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CONSTURCTION OF ROAD BY USING GEOCELL AND STEEL SLAG

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ABSTRACT

Geocell and iron steel slag is use for construction of rural road and improve the quality of road in all weathering condition for the rural traffic. Steel slag is a by-product from steel industry. It has been declared as useful construction material, not an indusial waste by most of the developed countries. Successively, it is recycled as an aggregate for construction of road, base and for the surfacing of flexible pavement. In this project, novel construction of rural road with high density polyethylene i.e. geocell and indusial steel slag by honeycomb shape of geocell compartment and filling the industrial steel slag as an aggregate to construct the road. The main purpose of the project is to construct the better quality rural road. The project is evaluate the behavior of **Geocell And Steel Slag Road** – Compressive strength, Settlement of sub grad, Condition of wearing surface, and properties of aggregate and geocell. The goal of our project research is to construct the road for the rural area at minimum cost with low maintains and longer life span with better srviceability. When the geocell is use in a road, it increases the load carrying capacity of road which is suitable for the rural traffic. This project work is conducted in Wardha city located at 20.7453^0 N & 78.6022^0 E. Sawangi Datta Meghe Institute of Engineering Technology and Research in Wardha.

KEYWORD: Geocell, recycled, steel slag, industrial waste, steel industry etc.

INTRODUCTION

Geosynthetics are human-made materials made from various types of polymers used to enhance, augment and make possible cost effective environmental, transportation and geotechnical engineering construction projects. They are used to provide one or more of the following functions; separation, reinforcement, filtration, drainage or liquid barrier. Geocells consist of a series of interconnected single cells that are manufactured from different types of polymers. The geocells are expanded at the construction site and filled with steel slag. The cell walls completely encase the infill material and provide all-round confinement to the slag. During vertical loading, hoop stresses within the cell walls and earth resistance in the adjacent cells are mobilized which increases the stiffness and the load-deformation behavior of the slag. Thus the slag-geocell layers acts as a stiff mat and distribute the vertical traffic loads over a much larger area of the sub grade soil. Large scale static load tests were carried out to evaluate the influence of a geocell layer on the load-deformation behavior of the slag. The test results show that a geocell layer increases the bearing capacity of the infill materials up to three times compared to an unreinforced soil.

The vertical stresses on the soft sub grade, measured by eight earth pressure cells, where also reduced about 30 percent. To verify the results of model tests in-situ field test where carried out within different road constructions. Earth pressure cells where installed on the sub grade to measure the influence of the geocell layers on the stress distribution.

After finishing the road construction vehicle crossing tests with a 40-ton truck were carried out while the stresses on the sub grade where measured. Compared to an unreinforced test section the stresses beneath the geocell layer were reduced by about 30 percent. In addition to vertical stress measurements, falling weight deflect meter (FWD) measurements were conducted in reinforced and unreinforced test sections. The results show that the deflections measured in geocell reinforced test section were significantly smaller than in the unreinforced section. Back calculated layer modules were significantly higher in the geocell reinforced section compared to an unreinforced section.

Steel slag is a byproduct obtained from steel industry. It is generated as a residue during the production of steel. Because of the high disposal cost as a waste material and the overall positive features of steel slag, it has been declared a useful construction material, not an industrial waste by most of the developed countries. Successively, it is recycled as an aggregate for the construction of roads, soil stabilization, and base and for the surfacing of flexible pavement. Despite this, a large amount of steel slag generated from steel industries is disposed of in stockpiles to date. As a result, a large area of land is being sacrificed for the disposal of this useful resource. Many researchers have investigated the use of steel slag as an aggregate in the design of asphalt concrete for the road construction. The best management option for this by product is its recycling. This leads to reduction of landfills reserved for its disposal, saving the natural resources and attaining a potential environment.

WORK DONE

3.1 Overview

The principle objective of our project is to construct the minimum costing road than WBM road for the rural areas where traffic intensity is not as that much, to construct economical and durable road.

For study and behavior of loading and settlement we constructed the patch of road at our college campus at size of (3*1.5*0.2m).

Fig no 3.1: Setup.

3.2 Material Specification

The basic materials used for construction of geocell and steel slag road are as follows:

Table No: 3.1: Material Specifications.

Sr No.	Material	Specifacion
1	Geocell	HDPE
2	Steel Slag	Coarser and finer

After selecting the material of those specifications, testing of material is to be carried out first.

3.3 Material Used

We use mainly two types of material in our project for formation of patch

1) Geocell
2) Steel slag (electric arc Furness).

3.3.1 Geocell (HDPE)

Cellular Confinement Systems are popularly known as “Geocells”. Geocells are strong, lightweight, three dimensional systems fabricated from ultrasonically-welded High Density Polyethylene (HDPE) strips that are expandable on-site to form a honeycomb-like structure (Fig. 1).Geocells are filled with compact non-cohesive soils which are confined within the cellular walls. The composite forms a rigid to semi-rigid structure. The depth of the geocells as well as the size of each cellular unit can vary as per design requirements.

Generally, the infill is sandy or gravelly material. However the infill may be plain concrete depending on the application such as erosion protection, water channel formation, etc.

The surface of the geocell is textured to increase soil-geocell wall friction. The geocell wall is punctured (Fig. 1) to assist in immediate dissipation of developed pore water pressures due to increased stresses within the infill of the individual cells.

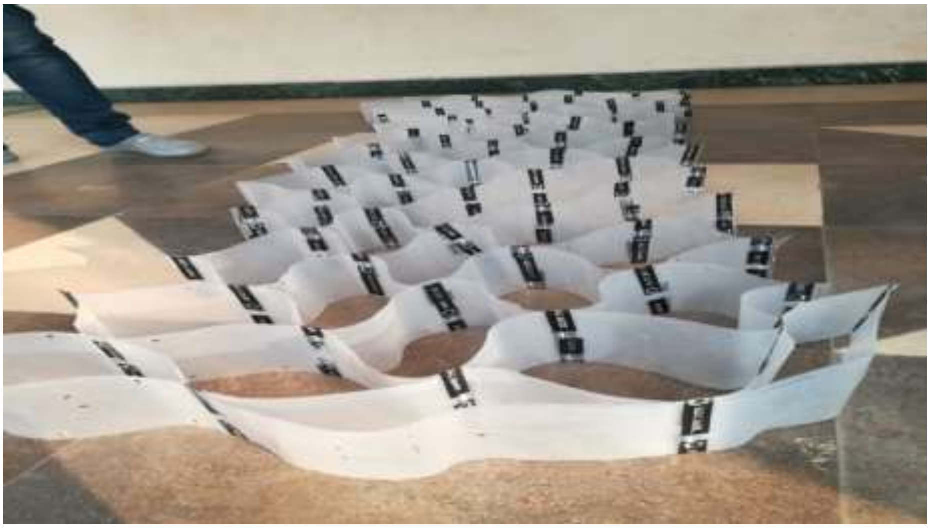


Fig no 3.2: Geocell.

3.4 Test Conducted For Geocell

Following tests were performed in VNIT Nagpur:-

1) Tensile Test

Table No 3.2: Tensile.

Width (MM)	Thicikness (MM)	C.S.A (MM2)	Max.Load (KN)	Tensile Strength (N/MM 2)
100	1.00	100	0.05	17.217

2) FTIR Analysis (Fourier Transform Infrared Spectroscopy)

- Material is found to be HDPE

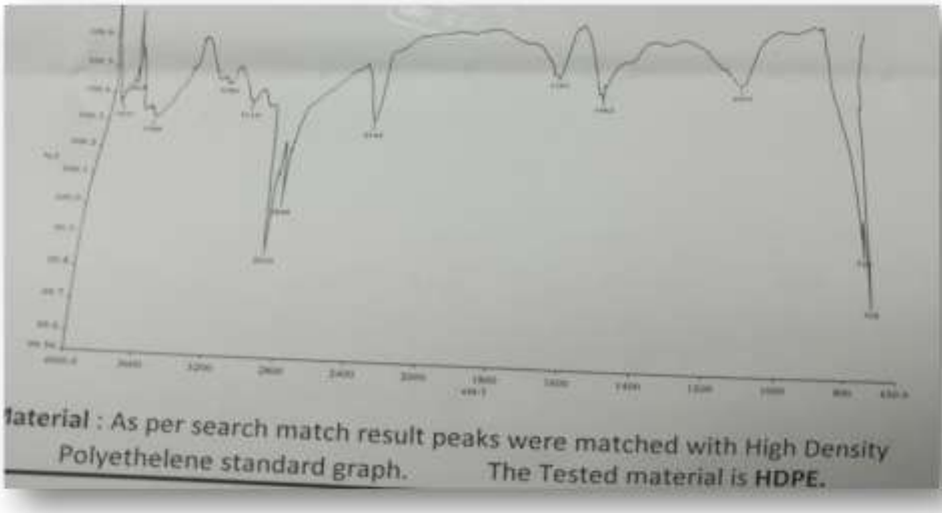


Fig No 3.4: FTIR Test.

3.5 Test Performed On Aggregate

3.5.1 Sieve Analysis

Sieve analysis helps to determine the particle size distribution of the coarse and fine aggregates. This is done by sieving the aggregates as per IS: 2386 (Part I) – 1963. In this we use different sieves as standardized by the IS code and then pass aggregates through them and thus collect different sized particles left over different sieves.

The apparatus used are – i) A set of IS Sieves of sizes – 80mm, 63mm, 50mm, 40mm, 31.5mm, 25mm, 20mm, 16mm, 12.5mm, 10mm, 6.3mm,4.75mm, 3.35mm, 2.36mm, 1.18mm, 600µm, 300µm, 150µm and 75µm. ii) Balance or scale with an accuracy to measure 0.1 percent of the weight of the test sample.

Total weight of steel slag = 2 Kg.

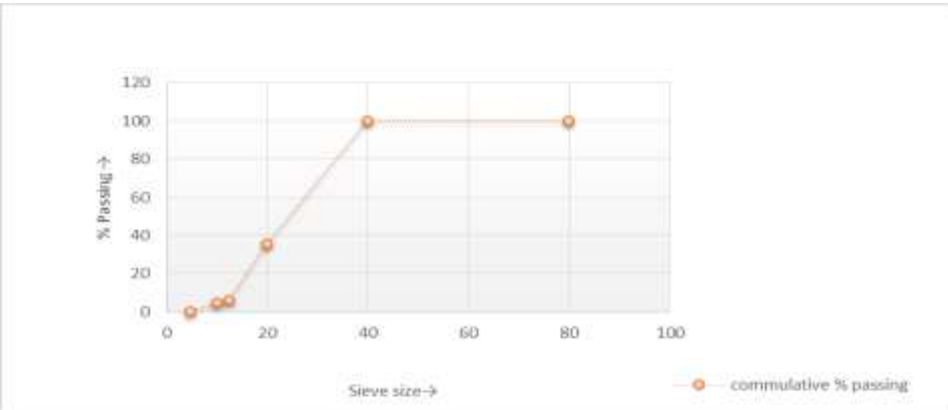
Table 3.4: Tests Conducted on Steel Slag.

Is Sieve size	Wt. Retained (gm)	Cumm. Wt. Retained	Cumm. Wt. Retained (%)	Cumm. Passing (%)
80 mm	0	0	0	100
40 mm	0	0	0	100
20 mm	1.29	1.29	64.5	35.5
12.5 mm	0.594	1.884	94.2	5.8
10 mm	0.032	1.916	95.8	4.2
4.75 mm	0.084	2	100	0
Total	-	-	354.5	-

Fineness modules $= \frac{total\ cunnulative\ \%\ wt.retained}{100}$

$= \frac{354.5}{100}$

$= 3.54$



3.5.2: Crushing Value Test.

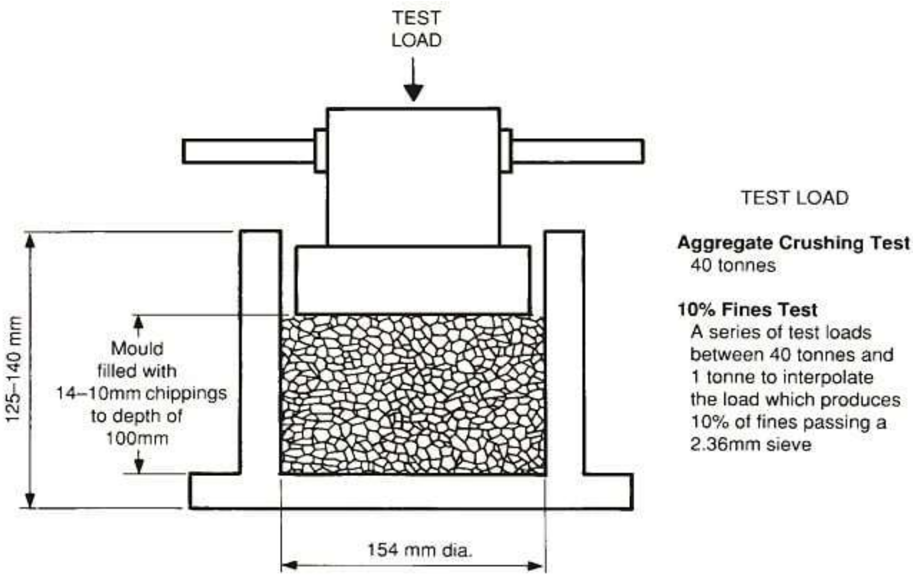


Fig no.3.6: Crushing Test mold and apparatus.

Observation for crushing value of slag

1. Empty weight of cylinder(W)= 11kg
2. Weight of cylinder plus slag (W1) = 13.80kg
3. Weight of slag passing through IS sieve 2.36mm(W2) = 0.35kg

Calculation of Aggregate Crushing Value

The ratio of weight of fines formed to the weight of total sample in each test shall be expressed as a percentage, the result being recorded to the first decimal place.

Aggregate crushing value = (W2 x 100) / (W1-W)

= (0.35 x 100)/(13.80-11)

= 12.5%

Result

The aggregate crushing value of the given sample=12.5%

Aggregate Crushing Values for Roads and Pavement Construction

The table below shows limits of aggregate crushing value for different types of road construction:

Table 3.5: Limits of aggregate crushing value.

Types of Roads / Pavements	Aggregate Crushing Value Limit
Flexible Pavements	
Soling	50
Water bound macadam	40
Bituminous macadam	40
Bituminous surface dressing or thin premix carpet	30
Dense mix carpet	30
Rigid Pavements	
Other than wearing course	45
Surface or Wearing course	30

3.5.3 Elongation Index

Elongation index of an aggregate is the percentage by weight of particles whose greatest dimension (length) is greater than one and four-fifth times their mean dimension. It is measured on particles passing through mesh size of 63mm and retained on mesh size of 6.3mm. Determination of elongation index of coarse aggregate is explained below.

Apparatus required

Apparatus required for elongation index determination tests are balance, elongation gauge (length gauge) and IS sieves of the following mesh sizes – 63mm, 50mm, 40mm, 31.5mm, 25mm, 20mm, 16mm, 10mm and 6.3mm.

Calculations

Sample – 200 pieces

Weight of 200 pieces = 2.75 kg

Table 3.6: Elongation index of steel slag.

Passing from	Retained on	Wt. of passing	Wt. on retained
50	40	-	-
40	31.4	-	-
25	20	-	-
20	16	0.85	0.73
16	12.5	-	-
12.5	10	0.622	0.524
10	6.3	0.018	0.006
total	-	= 1.49	=1.26

Elongation index $= \frac{\sum wt.of retained length gauge}{total wt.of\ 200\ pieces} \times 100$

$= \frac{1.26}{2.75} \times 100$

= 45.81 %Maximum elongation index is 45 %

3.5.4 Specific Gravity of Aggregate

The specific gravity of an aggregate is considered to be a measure of strength or quality of the material. Stones having low specific gravity are generally weaker than those with higher specific gravity values.

OBSERVATIONS AND RESULT

The specific gravity of aggregate calculated using desiccators is as below-

Table 3.7 Observation of Specific Gravity.

Weight of steel slag	= 1000 gm	
Weight of saturated dried steel slag	= 996gm	(C)
Weight of oven dried steel slag	= 970gm	(D)
Weight of saturated surface + Distilled Water + Desiccators	= 1888gm	(A)
Weight of distilled water + Desiccators	= 1204gm	(B)
Specific Gravity of steel slag	= D/C-(A-B) = 970/996-(1888-1204)) = 3.1	

3.5.5 Impact Value Test

Table 3.8: Observation for steel slag.

Observation	Sample 1	Sample 2
Total Wt. Of Dry Sample	1608	1573
Weight Of Portion Passing 2.36mm Sieve (W2 gm)	34 Gm	39 Gm
Slag Impact Value (Percent)	2.1 %	2.48%

$$\text{Impact value of slag} = \frac{\text{Wt of aggregate passing 2.36mm sieve}}{\text{Total wt.of aggregate}} \times 100$$

$$= \frac{34}{1608} \times 100$$

$$= 2.1\ \%$$

$$\text{Impact value of slag} = \frac{\text{Wt of aggregate passing 2.36mm sieve}}{\text{Total wt.of aggregate}} \times 100$$

$$= \frac{39}{1608} \times 100$$

$$= 2.48\ \%$$

Average impact value of slag = 2.29 (< 10% very tough)

3.7 Actual Procedure

As requirement of project we conducted following procedures:

Step1:- Finalized the site for construction of work and mark (3m x1.5m x 0.2m)

Finalized the work site mark it with the lime as actual size of work to be carried out on it.

Fig no. 3.7: Test Patch.

Step 2:- Excavated the marked surface.

For later operations we excavated earth surface about (3m x1.5m x 0.2m).

Fig no. 3.8: Excavation.

Step 3:- Formed the well compacted base surface with steel slag

For lying of geocell layer we formed well compacted base surface by applying compactor on it and form well compacted surface.

Fig no. 3.9: Compaction.

Step 4:-Lying of geocell

Then we applied the layer of geocell over well compacted base.

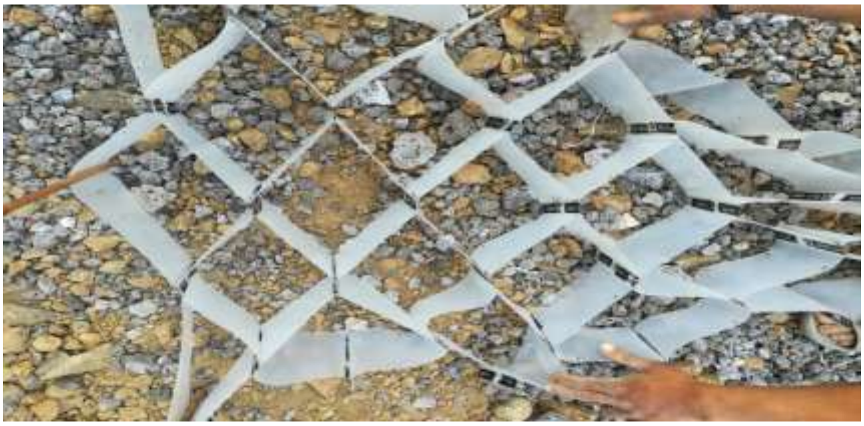


Fig no. 3.10: Placing of geocell.

Step 5:- Filled the geocell layer with steel slag (coarser particle) andcompacted.

Fig no.3.11: Placing of Coarse aggregate.

Step6:- Rolled and compacted fine steel slag at upper layer of geocell.

For the well compaction of various layers of we applied final compaction for better stability and support.

Fig no. 3.12: Compaction after placing.

Step 7:- For smooth movement of traffic we constructed the top surface by using locally available material (Moorum). It leveled and compacted.

4.1 RESULTS

Following are the test performed on the sample patch ofsize (3 X 1.5 X 0.2) m

1. Settlement test (Before Flooding).
2. Settlement test (After Flooding).

4.1.1 Settlement test (Before Flooding)

Settlement teston the patch is carried out to determine the behavior of test track with respect to various loading condition generally seen in the case of rural loads. In this test the different vehicles of various load capacity is allowed to pass over and the undulation over the ground is then measured. Following are the vehicles allowed to pass over the track:

a) Cars having 1500Kg
b) Water tanker having 12000Kg
c) Bus having weight 6440 Kg.

Procedure

1. At an initial stages the grids are been marked at ground.
2. The section A, B, C were marked resembling their respective position.
3. The Loading with different loads has been applied over the section with the axel of different vehicles (Cars, water tankers, Bus).
4. Each vehicle has made 20 pass each day over the section as specified by the rural road condition.
5. The pegs are been driven at each end section having a nail over it.
6. These nail are tied with the marking thread.

7. The deflection over Section A, B, C is then measured with reference to marking thread.
8. The values thus obtained is tabulated and computed graphically.

4.1.2 Settlement test (After Flooding)

Settlement teston the patch is carried out to determine the behavior of test track with respect to various loading condition in fully saturated state generally seen in the case of rural loads. In this test the different vehicles of various load capacity is allowed to pass over and the undulation over the ground is then measured. Following are the vehicles allowed to pass over the track

a) Cars having 1500 Kg
b) Water tanker having 12000 Kg
c) Bus having weight 6440 Kg.

Procedure

1. At an initial stages the section are filled with the water to a saturated state resembling the situation of heavy rainfall.
2. The water is then allowed to percolate in the section so as to make the section completely saturated.
3. The grids are then marked on ground.
4. The section A B C Are been marked resembling their respective position.
5. The Loading with different loads has been applied over the section with the axel of different vehicles (Cars, water tankers, Bus).
6. Each vehicle has made 20 pass each day over the section as specified by the rural road condition.
7. The pegs are been driven at each end section having a nail over it.
8. These nail are tied with the marking thread.
9. The deflection over Section A, B, C is then measured with reference to marking thread.
10. The values thus obtained is tabulated and computed graphically.

Fig No 4.1.1: Passing of car.

Fig No 4.1.2: Passing of Tanker.

Fig No 4.1.3: Passing of Bus.

The ultimate goal for this testing is to find out the ultimate load and settlement of road patch after passing various vehicles and to study the settlement behavior. The results are as follows:

4.2.1 Observation Table

Table No 4.2.1: Before Flooding for section A.

Sr. No	Notation	Initial Reading (mm)	Final Reading (mm)	Settlements(mm)
1	A1	68	60	8
2	A2	61	55	6
3	A3	78	68	10
4	A4	82	70	12
5	A5	49	54	-5
6	A6	47	54	-7
7	A7	50	55	-5
8	A8	62	60	2
9	A9	64	54	10
10	A10	78	70	8
11	A11	76	70	6
12	A12	78	75	3

Table No 4.2.2: After Flooding forsection A.

Sr. No	Notation	Initial Reading (mm)	Final Reading (mm)	Settlements(mm)
1	A1	68	75	7
2	A2	65	74	9
3	A3	60	75	15
4	A4	50	67	17
5	A5	35	45	1
6	A6	20	15	-5
7	A7	30	22	-8
8	A8	25	28	3
9	A9	20	38	18
10	A10	28	44	16
11	A11	24	34	10
12	A12	50	56	6

Table No 4.2.3: Settlement graph of section A on both cases.

Table No 4.2.4: Before Flooding for section B.

Sr. No	Notation	Initial Reading (mm)	Final Reading (mm)	Settlements(mm)
1	B1	84	70	14
2	B2	80	68	12
3	B3	83	67	16
4	B4	85	60	25
5	B5	55	60	-5
6	B6	49	55	-6
7	B7	35	45	-10
8	B8	33	40	-7
9	B9	65	50	15
10	B10	50	40	10
11	B11	58	50	8
12	B12	65	58	7

Table No 4.2.5: After Flooding forsection B.

Sr.No	Notation	Initial Reading (mm)	Final Reading (mm)	Settlements(mm)
1	B1	68	53	15
2	B2	65	52	13
3	B3	60	43	17
4	B4	50	24	26
5	B5	35	42	-7
6	B6	20	29	-9
7	B7	30	43	-13
8	B8	25	35	-10
9	B9	25	8	17
10	B10	20	8	12
11	B11	28	19	9
12	B12	24	16	8

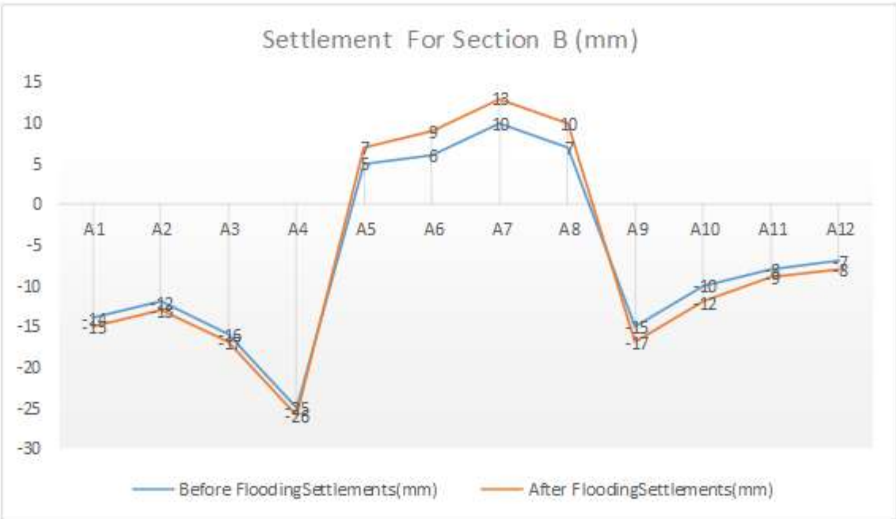


Table No 4.2.6: Settlement graph of section B on both cases.

Table No 4.2.7: Before Flooding for section C.

Sr. No	Notation	Initial Reading (mm)	Final Reading (mm)	Settlements(mm)
1	C1	85	75	10
2	C2	84	70	14
3	C3	86	68	18
4	C4	87	65	22
5	C5	66	60	6
6	C6	34	40	-6
7	C7	43	50	-7
8	C8	44	48	-4
9	C9	68	55	13
10	C10	55	45	10
11	C11	54	46	8
12	C12	56	50	6

Table No 4.2.8: After Flooding for section C.

Sr. No	Notation	Initial Reading (mm)	Final Reading (mm)	Settlements(mm)
1	C1	70	60	10
2	C2	60	45	15
3	C3	60	40	20
4	C4	50	26	24
5	C5	45	37	8
6	C6	40	47	-7
7	C7	35	45	-10
8	C8	38	44	-6
9	C9	45	30	15
10	C10	40	28	12
11	C11	55	46	9
12	C12	76	69	7

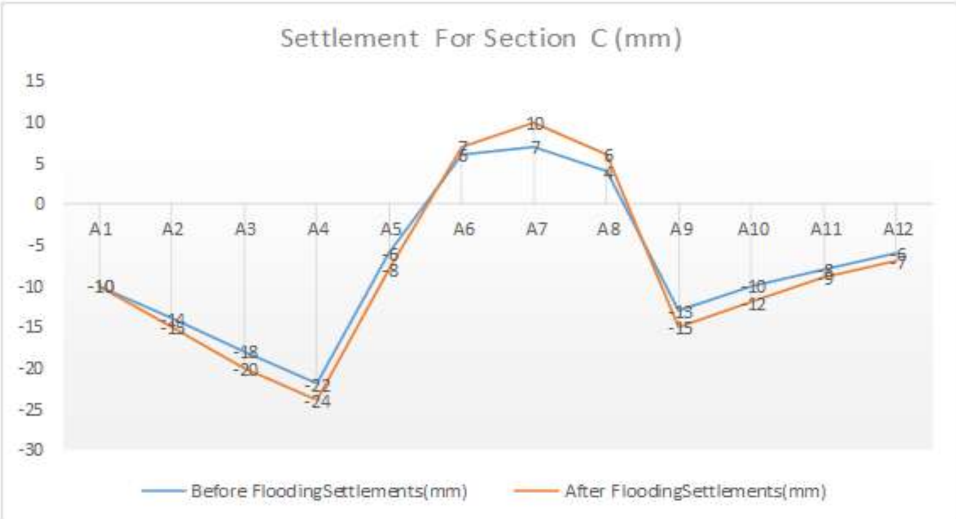


Table No 4.2.9: Settlement graph of section C on both cases.

4.2.2 DISCUSSION

- From the Graphical Comparison of above three graphs we have found that in section A settlement is found Slightly higher than other two section (i.e Section B & Section C).
- So we can say that the settlement found in the test track is nearly the same.
- The Geocell is found to be the efficient in the construction of the road in the rural areas in terms of settlement.
- It can also withstand the WBM in the fully saturated condition where the chances of the failure is most probable to be happen.
- With the help of Geocell we can accelerate the Time Required to construct the WBM road.
- The Slag used.

4.2.6. In Pavement and Road Construction

The geocell reinforcement reduced the vertical stresses transferred to the sub grade by distributing the load over a wider area have studied about the bearing capacity improvement of gravel base layers in road constructions using geocell and concluded that geocell layer placed within the gravel base layer of an asphalt paved construction reduced the vertical stresses on sub grade during vehicle crossing about 30 per cent and increased the layer modulus of the gravel base layers compared to an unreinforced layer. As a result the measured deflection s on the asphalt surface was also reduced.

4.4 Advantages

i. **Reduce cost** of construction: Cost of construction of road is much less than that of WBM road.

ii. **Reduce overall aggregates layer by 30% – 50%:**Geocells provide a stiffer layer which distributes the loads over a wider area and reduce the stress on the sub grade layer. The increased soil modulus allows you to save ~30% of the asphalt layer and greatly reduce the overall pavement thickness.

iii. **Increase Roads Long Term Performance:** Geocells spread the vertical loads on a wider area. Known as the “beam effect”, the result is a strengthened base layer, which prevents rut development and degradation of the sub-base layers. Thanks to the stiffness and strength of Neology, the soil confinement is retained for entire road design life. PRS is the only company which guarantees road performance for 75 years.

iv. **Reduce Roads Construction and Maintenance Costs**: Aggregate resources are becoming scarce and costly. With Geocells you can use locally available infill materials. The same increased modulus effect can be achieved with clay, sand and recycled asphalts.

v. **Reduce Construction Time**: By using geocell we can minimize the time of completion of road .In geocell steel slag are directly fill in geocell.

vi. **Strength and Life:** Improves the overall strength and enhances the life of the pavement

vii. **Economy in Design:** Allows thinner pavement section.

viii. **Economical Solution:** Use of locally available material and economy in designs reduces consumption of raw material and reduction in project time.

ix. **Logistics:** Easy transportation owing to its flat and collapsible structure.

x. **Rapid Installation:** Proven to be an all-weather installation system with minimal specialized equipment and labour, particularly for structures to be constructed in emergency / disaster situations.