

Production of an Artificial Soil from Domestic & Industrial Wastes

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ABSTRACT: Majority of the civil engineering structures are supported by soil; hence importance of soil as a foundation supporting material is of utmost significance. However too much usage of the natural resource is an alarming issue and finding a right alternative to reduce the usage of it is needed because there is a lack of natural earth materials in the present era due to continuous and fast development around us. There is an emergency to find new and innovative ways to recycle and reuse waste materials.

The theme of our project is based upon the creation of an artificial soil which is capable enough to compete with natural soil as its alternative in civil work applications. Bio solids and ground granulated blast furnace slag are the two components in consideration.

Bio solids, a treated sludge (domestic waste) from sewage treatment plant are produced annually in tones. They are stock piled and disposed off finally. This material has traits of cohesion. On the other hand, industrial waste such as steel slag is a glassy, granular product that is dried and ground into a fine powder. It has very good frictional properties in it.

This project work deals with the fusion of above mentioned two materials i.e. bio solids and steel slag, possessing strength parameters that of a soil. The ratio of mixing the materials in such a proportion which makes the composition viable and helps in achieving commendable geotechnical strength is finally achieved. The effort to rely more on unconventional waste materials and converting them into good useful resource is of prime importance for making earth a better place to survive.

KEYWORDS: Biosolids, Steel Slag, unconventional material, artificial soil.

INTRODUCTION

Innovation may be defined as exploiting new ideas leading to the creation of a new product, process or service. It is an important tool to compete and survive in this world. Same rule follows when it comes to survival of mankind. Human beings are reengineering their environment. The process has made humans to consume every natural resource available to meet their technological and advancement needs.

The concept of sustainable development, stability and longevity is totally missing and the repercussion of this will be very destructive. Soil is one such natural resource whose intense application in recent civil engineering works is quite enormous. For example; World famous palm Jumeirah Island was constructed with 110000000 meter cube of sand. It clearly suggests the rate at which the soil is being used for construction.

Alternative ways must be used to decrease the pressure upon the usage of soil. One such way of doing that is trying out the materials which have the properties of soil and modifying it suitably to act as a replacement. The artificial soil which we are proposing is produced from domestic and industrial wastes which are generally dumped out and are not considered as of much.

The alternative materials bio solids and steel slag have cohesion and frictional properties respectively which make them more suitable as a soil. Bio solids are cohesive in nature and produced in huge quantities. The frictional component steel

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slag is equally accessible. The reuse of these waste materials is a boon in disguise as it reduces the demand on natural resources, provides a more sustainable environment and last but not the least, lowers the carbon foot print compared to the usage of virgin resources.

UNIQUE FEATURES OF PROJECT#3

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- Reduces demand for non renewable resources
- Reuse of waste materials
- Re-engineering a sustainable environment

COMPONENTS USED

- Domestic waste-biosolids-main component
- Industrial waste-conditioner to soil-supplementary component

BIOSOLIDS INTRODUCTION

Biosolids is a term applied to treated sludge that meets requirements for beneficial reuse through application to agricultural land and use by the public [6]. The treatment and distribution of biosolids is governed by federal regulations contained in 40 CFR 503. These regulations set criteria and process requirements pertaining to various classifications of biosolids. The District has prepared and submitted to the State Division of Water Quality a written Biosolids Management Plan. The Biosolids Management Plan sets forth the District's methods for complying with the 503 regulations and declares the specific processes for achieving compliance.

As stated in the plan, "The goal of the District is to maintain compliance with all requirements to achieve 'exceptional quality' biosolids." "Exceptional quality" is an EPA term to define biosolids that meet the highest level of quality in three categories: 1. Reduction of pathogens; 2. Reduction of vector attraction (odor); and 3. Low concentrations of specific metals. The biosolids produced by the District meet the highest level in each of these categories and are designated "exceptional quality." As such, the biosolids given away by the District have relatively few restrictions for use. They can, in fact, be used in home gardens [5].

The treatment and preparation of biosolids begins during the solids treatment process and is completed on a large concrete slab storage area. As solids are processed in the digesters they are decomposed and stabilized. It is through the digestion process that the volatile solids, which contribute to odors, are reduced and pathogens begin to be reduced. The regulations require a minimum 38 percent reduction in volatile solids [4]. The average reduction achieved by the District's digestion process is 45 to 60 percent. Hence Biosolids availability should be utilised efficiently for a sustainable environment.

BENEFITS

Biosolids land application is a beneficial recycling process with economic and environmental benefits for many Americans. Biosolids recycling and reuse not only save local and state governments significant amounts of money through lower disposal costs and sales of biosolids-derived products, but add nutrients and positive soil characteristics to agricultural land.

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National biosolids generation rates are estimated to reach 47 dry pounds per American yearly. More than \$2 billion is spent annually treating and managing approximately 5.3 million dry metric tons of biosolids from publicly owned wastewater treatment plants in the United States. Because land application is considerably less costly than the next available residuals management option, significant savings are realized and passed on to consumers through reduced utility bills and purchase prices which must cover utility costs [3]. Land application of biosolids has gained popularity and widespread approval from the scientific and environmental communities and has increased.

Because biosolids provide nutrients in an organic form, they are utilized by the crops instead of lost to adjacent streams and groundwater. Therefore land application reduces and eliminates pollution that is often caused by traditional fertilization methods. The organic matter supplied by biosolids builds soil structure to reduce soil erosion and increase vegetative growth [2]. By reducing pollution and increasing soil productivity, land application improves the surrounding environment.

- Offers the Opportunity to Recycle
- Benefits the Community
- Lowers Costs
- Protects Water Quality
- Saves Diminishing Landfill Space
- Enhances Landscaping and Gardening
- Preserves Virginia Farmland
- Reduces Soil Erosion

BIOSOLIDS AS SOIL ADMIXTURE

- Cohesive nature
- Availability
- Fertiliser properties
- Non degradable
- Light weight
- Permeability

COMPOSITION

- High organic content (40% – 60%)
- Nitrogen
- Phosphorous
- Pottasium
- Calcium
- Magnesium
- Sulphur
- Zinc

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LABORATORY ASPECTS

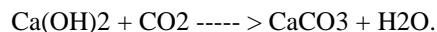
- High Liquid Limit
- Consolidation and compaction
- behaviour: Similar to high organic
- clay
- High deformation potential
- Lack of sufficient shear strength
- Low friction between particles

STEEL SLAG

Steel slag is very similar to blast furnace slag, yet it is also very distinct. Both types of slags are produced as limestone is chemically converted in high temperature processes [1]. The blast furnace slag is made in a blast furnace, and consequently steel slags are produced in steel making processes (e.g. basic oxygen furnace or in an electric arc furnace). Steel slag product names are identical to blast furnace slag products and the steel slags are also PennDOT certified. Since steel is produced at much lower temperatures, it typically has a much different chemistry than its blast furnace counterpart. There is usually much more residual iron in steel slags, which account for its darker color. Steel slags also have a higher magnesium concentration, so care must be taken when incorporating them into the cement/concrete processes. However, they can be used just about anywhere that blast furnace slags can be used.

PROPERTIES

Steel slags are calcium alumino-silicate oxides. Since they form at the melting point of iron (>2,700 degrees F), most compounds with lower boiling points have been driven off [7]. These compounds contain elements like sulfur, selenium, carbon, cadmium, lead, copper, and mercury. Most of the residuals are encased within a glassy matrix. Fortunately, the matrix is soluble and releases calcium and manganese oxides, which can drive the pH of the dissolving fluid to 10 or 11. Since slag is a coarse glass, it will maintain high permeability ($\sim 4.5 \times 10^{-2}$ cm/sec) regardless of how much water has passed through it. The permeability of this material can be reduced if it is compacted or ground up into smaller particles. Recmix, on the other hand is a much finer material and barely lets any water pass through (permeability is $\sim 1.0 \times 10^{-6}$ cm/sec). Unlike lime, steel slags do not absorb CO₂ from the air and convert back to relatively insoluble limestone according to the reaction:



This is an extremely important property, since it means slag can be left outside, exposed to the atmosphere for years, and still achieve high levels of alkalinity upon dissolution.

PHYSICAL & CHEMICAL CHARACTERISTICS

Physical characteristics – The shape of steel slag aggregates is highly angular. It has a rough surface texture. The aggregates of steel slag have high bulk density and specific gravity with moderate water absorption capacity. Typical physical properties of steel slag aggregates are:

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- Bulk density – 1.6 – 1.9 tons/Cu
- Specific gravity - More than 3.2
- Water absorption – Up to 3 %

Chemical characteristics - The chemical composition of the steel slag is generally expressed in terms of simple oxides determined by elemental analysis done with x-ray fluorescence spectrometer. The steel slag produced during steel making in a basic oxygen converter has the following typical range of composition.

- CaO – 46 to 52 %
- SiO₂ – 12 to 19%
- MgO – 9 to 11%
- Al₂O₃ – 1 to 3%
- MnO – 3- 6%
- FeO 15 to 25%
- P₂O₅ – 0.5 to 1.0%
- S – less than 0.1%
- Metallic Fe – 0.5 to 6%

Though all types of steel slags have composition within these chemical ranges but all steel slags are not suitable to be used as slag aggregates. For use steel slag as slag aggregate, the mineralogical form of the slag is more important and this in turn is mainly dependent on the rate of slag cooling during the process of steel making. The cooling rate of steel slag is to be sufficiently slow so that crystalline compounds are formed [8]. The predominant compounds in steel slag are di-calcium silicate, tri-calcium silicate, di-calcium ferrite, calcium aluminate, calcium-magnesium iron oxide, and some free lime (CaO) and magnesia (MgO). The relative proportions of these compounds depend on the steel making practice and the steel slag cooling rate.

During the process of steel making free calcium and magnesium oxides are not usually fully consumed in the steel slag, and the hydration of this un slaked lime and magnesia when in contact with moisture is mainly responsible for the expansive nature of the steel slag [9]. The free lime present in the steel slag hydrates rapidly and cause large volume changes of the slag over a relatively short period of time, while magnesia hydrates much more slowly and contributes to long-term expansion that may take long time to develop.

Steel slag is mildly alkaline, with a pH of the solution usually in the range of 8 to 10. However, the pH of leachate from steel slag can exceed 11. This level of pH can be corrosive to aluminum or galvanized steel pipes placed in direct contact with the slag [10]. Tufa like precipitates, resulting from the exposure of steel slag aggregates to both water and the atmosphere, has been reported. Tufa is a white, powdery precipitate which consists mainly of calcium carbonate (CaCO₃). It occurs in nature. Generally it is found in water bodies. The tufa precipitates associated with steel slags can be attributed to the leachate combining with atmospheric carbon dioxide. Free lime in steel slags may combine with water to produce calcium hydroxide (Ca (OH)₂) solution. Upon exposure to atmospheric carbon dioxide, calcite (CaCO₃) is precipitated in the form of surficial tufa and powdery sediment in surface water. Tufa precipitates usually clog drainage paths in pavement systems [11].

➤ MECHANICAL PROPERTIES

Mechanical Properties – Steel slag which has been processed exhibits favorable mechanical properties for aggregate use. These include good abrasion resistance, high bearing strength and good soundness characteristics. Typical mechanical properties of steel slag are as follows:

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- Hardness - 6 to 7 Moh's scale of mineral hardness
- Los Angeles Abrasion (ASTM C131) – 20 to 25%
- Sodium Sulfate Soundness Loss (ASTM C88) – Less than 12%
- Angle of Internal Friction – 40° to 50°
- California Bearing Ratio (CBR) - Up to 300 for maximum size of 19 mm.

USES OF STEEL SLAG

In sinter feed mix steel slag replaces limestone and dolomite. This recycling of steel slag in sinter plant as sinter feed is due to its high percentage of CaO and MgO. It is also used as railroad ballast and as a road base. Other uses of steel slag are in soil treatment, hot mix asphalt and as a land fill.

COLLABORATION

The mixture of bio solids and steel slag has to be made to get a complete package of Good strength soil which will be useful in recent advancements in civil engineering construction purposes. The mixture will provide improvements in following areas:

- Cohesion characteristic of recycled glass
- Shear strength of biosolids
- Internal friction angle of biosolids
- Deformation potential of biosolids

OBJECTIVES & NEED OF PROJECT

- To determine the right proportion of mix of Biosolids& industrial waste which yields a geotechnical strength comparable with naturally available Soil.
- To produce an artificial material that proves to be a good replacement of soil and environmentally sustainable.

APPLICATIONS

- Road Embankments
- Geotechnical Fill
- Bridge Abutments
- Soil Reserve
- High strength requirement.

FUTURE SCOPE OF PROJECT

- Making mixture odour free.
- Regulating the fibrous content in bio solid.

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- Identifying materials which chemically reacts and strengthens the biosolid.

CONCLUSION

The results are being performed upon Bio solids and it is found to be having very good cohesive nature and relatively moderate clayey content. The material is suitable to be a soil with good cohesive nature. The ultimate mixture will be having a good blend of Biosolid and steel slag which will collectively enhance the mixture strength. The project has not yet completed. Hence a complete conclusion cant be obtained. But the ideology of depending more upon the unconventional types of materials will help the mankind to prolong the generation and live harmoniously with the mother nature.

REFERENCES

- [1] Mahdi MiriDisfani, sustainable application of Recycled glass-biosolids mixtures in roadwork applications, The Royal Society of Victoria, 2010.
- [2] Kumar S.S., Rao M.R.K., Balasubramanian M.P., "Anticarcinogenic effects of indigofera aspalathoides on 20-methylcholanthrene induced fibrosarcoma in rats", Research Journal of Medicinal Plant, ISSN : 5(6) (2011) PP. 747-755.
- [3] Sally Brown And Chuck Henry, Using Biosolids For Reclamation of disturbed soils, 2006.
- [4] Rufus I. Chaney, Judith g. hallfrisch, Qi xue, Effect Of Biosolids Processing On Lead Bioavailability In An Urban Soil, journal 2009.
- [5] Jaikumar S., Ramaswamy S., Asokan B.R., Mohan T., Gnanavel M., "Anti ulcer activity of methanolic extract of Jatropha curcas (Linn.) on Aspirin-induced gastric lesions in wistar strain rats", Research Journal of Pharmaceutical, Biological and Chemical Sciences, ISSN : 0975-8585, 1(4) (2010) PP.886-897.
- [6] G.k. Evanylo, A.o.abaye, and W.I. daniels, Effects Of Biosolids-Amended Mined Land On Soil And Plant Quality, 2004.
- [7] Gopalakrishnan K., Prem Jeya Kumar M., Sundeep Aanand J., Udayakumar R., "Analysis of static and dynamic load on hydrostatic bearing with variable viscosity and pressure", Indian Journal of Science and Technology, ISSN : 0974-6846, 6(S6) (2013) PP.4783-4788.
- [8] Brennan, joseph e. (pottsville, pa, us), biosolids and fly ash composition for use in soil conditioning, Web Blog, 2008.
- [9] Srinivasan V., "Analysis of static and dynamic load on hydrostatic bearing with variable viscosity and pressure", Indian Journal of Science and Technology, ISSN : 0974-6846, 6(S6) (2013) PP.4777-4782.
- [10] John j. yzenasjr., Edward c. levy company, the utilization of steel furnace slag for soil stabilization
- [11] Subhashree A.R., Shanthi B., Parameaswari P.J., "The Red Cell Distribution Width as a sensitive biomarker for assessing the pulmonary function in automobile welders- a cross sectional study", Journal of Clinical and Diagnostic Research, ISSN : 0973 - 709X, 7(1) (2013) PP. 89-92.
- [12] AR.Arunachalam, Imperceptible Digital Image Watermarking, International Journal of Innovative Research in Computer and Communication Engineering, ISSN(Online): 2320-9801, pp 1321-1326, Volume 1, Issue 6, August 2013.
- [13] AR.Arunachalam, Spectrum Reuse in Multiple Primary User Environment, International Journal of Innovative Research in Computer and Communication Engineering, ISSN(Online): 2320-9801, pp 1475-1480, Volume 1, Issue 7, September 2013
- [14] B.Sundar Raj, A Third Generation Automated Teller Machine Using Universal Subscriber Module with Iris Recognition, International Journal of Innovative Research in Computer and Communication Engineering, ISSN (Online): 2320 – 9801, pp 565-571, Vol. 1, Issue 3, May 2013
- [15] B.Sundar Raj, The Efficiency of the Scalable Architecture for Revealing and Observing the Environment using Wireless Sensor, International Journal of Innovative Research in Computer and Communication Engineering, ISSN (Online): 2320 – 9801, pp 63-67, Vol. 1, Issue 1, March 2013
- [16] C.Anuradha, An Efficient Detection of Black Hole Attacks in Tactical MANETs, International Journal of Innovative Research in Computer and Communication Engineering, ISSN(Online): 2320-9801, pp 1636-1645, Volume 1, Issue 8, October 2013