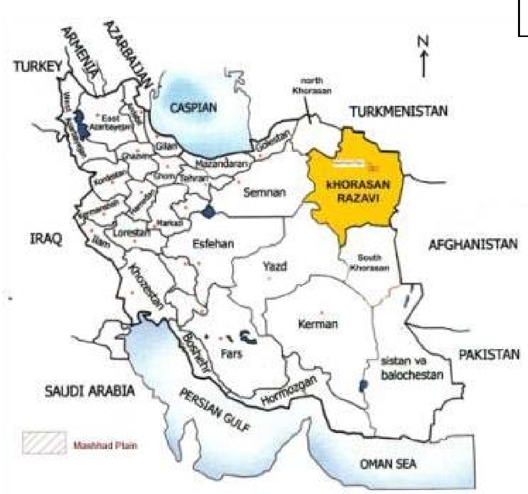

Figure 1- The location of Mashhad plain

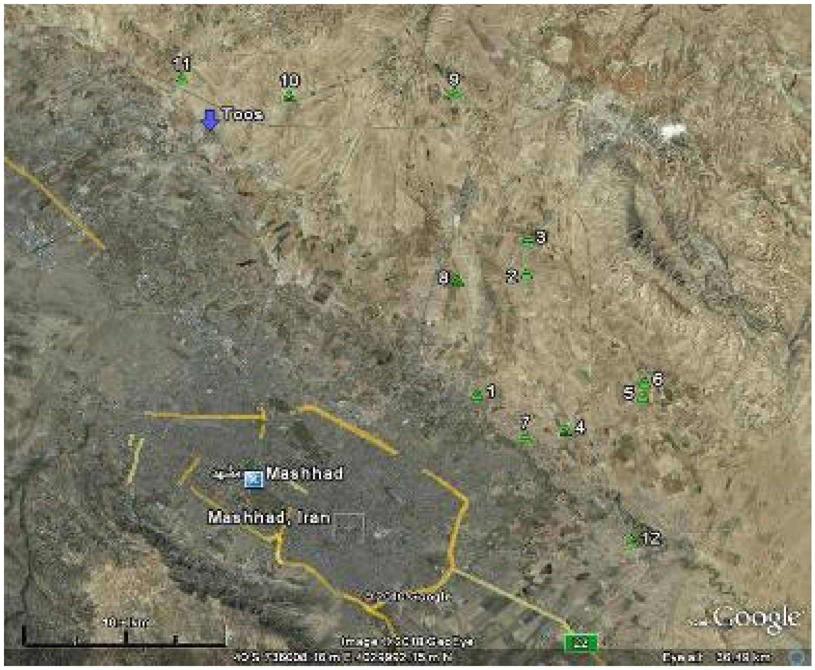

Figure 2- The locations of samples