EXPERIMENTAL INVESTIGATION OF PROPERTIES OF DUMPED SOIL BY ADDING STEEL SLAG

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Abstract— Illegal dumping of construction and demolition (C&D) waste is amajor source of waste soil and underground water pollution According to European Commission (2010), C&Dwaste amounts to about 35% of the total waste generatedEurope-wide. C&D waste dumped on bare ground, in forests andin scenic areas, also causes aesthetic damage to the naturallandscape As construction materials often containoil, solvents and fuel, these chemicals can leak into undergroundaquifers, thus contributing to underground water pollution. In addition, the combination of evaporationand heat can also cause forest fires starting at illegal C&D wastesites and resulting in the release of toxic gases into the atmosphere.Illegal dumping of construction waste also has economic implicationsassociated with waste cleaning and landscape restoration.In 2009 alone, local authorities in the UK spent around £45.8 millionon cleaning open areas from illegally dumped waste (Defra,2010). Accordingto Romeo et al. (2004), the City of San Antonioin the USA spends hundreds of millions of dollars every year tomitigate environmental consequences of illegal waste dumping, such as leaking of hazardous materials into underground water aquifers and forest fires.

I. INTRODUCTION

Geosynthetics are nowadays used for a lot of applications not only in geotechnical engineering. Without the use of geosynthetic reinforcement, in most cases geogrids, many road construction projects all around the world would not have succeeded. An impressive example for a geogrid reinforced soil structure was utilized to build up Highway B114 in a difficult geological surrounding in Austria from Trieben to Sunk. Up to 35 m high and 70_ sloped geogrid reinforced embankments over a distance of 3.5 km were constructed to connect two existing highways in upper Styria A deep knowledge in geotechnical engineering but also a fundamental understanding on geosynthetic engineering is an important issue to reliably manage such projects. Meanwhile, there are several designing standards and recommendations for the European regions Handbooks for soil improvement as well as for the designing with geosynthetics and books related to different applications on geosynthetics were written in the last decades. But today the requirements to geogrid reinforced soil structures increased more and more. In comparison to conventional road construction methods, such as bridge abutments, reinforced soil structures sometimes do not have enough strength and stiffness. Developing a system to improve the load displacement behavior of the geogrid reinforced soil structures is therefore, an important research task. To successfully work out that practical task, afundamental understanding of the soil geogrid interaction behavior rmust be gained first.

The construction industry is a major generator of wastes and other seemingly unusable materials that can easily be discarded as solid waste Construction wastes are generally bulkier, heavier and at times more toxic than domestic waste. Their disposal to a local sanitary landfill or dumpsite can prove to be less of a solution but more of an aggravation of the issue in the long run.

The cost of waste landfill is increasing, from 2008 to 2015, the cost of landfill for nonhazardous, hazardous waste and landfill tax increased for 4 to 5 times.

Heavy metal contaminated soils (HMCS) are one of the consequences of industrialization and represent a serious threat tohuman health and ecosystem stability.Among the available soil remediation techniques, conventional ''dig and dump'' operations and other civil engineering technologies such as thermal stabilization or soil washing, rapidly reduce the environmental risks associated with excessive heavy metals(HM) concentrations, but are expensive and lead to the irreversible loss of soil and its beneficial ecosystem services.

The dump sites is not of any use,no farming or any other work is not possible on such land.Such land are declared as no use land so it is preferable to construct buildings on it. But the dumped waste has different properties than a regular site or soil, it has not hard strata at specified depth as the material very loose in character itself. There by it is very important to understand the properties of such soil or solid waste.

In maximum cases it is much needed to increase the properties such as safe bearing capacity, density, compaction factor etc. Such properties are the backbone of any building so studying them and improving is main aim.

In our project we are introducing the modern way to study and improving the properties of waste soil by adding steel slag, Fly ash, crush lime stone etc. Material which can effectively increase them and make suitable and best base for construction purpose possibly for small case of hosing or such type of small case project and even for major projects also.

Problem Statement :

In case of dumped soil construction of foundation on that soil is not possible without any treatment otherwise settlement of whole structure will be takes place after some time.

Dumped land itself is land waste which occupied by dumped area, there is no possibility of doing any work, and the area of dumped waste is getting increase in large scale as the population is increase day by dat.

It also increase the air pollution while dumping the soil, as the dust is produced in very large amount which can cost very harmful deceases and naturally affect the near by area of dumping land.

Land water and air pollution in the neighborhood are preliminary caused by illegal dumping. the chemicals and non bio degradable material in the waste affect the physical environment and the waterways by contaminating ground water and soil.

If the dumping area is located at agricultural area it reduces the useful area and make it into waste. And also affect the near by agricultural land by dust, mixing in water,etc.

As an civil engineers point of view dumping areas effects the good appearance of city, as well it affects the price of near by areas of such dumping areas.

If the capacity of any dumping area is at it's end it is hard to find another dumping site due to growth of city or population and also living standard also matters.

Objective : The main purpose of experimental investigation of dumped soil is as follows :

To increase safe bearing capacity of soil.
To increase shear strength of soil.
To reduce swelling potential of dumped soil
To reduce permeability of dumped soil.

FIG: Dumped Soil

1.4 Basic test to be perform on dump soil :

- Determination of compaction properties of soil by standard proctor test
- Determination of Field density by core cutter method.
- Determination of water content by
  1. Oven drying method.
  2. Pycnometer method.
- Sieve analysis of soil.
- Specific gravity by pycnometer.
- Unconfined compressive test.
- Differential free swell test.

Types of Dumped:

- **Garbage dump or open dump :**

The place where solid wasteis thrown without any attempt at sorting or treatment is called a dump. This siteusually functions without technical criteria in a recharging area near a body ofwater, a natural drainage, etc. It has no sanitary control, nor are measures takento prevent environmental contamination; the air, water and soil in the vicinity areimpacted by gases released, leached liquids, burning and smoke, dust, andnauseating odours.Open dumps are the breeding ground and habitat of harmful fauna thattransmit many diseases. Dogs, cattle, pigs and other animals found at the dumpsare a hazard for the health and safety of the local inhabitants, in particular for thefamilies of the scavengers who survive under subhuman conditions on or near the garbage heaps.

The segregation of byproducts of the waste encourages the rapid growth ofbusinesses dedicated to the resale and illegal trading of these materials. This, in turncauses the depreciation of adjacent areas and buildings; it also produces filth, anincrease in air contamination, and lack of safety because of the type of persons whole frequent such places.

Nowadays it is considered irresponsible toward present and future generations, as well as contrary to sustainable development, for a municipality to dispose of its waste in open dumps.

- **Sanitary landfill :**

The sanitary landfill is a technique for the final disposal of solid waste in theground that causes no nuisance or danger to public health or safety; neither does itharm theenvironment during its operation or after its closure. This technique usesengineering principles to confine the waste to as small an area as possible, covering itdaily with layers of earth and compacting it to reduce its volume. In addition, itanticipates the problems that could be caused by the liquids and gases produced bythe decomposition of organic matter.

The sanitary landfill emerged just under a century ago in the United States asthe result of experiments employing heavy equipment to compact and cover waste;since then, this term has been used to refer to the site in which waste is first depositedand thencovered at the end of each working day.

A modern sanitary landfill can be defined as a facility designed and operatedas a basic sanitation project that has sufficiently safe elements of control, and thesuccess of which lies in the selection of the suitable site, its design, and ofcourse, itseffective and efficient operation and control.

Scope of the project work :

Today, the disposal of wastes by land filling or land spreading is the ultimate fate of all solid wastes, whether they are residential wastes collected and transported directly to a landfill site, residual materials from materials recovery facilities (MRFs), residue from the combustion of solid waste, compost, or other substances from various solid waste processing facilities. A modern sanitary landfill is not a dump; it is an engineered facility used for disposing of solid wastes on land without creating nuisances or hazards to public health or safety, such as the problems of insects and the contamination of ground water.

Landfills are created by land dumping. land dumping methods very, most commonly it involves the mass dumping of waste into a designated area, usually a hole or sidehill. After the waste is dumped, it is then compacted by large machines. When the dumping cell is full, it is then "sealed" with a plastic sheet and covered in several feet of dirt.

Therefore we are investigating dumped soil in this project to make it suitable for construction purpose by adding various material like steel slag, crushed limestone, etc.

Materials to be used to increase strength of dumped soil :

- **Steel Slag :**

In many developed countries, concern over waste production, resource preservation and reduced material cost have focused attention on reusing solid waste materials. Waste materials when properly processed can meet various design specifications in the construction industry. So recovering useful materials from industrial wastes not only offers environmental gains, but also helps to preserve natural resources. It has therefore become necessary that the research efforts in using various types of solid wastes need greater attention . Slag is a by-product of the iron and steel making process. Iron cannot be prepared in the blast furnace without the production of its by-product blast furnace slag. Similarly, steel cannot be prepared in the Basic Oxygen Furnace (BOF) or in an Electric Arc Furnace (EAF) without making its by-product, steel slag.

The current utilization rate of steel slag is only 22% in china, far behind the developed countries. At present, the amount of slag deposited in storage yard adds up to 30Mt, leading to the occupation of farm land and serious pollution to the environment. Improving the slag utilization is an important way to resolve these problems. thephysical and chemical characteristics of steel slag were analyzed and then the research progress of steel slag utilization at home and abroad as recycled raw material in steel enterprise interior, aggregate of road and hydraulic construction, cement additive and concrete admixture, materials for waste water or gas treatment, construction materials and fertilizer in agriculture production were introduced respectively. At last, the important routes andcritical problems for large-scale utilization of steel slag were proposed.Steel plant slags mainly include blast furnace slag and steel melting slag (open hearthor LD process slag). Various efforts have been made on the utilization of blastfurnaceandsteel slags.

LD slag is a byproduct of steel industry, which comes from pig iron refining processing using LD converters. Because of its physical, chemical and mineralogical properties, it can be used as a substitute for aggregates in civil engineering projects. LD slag has the useful components like CaO, MgO with high basicit is (CaO/SiO_2) of above 3.0. LD slag therefore has high fluxing capacity and is being charged in the blast furnace due to easy melt and better utilization of calcium values. In the European countries, 30% of such slags are recycled into the blast furnace. However, the most harmful components in the LD slagis P&S which are to be removed before use either in sintering plant or blast furnace. LD slag, used in blast furnace at Siddhi fordge Steel Plant, India was therefore discontinued due to sulphur and phosphorus content. The slag is however not suitable in cement making due to the presence of high percentage of iron oxide. In many instances it is usually subjected to metal recovery before its application in steel and iron industries.

The objective of this study was to investigate the use of by-product steel slag aggregates (SSA) as a stabilizer. Largequantities of steel slag are produced daily in Ahmednagar from steelmanufacturing processes.

Currently, by-product steel slag material is dumped randomly in open areas. if not recycled or disposedin properly designed landfills, the toxic elements such asCr, Ni, and Zn may migrate to and pollute the surfacewater and groundwater and affect the human life and theenvironment. In addition to that, the very fine particles of by productsteel slag are expected to pollute the air. The investigation ofthis work focused on the engineering properties of a stabilizedclay soil as a sub-grade material used in road pavement andfoundation. The investigation considered the effect of SSA onplasticity, swelling behaviour, compressibility, shear strengthand California bearing ratio (CBR) of the treated clay soil.

Methodology

Clay soils, mainly if they contain swelling minerals such as smectite or illite, may cause severe damage to structures, especially when these soils are subjected to wetting and drying conditions.High expansion and reduction in shear strength and foundation bearing capacity will takeplace due to the increase in water content of these soils. The engineering properties of these kindsof soils can be improved by using additives and chemical stabilizers. In this work, by-product steelslag was used to improve the engineering properties of clay soils. Lab and field experimental programswere developed to investigate the effect of adding different percentages of steel slag on plasticity,swelling, compressibility, shear strength, compaction, and California bearing ratio (CBR) ofthe treated materials. The results of tests on the clay soil showed that as steel slag content increased,the soil dry density, plasticity, swelling potential, and cohesion intercept decreased and the angle ofinternal friction increased. For the CBR, the results of the tests showed an increase in the CBR value with the increase in slag content.

Properties of the used materials.

Property	Clay soil	Steel slag
Specific gravity	2.71	¥FA: 3.2 ¥CA: 3.1
Minerals or chemical composition (ppm)	Major: quartz Minor: smectite Trace: illite, calcite, dolomite, and kaolinite	Cr=0.063 Ni= 0.004 Fe=0.019
Gravel size %	3.1	91
Sand size %	10.3	9
Silt size %	64.1	0

Construction and demolition (C&D) waste dumped alongside roads and in open areas is a major source ofsoil and underground water pollution. Since 2006, Israeli ministry for environmental protection enacted apolicy of vehicle impoundment (VI) according to which track drivers caught while dumping C&D wasteillegally have their vehicles impounded. The present study attempted to determine whether the VI policywas effective in increasing the waste hauling toauthorized landfill sites, thus limiting the number of illegalunloads of C&D waste at unauthorized landfill sites and in open areas. During the study, changes inthe ratio between the monthly amount ofC&D waste brought to authorized landfills sites and the estimatedtotal amount of C&D waste generated in different administrativedistricts of Israel were examined,before and after the enactment of the 2006 VI policy. Short questionnaires were also distributed among local track drivers in order to determine the degree of awareness about the policy in question and estimateits deterrence effects. According to the study's results, in the district of Haifa, in which the VI policywas stringently enacted, the ratio betweenC&D waste, dumped in authorized landfill sites, and the totalamount of generated C&Dwaste, increased, on the average, from 20% in January 2004 to 35% in October2009, with the effect attributed to the number of vehicle impoundments beinghighly statistically significant($t = 2.324$; $p < 0.05$). By contrast, in the Jerusalemand Southern districts, in which the VI policy wasless stringently enforced,the effect of VI on the above ratio was found to be insignificant ($p > 0.1$).Theanalysis of the questionnaires, distributed among the local truck driversfurther indicated that thechanges observed in the district of Haifa are not coincident and appeared to be linked to the VI policy'senactment. In particular, 62% of the truck drivers, participated in the survey, were aware of the policy and47% of thepersonally knew a driver whose vehicle was impounded. Furthermore, the drivers estimatedtherelative risk of being caught for unloading C&D waste in unauthorizedsites, on the average, as high as67%, which is likely to become adeterrent on its own. Our conclusion is that the VI policy appears to havea deterring effect ontruck drivers, by encouraging them to haul C&D waste to authorized landfill sites.Aswe suggest, the research methodology implemented in the study and its results may help policy make other regions and countries, which experience similar environment enforcement problem, to analyzepolicy responses.

Steel slag is produced as a by-product during the oxidation of steel pellets in an electricarc furnace. This by-product that mainly consists of calcium carbonate is broken down to smallersizes to be used as aggregates in pavement layers. They are particularly useful in areas where a good quality aggregate is scarce. This research study was conducted to evaluate the effect of quantity ofsteel slag on the mechanical properties of blended mixes with crushed limestone aggregates, whichused as subbase material in Egypt. Moreover, a theoretical analysis was employed to estimate theresistance for failure factors such as vertical deformations, vertical and radial stresses and vertical.strains of subbase under overweight trucks loads. These loads cause severe deterioration to thepavement and thus reduce its life. The results indicated that the mechanical characteristics, andthe resistance factors were improved by adding steel slag to the crushed limestone.Soil excavation associated with energy production or mineral extraction results in heavily disturbed landscapesthat must be reclaimed to avoid long-term economic and environmental losses. A common practice in reclamation nof these sites is topsoil replacement across the disturbed area. In some instances, this process requiresimporting topsoil from another location, known as topsoil transfer, which can be expensive and introduce a newseedbank, insect community, or plant pathogens. This research describes a soil-mixing process for disturbed soilsthat may be used to reduce costs associated with topsoil transfer and accelerate the recovery of soil functionfollowing a large excavation. This process was applied to two disturbed soils: i) crude-oil contaminated subsoilmaterial; and ii) crude-oil contaminated subsoil material that was remediated using ex-situ thermal desorption.These soils were separately mixed with native, non-contaminated agricultural topsoil at 1:1 ratio (by volume).The native, disturbed, and mixed soils were characterized for soil physical, chemical, and biological properties,and statistics indicated that the mixtures were homogenous both spatially and with depth. However, the mixtureswere significantly different from both the disturbed materials and native topsoil, primarily driven bychanges in soil organic carbon, plant available nutrients, and biological activity. These results suggest that thismixing process can be used for soil reclamation at large-scale excavation sites to both reduce project costs andenhance recovery of soil parameters.

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