# Study The Potential Of Plastic Waste Bottles As Geo-cells For Maintenance Of Pot-Holes In Flexible Pavement

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**Abstract.** Flexible pavements are frequently damaged with excessive cracks, settlements, and potholes. Due to various reasons these defects are occurring namely: less bitumen content, over load and poor subgrade compaction, poor drainage or poor subgrade itself. There are many options to maintain and repair such defects. Since last few decades Geo-synthetics material are introduced in market for various geotechnical application. These include use of Geotextiles, Geo-nets, Geo-grids, Geo-membrane and Geo-cell etc. for ground improvement, providing drainage, separating two layer, as impervious layer and reinforcement. Out of all these applications Geo-cell have great capacity to overcome poor bearing capacity of subgrade by its installation. On other hand use of plastic bottles for storing water, juice, oil, milk and other multiple things have increased exponentially. The polyethylene bottles have same material properties as that of geo-synthetic material. In this study an attempt is made to study the effectiveness of waste plastic bottle fabricated in Geo-cell for repair of potholes. For this, Geo-cell derived as above is placed at the area of pothole near base course. This is simulated in the laboratory model of 1 x 1 x 1 m pit and plate load test as well as CBR is carried out for pavement performance after repair in terms of settlement and bearing capacity.

**Keywords:**potholes, repair techniques, geo-synthetics, geo-cells, plastic waste

## 1 Introduction

Majority of the roads in India are flexible and are under heavy weight. Further, they are in incredible need of modernization with a specific end goal to deal with the expandable growth of the vehicles. Increase and development of potholes on Indian streets still continued from the time of bitumen macadamized road is arise. The problem behind these defects of road is climate, weather, wheel load and workmanship[1,2]. From few decades many techniques are followed for the repair and maintenance of such defects such as cementitious and polymers[3-5]. Geosynthetics, the synthetic polymer product which has become popular from last few decades and manufacturing is also increased. Geosynthetics have wide range of application in civil engineering such as embankments, separation, retaining structures, reservoir, dams, canals, sediment and erosion control, reinforcement, filtration[6,7]. Geocell are the honeycombed structure made up of high density polyethylene materials have great

capacity of confining the cohesionless soil particularly gravels and has proven versatile in stabilizing slope and increasing the bearing capacity of poor soils beneath footing and pavements[8-11] also it has good performance in dynamic conditions too[12] On the other hand plastic bottles are use tremendously for drinking water, cola, oil and other soft drink, which are only single use and its waste management is a great challenge. Daily approximately 10tons of plastic bottles are generated in a city like Ahmedabd[13]. In this study the aim is to re-use the plastic waste bottle and make geo-cell out of it and check its feasibility to act as Geo-cell. This has many fold advantages like Reduction of plastic (Environment friendly), Employment (For collecting plastic bottles, cutting and joining) and Cost effective (Less price than original geo-cell)

# 2 Materials

### 2.1. Plastic waste bottle Geocell

The polyethylene (PET) bottles were obtained from the local scrap shop after that it was cut in to three pieces at equal height. The cap portion was not utilized but the middle and bottom portions were joined by the fish net strips and perforations were made by soldering rod to make it permeable figure-1. Thus, a three-dimensional structure with interconnected like honeycomb was prepared as shown in figure-2

Fig 1. Preparation of Geo-cell from Plastic Bottles (cutting, joining and perforations).

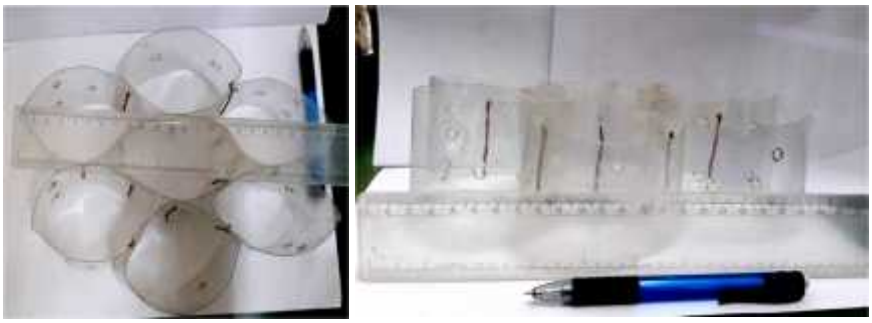

Fig 2. Sample size of Geo-cell

Before the using the Geocell derived from such plastic waste in place of traditional Geocell it was necessary to check its properties and its behaviour. Therefore, few basic tests like load carrying capacity, permeability and its physical properties were tested, The table-1 shows the comparison of the physical properties of the both the goecells.

Table 1. Comparison of Properties Regular Geo-cell with Geocell derived from Plastic Waste Bottles

| Properties | Geocell | Plastic waste bottles geocell |
|---|---|---|
| Materials | HDPE | LDPE |
| Density | 930 to 970 kg/m$^3$ | 917 to 930 kg/m$^3$ |
| Temperature | 90 degree Celsius | 80 degree Celsius |
| Welded space | 712mm | 110mm |
| Depth | 100mm | 60mm |
| Width | 3mm | 0.5mm |

## 2.2 simple tests on Geocell derived from plastic waste bottles

To check the performance two simple preliminary tests like its compressive strength, sand heap test and permeability were performed to ensure its final use in the experiment

Fig 4. Demonstration of Geo-cell with sand

**Test 01 Heap of sand with and without Geocell.** Here, the sand volume was done by freely falling on 24X24 cm square section without Geocell and then it was loaded

the height of heap was 20cm and after and loading of 106.36kg it was deformed by 7.5 cm as shown in figure 4,

The same experiment was repeated but now with Geocell, and when same load was applied deformation was only 4cm

**Test 02Compressive strength of Geo-cell.** In this, compressive loading carrying capacity of geo-cell was checked by increasing the loading step by step, approximately 300 kg of load was bearded by such Geocell without substantial deformation


Fig 5. Demonstration of Compressive strength of Geo-cell.

**Drainage in Geo-cell with sand.** In this only simple drainage test was carried out for the perforated geocell, placing geocell and filled with soil and water is passed from geocell for checking of perforated geocell as shown in figure 10

Fig 5. Drainage test using Geo-cell

## 3. Experimental Work

After the confidence of the preliminary tests 'success, the authors have attempted the final testing of the Geocell derived from the plastic waste bottles.

### 3.1 CBR test with and without Geocell

CBR is the ratio expressed as a percentage of force per unit area required to pass through the soil mass of a standard circular plunger having a diameter of 50 mm at a rate of 1.25 mm/min, which is the ratio required for corresponding penetration in standard materials. This ratio is usually determined to be a penetration depth of 2.5 and 5 mm. When the ratio at 5 mm is always higher than 2.5 mm, the ratio at 5 mm is used. A different type of apparatus is required for this test like CBR Testing machine, cylindrical mould, Collar, Spacer Disc, Compaction Rammer. This test result is taken without 5Geocell only for base coarse and reading of 2.5 and 5 penetration was carried out and for aggregate as shown in figure 6. Further, the same test was repeated with Geocell same as above but with geo-cell in base course while filling aggregate as shown in figure

Fig 6. CBR Test under performance

### 3.2 Plate Load Test with and without Geocell

The plate load test was carried on a plate of 300 x 300 mm size having 25mm thickness. The location and depth test pit (1m) were selected as per the Layer Criteria: for the 2 MSA traffic with CBR 4%, (Source: IRC:37 (2001) Page No. 23, Pavement Design Catalogue) Granular Sub base = 265 mm, Base Course = 225 mm, Binder Course = 50 mm, wearing Course = 20 mm [14] and then loading platforms was created above which the sand bags were placed. Field CBR machine with necessary proving ring and dial gauges were taken at the site. The entire setup is shown in the figure-7. After assembling the sitting load was given and test was started and Settle-

ments were observed for each increment of load for an interval of 1, 2.25, 4, 6.25, 9, 16 and 25 min and thereafter at hourly intervals, when the settlement is less than to the nearest 0.02 mm then the loading was increased. The rutting behavior was observed the test was stop because of failure in base course, and this test was carried out two times first without geo-cell and second with geo-cell.

Fig 7. Plate load test using Geo-cell

Fig 8. Closed views of Geocell and plates for plate load test

## 4 Results and Discussions.

As discussed earlier in this section the results of CBR and plate load tests are discussed . the table 2and 3shows the CBR values of without and with Geocell, it is clear that CBR value of the aggregates with Geocell has increased from 8.5 to 9.6, thus increase of around 10% is found this may be due to the confinement of the Geocell. Thus we can say that Geocell are showing its effect and plastic waste bottle Geocell is showing it action perfectly as Geocell.

Table 2. When Geo-cell is not added

| CBR OBSERVATION SHEET (Without geo-cell) | | | | |
|---|---|---|---|---|
| Penetration (mm) | Proving Ring reading | Factor (Kg) | Load Kg | CBR value |
| 2.5 | 102 | 1.199 | 112.29 | 8.1 |
| 5 | 146 | 1.199 | 175.0 | 8.5 |

Table 3. When geo-cell is added

| CBR OBSERVATION SHEET (With geocell) | | | | |
|---|---|---|---|---|
| Penetration (mm) | Pro. Ring reading | Factor (Kg) | Load Kg | CBR value |
| 2.5 | 112 | 1.199 | 134.29 | 9.8 |
| 5 | 165 | 1.199 | 197.84 | 9.6 |

Additionally, Figure-9 is showing the results of the plate load test carried out in the field. From the figure it is evident that, when Geocell is used the load carrying capacity has increased from the 700 to 1200kg for sudden failure where as the final load is 2157 to 2559 kg. Therefore one can predict that the geocell's confining effect is mobilized and load carrying capacity of the aggregate has increased by approximately 40%.

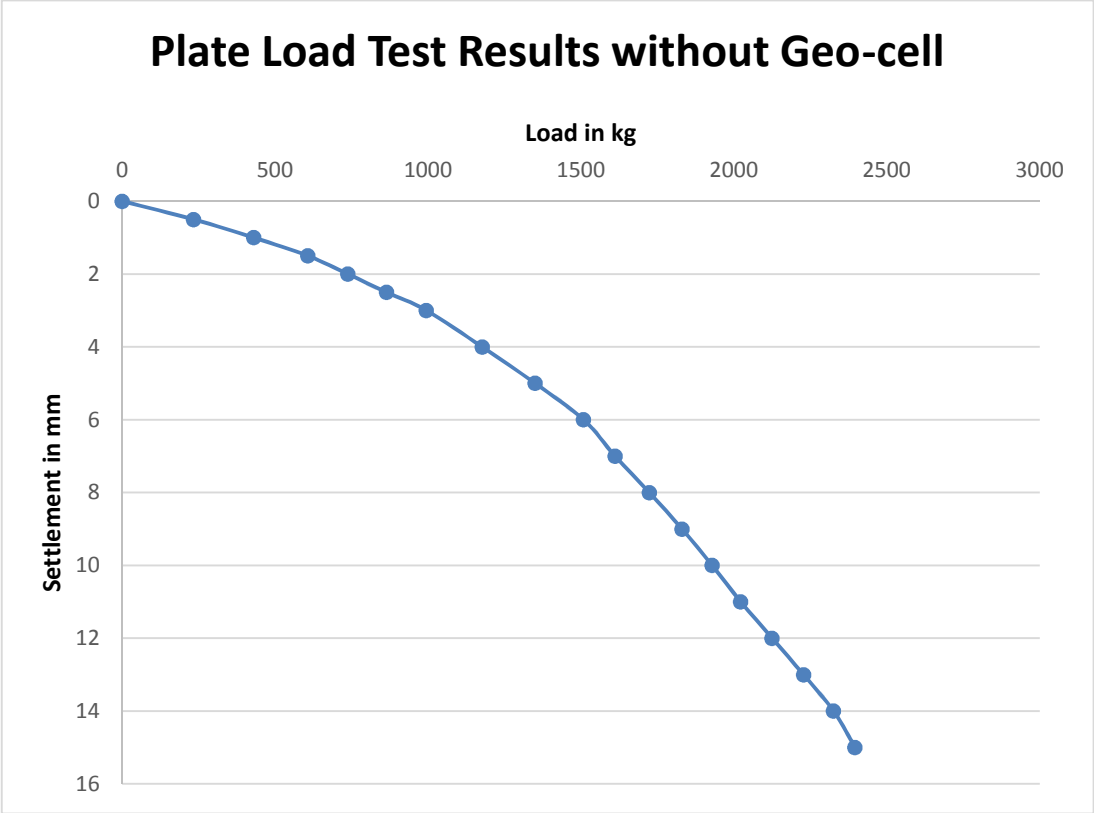


Fig-9 Plate Load Test Results without geocell

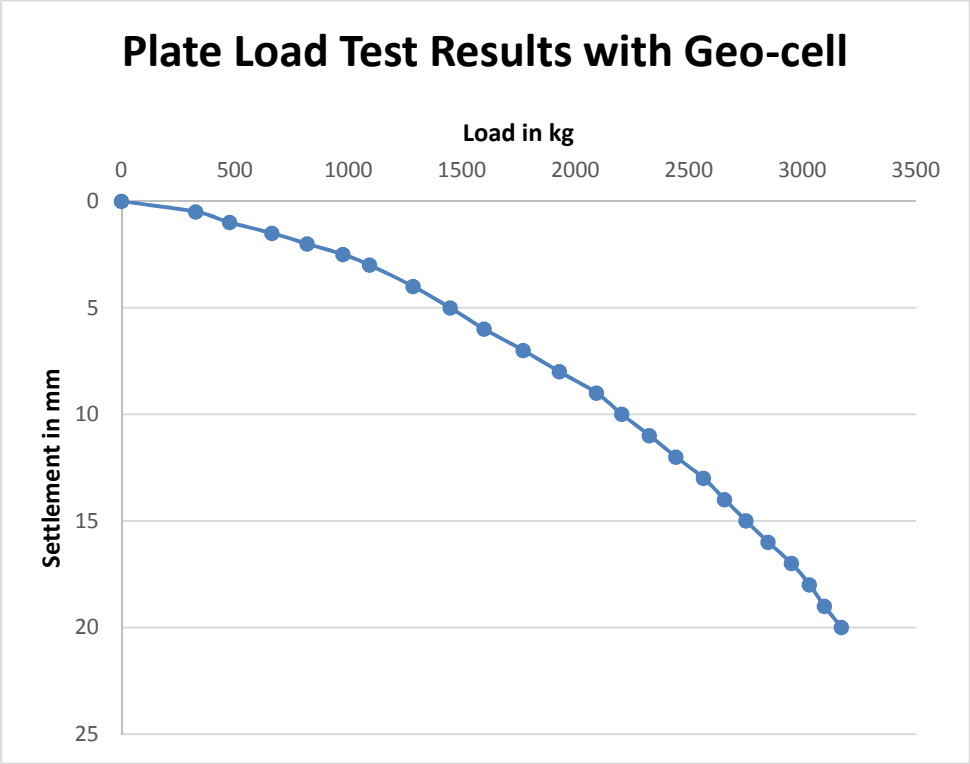


Fig-10 Plate Load Test Results with Geocell

## 5 Conclusions

Based on the experiments and analysis, the following broad conclusions are drawn:

1. Geocell derived from the plastic waste bottle has potential to act as HDPE Geocell available commercially in the market.
2. The performance of Geocell derived from the plastic waste bottle is increasing the CBR value by 10% and bearing capacity by 40% approximately

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