# The effect of the effect of adding ethylene-vinyl acetate (EVA) on soil resistance parameters

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**ABSTRACT**

Soil stabilization and reinforcement has long played an important role in civil engineering, especially in geotechnics, and over time and the need for a more robust and stable ground to withstand gravity and higher shear forces, has become particularly important. Also, in recent years, with the entry of the environment into the construction industry, with the aim of reducing the adverse effects of industrial waste and construction waste on people's living environment and preserving the environment for the future, in many cases reduces the economic costs of projects. In this research, granular soil is reinforced in two loose and semi-dense states using a waste material called ethylene-vinyl acetate (EVA). The experiments were performed without adding moisture, by weight percentage method and using CBR device. The results show that soil resistance increases significantly with the use of these additives and its effect on soil increases with decreasing soil specific gravity. Also, the optimal amount of additives in loose and semi-dense state is 2% additive and 1% additive, respectively.

**KEYWORDS:** Soil improvement, granular soil, EVA, soil reinforcement, waste material, material mixing, environment

## Extended Abstract

### Introduction

There have long been methods to improve the mechanical properties of soils to increase the bearing capacity of soils and constructions with greater consolidation and resistance against earthquakes and other external factors. But with the passage of time and especially in recent years with the progress of growing societies, especially in big cities, the importance of this issue has doubled, which is one of the reasons for this: problems such as problematic soils, which are caused by the lack of suitable land with high resistance for Provision of more housing and technical and

engineering problems of structures under construction, especially high-rise structures. As a result of solving such issues and problems, the attention and focus of civil engineers and the construction industry, especially geotechnical engineers and geologists, and new methods should be presented in addition to the old methods for soil improvement. There have long been methods to improve the mechanical properties of soils to increase the bearing capacity of soils and constructions with greater consolidation and resistance against earthquakes and other external factors. But with the passage of time and especially in recent years with the progress of growing societies, especially in big cities, the importance of this issue has doubled, which is one of the reasons for this: problems such as problematic soils, which are caused by the lack of suitable land with high resistance for Provision of more housing and technical and engineering problems of structures under construction, especially high-rise structures. As a result of solving such issues and problems Researchers with a new attitude on the issue of stabilizing and strengthening problematic soils interest using safe and clean materials to rehabilitate the soil. Using waste materials with minimum environmental damage to soil are in these categories.

**Material and Methods**

In this research, the soil tested is poorly granulated sand with a specific granulation (passed from sieve # 4 to residue on sieve # 50). also, Based on a kind of geotechnical and geoenvironmental material, granular soil is reinforced and rehabilitated in two loose and semi-dense (medium density) densities using a waste material called ethylene-vinyl acetate (EVA). The elasticity modulus of used EVA in this research is about 2.9 Mega pascal. This waste material doesn’t have negative effect on soil (dry or saturated) parameters and characters and also it is obvious that this waste material is a problem for environment.

The vast laboratory experiments are performed in dry condition, using weight percentage method for mixing the natural granular soil and EVA to study EVA effect on reinforced granular soil. In this paper, the test results are obtained based on the CBR test. This test is a proper evaluation method to examine shear strength of reinforced soil.

**Results and Discussion**

The CBR results for samples reinforced with EVA in weight percentages of 0, 0.2, 0.5, 1, 1.5, 1.75, 2, 2.25, 2.5, 3 and 4 for loose samples and weight percentages 0, 0.2, 0.5, 0.75, 1, 1.25, 1.5 and 2 have been done for semi-dense samples. results extracted in this research show that using EVA waste material has a significant increase effect on CBR test results. The baes natural granular soil studied in this research is SP in Unified Soil Classification System (USCS) with

approximately 2.65 for specific gravity. Based on evaluated results it is clear that reinforced granular soil with EVA has higher shear strength in comparison with unreinforced granular soil studied in this research.

Another important result in these tests are decreasing the unit weight of granular soil –EVA mixture in comparison with granular soil in a specific volume. This advantage makes this reinforced soil mixture a proper material for backfill to retaining wall and other similar structure, performing drainage and also higher shear strength geotechnical parameters. In this research the optimum content of EVA in granular soil to reach the maximum CBR results are also studied. This is a significant aspect of this experimental that represent a clear answer for geotechnical engineering and also researcher to use this waste material to reinforce granular soil in projects. Based on many CBR tests that are explained in the main paper text, the optimum content EVA for loose granular soil is evaluated to 2% and this optimum content for semi-dense is 1%. It should be mentioned that these optimum contents are based on weight percent and also in dry condition. These obtained result show that optimum contents of reinforcement are different with each other in two different soil densities. The CBR test results show that loose granular soil needs more reinforcement EVA to reach the maximum CBR. Another important matter that should be mentioned in detail of tests is that compaction of higher weight content of EVA is a hard process, so it was very important to evaluate optimum weight percent to obtain maximum CBR.

**Conclusion**

The optimal amount of adding EVA material to sandy soil, which shows the highest relative resistance, is 2% additive in loose state and 1% additive in semi-dense state. Also, according to the results, it can be seen that with the increase in weight percentage, the CBR number increases compared to the base soil; Of course, the CBR number increases with the increase in specific weight.

In addition to the advantages mentioned above, the fact that this additive is wasteful and requires little energy to mix it with the soil and achieve greater resistance, even in the weakest soil density, is one of the advantages of this method, and it reduces the cost and time in the project. and due to the long life of this reinforcing material and its durability in the living environment, the use of such materials in soil reinforcement and improvement not only increases soil resistance but also preserves the environment.

**KEYWORDS:** Soil improvement, granular soil, EVA, soil reinforcement, waste material, material mixing, environment.

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