International Journal of Advanced Technology in Engineering and Science
Vol. No.5, Issue No. 06, June 2017
www.ijates.com
ijates
ISSN 2348 - 7550

STABILIZATION OF SUB-GRADE USING FLY ASH AND GEOSYNTHETIC MATERIAL

Sandeep Kumar[1], Er. Arti Chouksey[2], Priyanka[3]

[1]M.TECH Student, Department of Civil Engineering, DCRUST Murthal Haryana (India)
[2]Assistant Professor, Department of Civil Engineering, DCRUST Murthal Haryana (India)
[3]Department of Civil Engineering, DCRUST Murthal Haryana(India)

ABSTRACT

Soil is the basic foundation for any civil engineering structures. It is required to bear the loads without failure. In some places, soil may be weak which cannot resist the incoming loads for which soil stabilization is needed. Numerous methods are available in literature for soil stabilization. But sometimes some of the methods like chemical stabilization, etc., adversely affect the chemical composition of the soil. Geosynthetics is manmade material used for soil stabilization; geogrid mesh may be introduced in the soil to increase the strength of the poor soil. Geosynthetics is used in locations where shear stresses are generated because shearing stress between soil and reinforcement which restrains the lateral deformation of the soil. To enhance the property of soil, Geosynthetics is used which increases the bearing capacity and permeability of soil, and also reducing the settlement of soil. Fly ash is mixed with soil to investigate the relative strength gain in term of bearing capacity and compaction. In this paper an attempt has been made to evaluate the strength of soil by using a multilayer geogrid in the soil and by conducting grain size distribution, standard Proctor compaction tests, OMC tests, and CBR tests. The experimentation results show that how the use of geogird and fly ash leads to effectively enhance the property of soil.

Key Words: Geogrid, Fly Ash, CBR Test, OMC Test.

I. INTRODUCTION

Engineers are continually faced to maintain and develop pavement infrastructure with limited source.In traditional pavement design and construction practices require high quality material for fulfillment of construction standards. In many areas of the world, quality materials are unavailable or in short supply. Due to these restrictions, engineers are often forced to seek alternative designs using substandard material, commercial construction aid, and innovative design practices. One category of commercial construction aids is geo-synthetics. It includes different types of geo-textiles, geo-nets, geo-membranes, geo-grids, geo-compositors etc.

Geo-synthetics have proven to be among the most versatile and cost effective ground modification material. Their use has expanded rapidly into nearly all areas of Civil, geo-technical, environmental, coastal and hydraulic engineers.

A geo-grid is defined as a geo-synthetics material consisting of connected parallel sets of tensile ribs with apertures of sufficient size to allow strike-through of surrounding soil, stone or other geo-technical material.

Geo-grid are single or multilayer material usually made from extruding and stretching high density polyethylene or polypropylene or by weaving or knitting and coating grid structure possesses large opening (called apertures) that enhance interaction with the soil on aggregate. The high tensile strength and stiffness of geo-grids make them especially effective as soil and aggregate reinforcement.

II. AIM OF STUDY

Engineers do most of works on the basis of old techniques; this consists of flyover construction by soil filling. But, now a day, the agriculture land is going on lapse so that availability of soil is short and costly. Due to this short supply, substandard materials are used for that innovative design are required for maintaining the standards.

But, now days, the production of fly ash is in limited form, there is hazardous problem for it transportation also. It is also difficult in mixing fly ash and also costly in use on the basis of replacement of soil. To over comes these problems, geo-grid have been successfully used to provide a construction platform over soft subgrades.

We justify that how the geo-grids are beneficial for work. Geo-grids improved the bearing capacity which found by CBR test. To know this, we check the CBR value by OMC and CBR test. By collecting different types of soils, different layers of geo-grids, we check the CBR value in laboratory set up, and suggest use of geo-grids by giving these benefits on the basis of practical result.

III. REVIEW OF LITERATURE

Kumar et al, find out that the CBR of a soil increases up to nearly three times (CBR value 8.8%), when it is reinforced with a single layer of geo-grid. The amount of improvement depends upon the type of soil and position of geo-grid. The optimum position for single layer of geo-grid is at 100mm from the bottom of CBR test mould.

The CBR value of the soil increases significantly with increase in number of reinforcing layer (when3-layer geo-grid, CBR value 17.2% and their relative position within the soil and type of reinforcement. The optimum position for 3-layear geo-grid is at 100mm, 75mm and 500mm from the bottom of CBR test mould.

The results indicate that the use of geo-grid as a reinforcing agent in the sub grade is effective to increase the CBR value but the optimum value can be achieved by providing the geo-grid layer at the top surface of sub-grade. The CBR value can also improve by them providing the two or more geo-grid layer as shown in results section.

Chaudhary et al. (2011), describes results of a series of CBR and swells tests to evaluate the beneficial effects of placing a single layer of horizontal reinforcement at varying depths from the top surface of the expansive subgrade soil. The aim of the paper is to optimize the position of the reinforcing layer for two different types of reinforcement used in the investigation, namely- geo-grid and jute geo-textile.

Chaudhary et al. (2012), find out that the insertion of a single layer of reinforcement within the expansive soil subgrade controls the swelling significantly. The percentages reduction in swell depends on its depth of embedment used. The CBR value of the soil increases substantially when a single layer of reinforcement is placed horizontally within the soil. The extent of improvement depends on the type of reinforcement and the embedment ratio. The stress-strain behavior of expansive soil subgrade improves considerably when the reinforcement is provide at optimum embedment depth under static load condition as evident from the scant modulus values obtained for different cases. The jute geo-textile offers a better reinforcing efficiency as compared to the geo-grid and can be used for low cost road projects in rural areas. But durability study is required for long term application of the jute geo-textile.

Parsed et al, (1983) reported that removal of lignin, hemicelluloses, silica and pith from fibers results in better interaction with the soil. Shankar et al., (2004) have reported a similar study on coir fiber stabilized lateritic soil and it was found that, in lateritic soils, the CBR value increases up to 10% by volume of coir fibers added. It may thus be concluded that discrete coir fiber contributes substantially in improving the CBR value of weak sub-grade soils. A maximum value of CBR is attained at a specific fibers content corresponding to the specific optimum moisture content attained by the soil-coir matrix.

Lekha and Sreedevi (2006) conducted the study on soil reinforced with coir fibers at different proportions to study the changes in optimum moisture content and maximum dry density. Their study reveals that the optimum moisture content is found in increase with the increase in coir fibers content and correspondingly, the maximum dry density is found to decrease. Muntohar (2009) reported that the brittle behavior of soil is reduced using fibers of length 20mm to 40mm. Dasaka and Sumesh (2011) reported that varying the length of coir fibers and content in soil results improvement in strength characteristics. They further reported that length of fibers play a significant contribution in the strength enhancement of soil. However studies relating to compaction and CBR behavior of soil reinforced with dry/treated coir fibers have not been reported so far. The present study is one such attempt to examine the effect of inclusion of dry/treated coir fibers on the optimum moisture content, maximum dry density and CBR for improving strength of subgrade soil.

Dutta et al, done experiment on compaction and C.B.R. tests on clay was reinforced with dry/treated coir fibers at varying percentage. He concluded that, when soil is reinforced with coir fibers, the optimum moisture content increases whereas maximum dry density decreases with the inclusion of dry/treated fibers to soil. The clay + treated fibers shown marginally higher density and lower optimum moisture content as compared to clay + dry fiber mix.

The CBR and Ks values for reinforced clay at different fiber content were substantially higher than of pure clay alone. Further the CBR and Ks values for clay + treated fibers were slightly better than clay +treated fibers were slightly between than clay + dry fibers.

The compaction and C.B.R. properties of reinforced clay obtained from present study will be useful for the village road construction and other ground improvement measure. Further, its use will also provide environmental motivation for providing a means of recycling large quantities of waste coir fiber. **Various research workers to improve the locally available weak materials by using some admixtures or reinforcing material (Haas, 1985, Nejad and Small, 1996, Ling and Liu, 2001, Srinivas et.,2008, Asha et al., 2010, Stalin et, al.,2010).**

Singh et al, find out, reinforced benefits of geo-grid at different depth form the top of specimen i.e. CBR values for soaked CBR and un-soaked CBR and the -important findings of this research are summarized as – The CBR of a soil increases by when it is reinforced with a single layer of geo-grid. The amount of improvement depends upon the type of soil and position of geo-grid.

The un-soaked CBR value increased from 6.5% for virgin soil to 15.05%, when geo-grid was placed at 0.2H and for greater depths of geo-grid layer, CBR value starts decreasing. The increased is 147%.

In case of soaked CBR test, the CBR value increased from 2.9% to 9.4% for geo-grid position at 0.2% and for greater depth of layer the trend is similar to un-soaked case. This increase is 224%.

As the CB value is one of the important parameter controlling the thickness of a flexible pavement, hunger saving in the cost can be achieved by reinforcing the subgrade soil with geo-grids.

IV. APPLICATIONS OF GEO-SYNTHETICS

There are four main applications for geo-synthetics in roads are Sub-grade separation, base reinforcement, overlay stress, absorption and reinforcement.

In first application-: The construction of unpaved road over soft subsoil has been popular. At the small rut depth the strain in geo-synthetics is also small and geo-synthetics acts primarily as a separator between the soft subgrade and aggregate. Any geo-synthetics that survive construction will work as separator.

In 2nd application -:In addition of a appropriate geo-synthetics, the soil geo-synthetics aggregates (SGA) system gains stiffness. The SGA system is able to provide the following structural benefits.

- Preventing lateral spreading of base
- Improve vertical stress distribution on the subgrade
- Reduce shear stress in the subgrade
- Increasing confinement and thus stiffness of base

In 3rd and 4th application-: use overlay stress absorption and reinforcement. A geo-synthetic interlayer can be placed over the distress pavement or within the overlay to create an overlay system and following benefits of geo-synthetic interlayer.

- Delaying the appearance e of reflective cracks.
- Lightening the useful life of overlay.

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www.ijates.com
ijates
ISSN 2348 - 7550

4.1 Geosynthetics in Pavement

Separation and Reinforcement

1) Soft subgrade materials may mix with the granular base or sub base material as a result of loads applied to the base course during construction
2) Geotextiles have been used in construction of gravel roads and airfields over soft soils to solve these problems and either increase the life of the pavement or reduce the initial cost.
3) The placement of a permeable geotextile between the soft subgrade and the granular material may provide one or more of the following functions,

a) A filter to allow water but not soil to pass through it.
b) A separator to prevent the mixing of the soft soil and the granular material.
c) A reinforcement layer to resist the development of rutting.

V. TESTING PROGRAMME

5.1 Introduction

Large scale utilization of fly ash in geotechnical constructions will reduce the problems faced by the thermal power plants for its disposal mostly because of its property closely related with the natural earth material. So assessment of the behavior fly ash at different condition is required before its use as a construction material in Civil engineering structures. Even through adequate substitute for full scale field tests are not available; tests at laboratory scale provide a measure to control many of the variable encountered in practice. The trends and behavior pattern observed in the laboratory tests can be used in understanding the performance of the embankment and may be used in formulating mathematical relationship to predict the behavior of embankment. Details of material used, sample preparation and testing procedure adopted have been outlined in this chapter.

5.2 Material Used

5.2.1 SOIL

The soil samples were taken from DCRUST campus which covers the entire university. Sample was taken from AUDITORIUM. The soil used in this investigation is local soil of DCRUST campus, Murthal, Sonipat. According to Indian Standard of Soil Classification, the soil is medium to low compressibility Silt. The properties of soil are as under in table 5.2.1.

TABLE 5.2.1 PROPERTIES OF SOIL

S. NO.	CHARACTERISTIC	VALUE
1	Specific Gravity	2.72
2	Particle Size Distribution (%)	
(a)	Sand	38

(b)	Silt	60
(c)	Clay	2
3	Liquid Limit (%)	23
4	Plasticity limit (%)	21
5	Plasticity Index (%)	2
6	Classification Of Soil	ML
7	Maximum DRY DENSITY (kN/m3)-Standard Proctor Compaction	17.55
8	Optimum Moisture Content(%) - Standard Proctor Compaction	10.6
9	Unconfined Compressive Strength (kN/m2)	124.8
10	Un-soaked CBR (%)	6.08
11	Soaked CBR (%)	2.5

5.2.2 FLY ASH

Fly ash was collected from the Thermal power plant of Panipat .The sample was screened through 2mm sieve to separate out the foreign and vegetative matters. The collected samples were mixed thoroughly to get the homogeneity and oven dried at the temperature of 105-110 degree Celsius.

5.2.2.1 PROPERTIES OF FLY ASH

Fly ash used in present study is from Thermal Power Plant of Panipat. The Chemical properties are given in Table 5.2.2.1.

TABLE 5.2.2.1

S. No	NAME OF CONSTITUENT	PERCENTAGE (%)
1	Silica (SiO_2)	55.9
2	Alumina (Al_2O_3)	27.7
3	Iron Oxide (Fe_2O_3)	5.3
4	Calcium Oxide (Ca O)	3.2
5	Un-burnt Carbon	4.1
6	Un-burnt Oxides	2.7

5.2.3 MIXING PROPORTIONS

Lime, Fly ash & Soil and are to be mixed thoroughly to have a uniform mixture by mechanical means .These are to be mixed in proportions given below in Table 5.2.3

TABLE 5.2.3 MIXING PROPORTION

S.NO.	NAME OF PROPORTION	LIME (%)	FLYASH (%)	SOIL (%)
1	L4F25S71	4.5	25	70.5
2	L7F25S68	7	25	68
3	L10F25S65	10	25	65
4	L4F35S61	4.5	35	60.5
5	L7F35S58	7	35	58
6	L10F35S55	10	35	55
7	L4F45S51	4.5	45	50.5
8	L7F45S48	7	45	48
9	L10F45S45	10	45	45

VI. RESULTS AND DISCUSION

6.1 Grain Size Analysis

From table 7.1, coefficient of uniformities' (Cu) values are 17.50 for AUDITORIUM,. And values of coefficient of curvature (Cc) are 1.05, so point of literature it is clear that all the three samples are either poorly graded sandy soil or well graded sandy soil but from Fig 7.1 it is clear that the sample is contains all types of particles ranging from 0.1mm to 10 mm. And this proves that the sample is well graded. Combining both results it is concluded that the the sample is well graded and soil is sandy.

TABLE 6.1

SIEVE ANALYSIS	
SIEVE DIA(mm)	%FINER
4.75	63.35
2.36	49.80
2.00	43.75
0.60	24.20
0.43	20.95
0.30	12.15
0.15	3.65
0.08	1.50

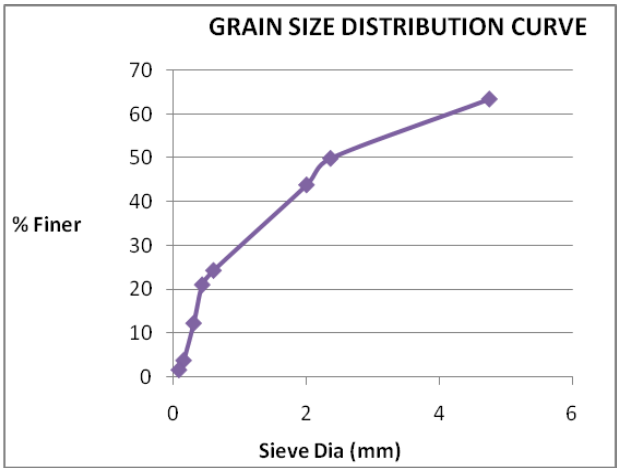

Figure 7.1 Grain Size Distribution Curve

6.2 Calculating the Co-Efficients of Uniformity and Curvature

Calculating the coefficients of uniformity and curvature requires grain diameters. The grain diameter can be found for each percent of the soil passing a particular sieve. This means that if 40% of the sample is retained on the No. 20 sieve then there is 60% passing the No. 20 sieve.

The coefficient of uniformity, C_u is a crude shape parameter and is calculated using the following equation:

$$C_u = \frac{D_{60}}{D_{10}}$$

Where D_{60} is the grain diameter at 60% passing, and D_{10} is the grain diameter at 10% passing

The coefficient of curvature, C_c is a shape parameter and is calculated using the following equation

$$C_c = \frac{(D_{30})^2}{D_{10} \times \ D_{60}}$$

Where D_{60} is the grain diameter at 60% passing, D_{30} is the grain diameter at 30% passing, and D_{10} is the grain diameter at 10% passing

Once the coefficient of uniformity and the coefficient of curvature have been calculated, they must be compared to published gradation criteria.

International Journal of Advanced Technology in Engineering and Science
Vol. No.5, Issue No. 06, June 2017
www.ijates.com
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TABLE 6.2 COEFFICIENTS OF UNIFORMITY AND CURVATURE

%PASSING	SIEVE DIA (mm) AUDITORIUM
D10	0.240
D30	1.020
D60	4.160

PROPERTY	
Cu=D60/D10	17.50
Cc=(D30)^2/(D60*D10)	1.05

6.3 Specific Gravity

Specific gravity of soil solids is the ratio of weight, in air of a given volume; of dry soil solids to the weight of equal volume of water at 4ºC.Specific gravity of soil grains gives the property of the formation of soil mass and is independent of particle size. Specific gravity of soil grains is used in calculating void ratio, porosity and degree of saturation, by knowing moisture content and density. The value of specific gravity helps in identifying and classifying the soil type.

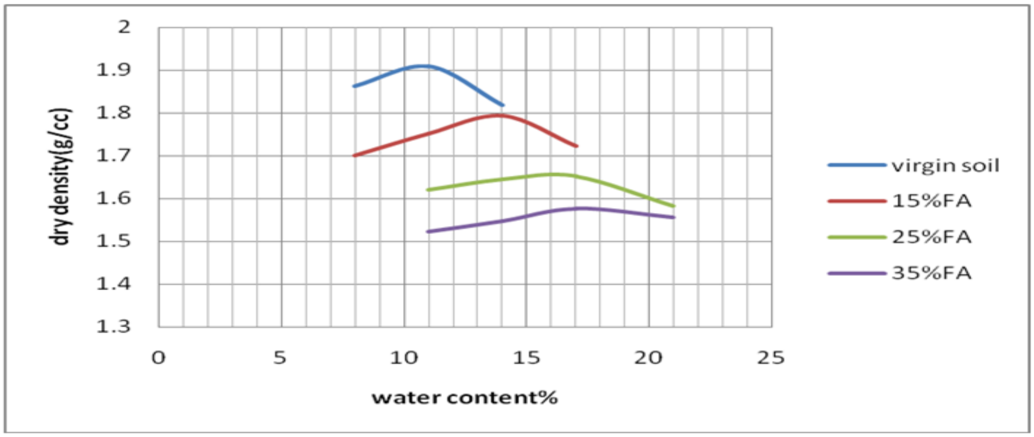
TABLE 6.3

SFECIFIC GRAVITY	
MASS	AUDITORIUM
MASS OF EMPTY PYCNOMETER	461 gm
MASS OF PYCNOMETER AND DRY SOIL	959gm
MASS OF PYCNOMETER, DRY SOIL AND WATER	1540gm
MASS OF PYCNOMETER, DRY SOIL AND WATER	1227gm
SPECIFIC GRAVITY	2.60

6.4 COMPACTION TEST

This laboratory test is performed to determine the relationship between the moisture content and the dry density of a soil for a specified compaction effort. The compaction effort is the amount of mechanical energy that is applied to the soil mass. Several different methods are used to compact soil in the field, and some examples include tamping, kneading, vibration, and static load compaction. This laboratory will employ the tamping or impact compaction method using the type of equipment and methodology developed by R. R. Proctor in 1933, therefore, the test is also known as the Proctor test.

6.4.1 COMPACTION CURVES



Graph of curves relation between water content & dry density at different ratio of soil and fly ash and their comparison.

6.5 CALIFORNIA BEARING RATIOS

6.5.1 CBR Method:

California bearing ratio is the ratio of force per unit area required to penetrate in to a soil mass with a circular plunger of 50mm diameter at the rate of 1.25mm / min.This method was originally devised by O.J. Porter, then of the California state highway Department, but it has since been modified by various organizations for different conditions. C.B.R. method as recommended by IRC 37-1970, is generally structural evaluation of sub -Grade soil in India. The sample obtained from sub grade soil is compacted to maximum dry density at optimum moisture content and CBR value for these samples are determined.

6.5.4 GRAPH COMPARISON BETWEEN DIFFERENT RATIO OF (SOIL & F.A) (i) WITH 1LAYER GEOGRID, (ii) WITH 2LAYER GEO-GRID, (i) WITH 1LAYER GEOGRID, (ii)WITH 2LAYER GEO-GRID

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Vol. No.5, Issue No. 06, June 2017
www.ijates.com
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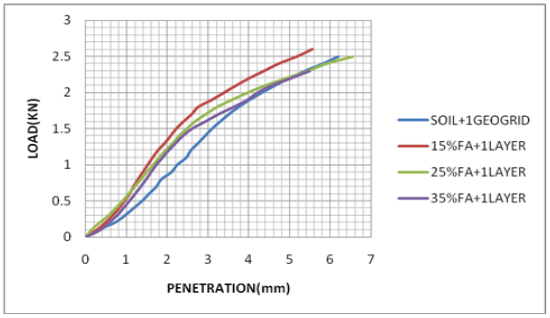
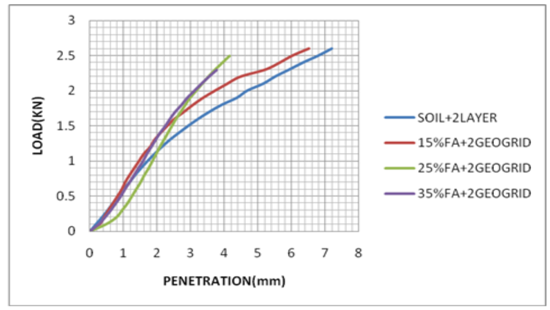
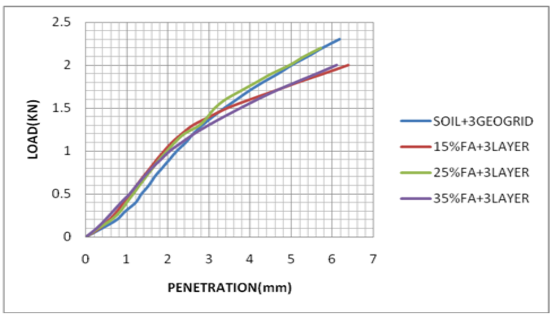
ISSN 2348 - 7550



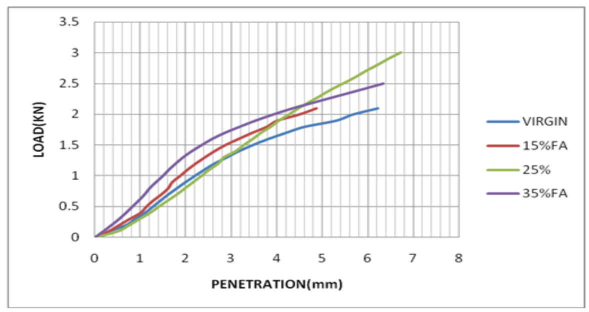
(i) WITH 1LAYER GEOGRID



(ii) WITH 2LAYER GEO-GRID



(iii) WITH 3LAYER



(ii) WITHOUT GEOGRID

6.5.5 COMPARISION RESULTS OF CBR (SOIL +FLY ASH) WITH GEO-GRID (DIFERENT LAYERS)

VIRGIN SOIL	15%FA	25%FA	35%FA
8.170	9.490	10.31	10.99
SOIL + 1 LAYER	**15%FA+1LAYER**	**25%FA+1LAYER**	**35%FA+1LAYER**
9.50	11.70	12.45	11.90
SOIL + 2 LAYER	**15%FA+2LAYER**	**25%FA+2LAYER**	**35%FA+2LAYER**
10.40	12.50	13.40	12.42
SOIL + 3 LAYER	**15%FA+3LAYER**	**25%FA+3LAYER**	**35%FA+3LAYER**
9.35	9.60	10.75	10.00

VII. FUTURE SCOPES

1) The present investigation should be carried out in actual Highway or Road so that comparative serviceability can be judge.
2) A numerical model can be developed using computation technique or software.
3) Other form of Geo-synthetics such as Geo-cell can be studied in future.

IX. CONCLUSIONS

1) The CBR value is increased with increase proportion of soil and fly ash.
2) This increase is significance up to 25% fly ash after that this increase value is minimum.
3) The CBR value is increase with addition of Geo-grid.
4) The maximum CBR value with Geo-grid is significance up to 2layer of Geo-grid. After that increase value is minimum.

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