APPLICATION OF GEOCELL IN LANDFILL

[1]NIKHAT ARA ABBASI, [2]Dr. RAJEEV JAIN
[1]M.E (Environmental Engineering) Student, [2]Professor,
[1]Department Of Civil Engineering S.A.T.I. Vidisha,
[1]Samrat Ashok Technological Institute, Vidisha (M.P.), India.

Abstract : The study was aimed for improving the approach road conditions and designing of approach roads for the future better flow of heavy vehicles by confining the infill material. Due to repeated application of heavy loads, pavement layers deteriorate and hence damage assessment procedures are performed to rectify the defects produced in approach road. The impending monsoon season and ongoing frequent showers, conditions were getting increasingly difficult and posed major challenges in maintaining the serviceability of the approach road because of that difficulty in reaching to destination the garbage dumpers dropping the disposable waste before the point. So the whole point of disposing it in landfill and managing to relocate it to the disposal area tends to cause financial losses. Geocell is a cost-effective and permanent solution, hence the use of geocell has been proposed. The use of geocells increases the stability of the roads and improves its performance by improving the bearing capacity of the infill. This study is an effort to do a relative study between the conventional approach road and geocell reinforced approach road. Both results are compared, analysed and likely conclusions are described.

Keywords: Geocell, Approach Road, Landfill, Cyclic loading & Bearing capacity.

I. INTRODUCTION

Population growth in India increases the production of solid wastes proportionally which increases more land requirement for landfill site. About 90% of MSW is thus disposed of by land dumping; about 8.5% is disposed of by composting; while the remaining about 1.5% is disposed of by other methods like pelletization, vermi-composting, etc. Later on, dumping the solid waste these sites are hardly used in future for developing some green land, parks, or other recreational spots. The land is grassed or planted, fenced, and hence left out as reserved green land because of unequal settlement and odour trouble normally, for the first 1-2 years. This can, on a later date, be preferably used for developing some playgrounds, or picnic spots. The solid waste going to be dumped, the approach road to the landfill site should be such that it is accessible to heavy vehicles like garbage dumpers. Due to repeated application of heavy loads, pavement layers deteriorates and develope challenging condition for heavy vehicles like garbage dumpers to move. Because not having sufficient stability there are deformations in the pavement. The impending monsoon season and ongoing frequent showers, conditions were getting increasingly difficult and posed major challenges in maintaining the serviceability of the approach road because of that difficulty in reaching to destination, garbage dumpers dropping the disposable waste before the point. So the whole point of disposing it in landfill and managing to relocate it to the disposal area tends to cause financial losses. These challenging conditions were, however, overcome by the introduction of geocells. Cellular Confinement Cells (CCS) develope from three-dimensional polymeric strips known as geocell that are manufactured to form a small cage-like structures that can then be filled with granular materials like sand, local soils, and recycled asphalt. Restriction of movement of the filled material is the main purpose of these structured cells and this, in turn, makes geocells an ideal soil stabilization system for all types of soil stabilization and ground reinforcement.

Soil stabilization system is distinctively designed to increase the strength and stiffness of the pavement layer via confinement of infill material and load distribution over a wide area. To resist sliding, prevent severe erosion caused by surface runoff, and allow steeper slopes, the upper soil layer is secured on embankments with the **geocell slope protection arrangement** to be built. Protection of dams, landfills, and containment basins with **geocell** gives us a vast opportunity and is the solution of various problems.

II. LITERATURE REVIEW

The geocell is different from all the other products , they are all planar products, that is they can provide reinforcement action or they can act as a separator or they can act as a filter whereas, a geocell, it possess three dimensional effect on the soil. It can provide some confinement, because it has number of openings, this geocell is more of a honeycomb structure wherein, we take thin sheets of a plastic products, similar to a geomembrane and the weld it at several places at along the length like this. These plastic sheets are ultrasonically welded and then the entire thing comes in a collapsed form in small rolls and once they have taken to the site, they can be expanded and once you expand them, these pockets form and these pockets can be filled with soil to construct road base or several other things.

When the geocells first came into the market, the geocells are made of plain plastic sheets like very similar to a geomembrane without any openings or without any rough surface. And now the more recent geocells are made with a either corrugated surface. So that they have a very good interaction with the infilled soil or with some openings, so that the geocell layer can also act as a drainage

layer. During that time, the geocell is made of a plastic sheet without any openings, it cannot allow the water to flow, the water can only go down and below that, below the geocell, we should have some geotextile or something, that can act as a drainage layer.

And some of the advantages of the geocells, that they are easy to transport, because they come in a collapsed form. They also do not occupy much volume and once these geocells are taken to the site and expanded, we can cover very large area, sometimes even as wide as about 4 meters wide and 10 meters long. Once it is in a collapse form, it may not occupy much space, it might be as compact as just a laptop bag. And we can use any fill material in these geocells and because of the all round confinement, that is given to the soil, it forms a semi-rigid layer giving a rigid support to the loads, that we apply.
Because of the layer that perform semi-rigid nature, it can spread the load over a very wide area, thus reducing the pressures that are transmitted into the subgrade and because of that, we have very good load distribution and reduced settlements and reduced bearing capacity failures in the foundation soil. And this geocell layer, it can also provide excellent support even under cyclic loading, for example, under railway tracks or under high speed highways and so on.

And some of the typical applications apart from the load carrying functions, it can also be used as a erosion control product or for construction of steep slopes and retaining walls. As a sub-base support it is a very excellent product that can be used in road bases or it can be used in the railway tracks or it can be used for construction of the container yards and so on. We can now lay the geocell and whenever there is a continuation of the geocell, we can staple them. So, that they are joined together and the geocells are filled with aggregates and then once it is filled with aggregate, we can do the compaction using our rollers. And then the entire surface, just simply left without any treatment, because of the surface, because of the confinement that is given by the geocell.

III. RESEARCH METHODOLOGY

- Adampur chhawani Site is located at a distance of around 16 km from the Bhopal center towards east direction on 23.2552892°N 77.5400876°E and is 1.5 km from the NH-86.
- The site is covered in an area of about 63 acres provided on lease for 99 years(2018-2117).

The methodology of the study is portrayed and explained based on the objectives and the aims of the study. As a result of literature study the properties and behaviour of geocell was known. The methodology adapted for this research is outline in the fig.10. Collection of information and data for study are gathered from Adampur chhawani waste management office, Bhopal Municipal Corporation and the office of the MITCON Consultancy & Engineering Services Ltd.. MITCON Consultancy & Engineering Services Ltd. has gained proficiency in providing corporate solutions in Power Generation, Energy Efficiency, Renewable Energy, Ethanol, Distillery, Climate change and Environment Management Sector. Regarding the information and data collected from the various sources an estimate of total power generation from these waste materials is prepared. For the construction of the approach road to the Adampur chhawani landfill site geocells are found to be suitable.

As per International Solid Waste Association (ISWA) type of landfill roads are

1. SITE APPROACH AND ENTRANCE ROADS
2. PRIMARY ACCESS ROADS
3. SECONDARY ACCESS ROADS
4. TERTIARY ACCESS ROADS

The approach road is designed according to traffic and soil of road. It is found out that traffic of 2.92 MSA according to traffic on approach road and soil of 6.93 CBR during earlier survey so according to that it will be designed as per IRC:37-2012. Now, according to that Sub-base of 210mm, base of 250mm which is with use of 150mm geocell is reduced to 150mm, DBM of 60mm & BC of 25mm is proposed. It is also established that the introduction of the geocells for approach road of landfill purposes not only proves to be time efficient but also economical.

IV. DATA COLLECTION

4.1 GENERAL

The landfill site at Adampur Chhawani is developed to be fully operational with an integrated solid waste management facility and designed by MITCON Consultancy & Engineering Services Ltd.. MITCON Consultancy & Engineering Services Ltd. has gained proficiency in providing corporate solutions in Power Generation, Energy Efficiency, Renewable Energy, Ethanol, Distillery, Climate change and Environment Management Sector. Based on the information and data collected from the various sources an estimate of total power generation from these waste materials is prepared. The Geocells are found to be suitable for the construction of the approach road to the landfill site. It is also established that the introduction of the geocells for approach road construction purposes not only proves to be time efficient but also economical.

4.2 DATA COLLECTION

A comprehensive primary data collection supported by secondary data collection was undertaken by the study team.

The team carried out ward wise household survey on foot and on motorbike for collecting the following data Grid wise. The Satellite image of Bhopal is divided into 450 grid of 1Km By 1 Km. There are multiple "tagging points" under each beat. Tagging points are area points/ land marks where waste carts shall be stationed for collection of waste for certain number of households and commercial establishments.

Data was collected for 85 wards under Bhopal Municipal Corporation. The information collected by surveyors is as follows:

1. Grid No.
2. Start destination to end destination
3. Number of household
4. Tagging Location Name/ Land mark
5. Number of Apartments
6. Number of Flats in Apartments
7. Number of Shops
8. Number of malls
9. Number of Hotels/Banquet/Halls/Restaurants
10. Number of religious establishments
11. Number of nursing homes/ hospitals
12. Schools and Banks

Tagging was undertaken for enabling geo-tagging of the landmarks for a robust and diligent monitoring of work during collection and transportation of waste from respective areas.

The survey results were compiled ward wise in a tabulated form for bringing out the number of households and commercial establishments. The numbers of malls and hotels along with banquet halls have been clubbed together.

As per conducted survey, there are 493194 household spread under Bhopal Municipal Corporation with total comm. establishment of 49154 including institutional and religious places in 2018.

V. DESIGN

5.1 Design of Approach Road

Design of approach road is done as per the recommendations made in IRC: 37 (2012). The traffic load was obtained as 2.92 msa from the traffic survey conducted at the selected site. The thickness of the various layers of pavement are given in table 1.

Table 1 Thickness of layers of Approach road

LAYER	BC	DBM	BASE	SUB-BASE
Thickness (mm)	25	60	250	210

5.2 Design of geocell reinforced Approach Road

Following steps are followed in design of geocell reinforced approach road.

1. Determination of CBR of the subgrade
2. Determination of design traffic load (in msa)
3. Selection of conventional pavement from IRC:37 design catalogue for specific subgrade CBR and design traffic.
4. Determine the elastic modulus and Poisson's ratio of the subgrade, sub-base and base layers.

5. Calculation of stresses and strain
6. Modified modulus of base layer due to geocell confinement
7. Calculation of fatigue failure and rutting failure.

From the California Bearing Ratio test conducted in the laboratory, the CBR value for the soil sample was obtained as 6.93%. This indicates that the soil has a good bearing capacity.

The traffic load was obtained as 2.92 MSA from the traffic survey conducted at the selected site.

The conventional flexible pavement was designed as per IRC:37 (2012) with total thickness of 545 mm. The thickness of the layers are given in table 1.

The elastic modulus of the subgrade is calculated from following equations from IRC37:2012.

$$E_{subgrade} = 10*(CBR) \quad \text{for CBR } <5\%$$
$$E_{subgrade} = 17.5*(CBR)^{0.64} \quad \text{for CBR } >5\%$$

Since the CBR value was obtained to be 6.93%, the elastic modulus of the subgrade is 60.75 MPa.

The elastic modulus of base and sub-base layer is determined from the elastic modulus of underneath layer and thickness of the same layer.

$$E_i/E_{i+1} = 0.2*(h_i)^{0.45} \quad E_{subgrade} \text{ and } (2 < E_i/E_{i+1} < 4)$$

Elastic Modulus and Poisson's Ratio for Different Layers of Conventional Section is tabulated in table 2.

Table 2 Elastic Modulus and Poisson's Ratio for Different Layers of Conventional Section

Layer	Elastic modulus (MPa)	Poisson's ratio
Asphalt layer (BC+DBM)	1700	0.35
Base layer	145.78	0.4
Sub-base layer	134.78	0.4
Subgrade	60.75	0.4

The stress-strain relationship can be determined either manually (theory of elastic layer system) or with the help of software's such as IITPAVE, KENPAVE etc.

The modulus of the base layer is increased due to geocell confinement. This can be determined from the following equation:

$$E_{reinforced\ base\ layer} = MIF * E_{unreinforced\ base\ layer}$$

MIF = Modulus improvement factor

The MIF value obtained from the field test (plate load test) conducted on site Govind dairy factory, Phaltan (Maharashtra) was 2.75. MIF is the increase in the modulus of the base layer. It ranges from 1.5-5.0 depending on the material of infill, subgrade and the position of the confined layer.

The increased modulus is applicable only for the reinforced zone. The confinement action is extended to 2-3cm above and below the reinforcing the layer due to interlocking of particles. Hence, the fully confined zone is extended to 25mm above the geocell and 20mm below the geocell. Therefore, Total thickness of the confined base layer = height of geocell (to be assumed)+25mm above geocell+20mm below geocell i.e. 180mm.

$$E_{composite\ base} = \{(E_{reinforced\ base} * H_{confined\ base}) + (E_{unreinforced\ base} * H_{unconfined\ base})\} / (H_{confined} + H_{unconfined\ base})$$

The calculated Elastic modulus of subgrade, sub-base base and asphalt layers for reinforced section are tabulated in table 3.

Table 3 Elastic Modulus and Poisson's Ratio for Different Layers of Geocell reinforced Section

Layer	Elastic modulus (MPa)	Poisson's ratio
Asphalt layer (BC+DBM)	1700	0.35
Base layer	400.88	0.4
Sub-base layer	134.78	0.4
Subgrade	60.75	0.4

By trial and error method, the thickness of Base is decreased and is less than the conventional section. Assume Base thickness reduction = 100mm. The reduced reinforced section is tabulated in table 4.

Table 4 Thickness of the various layers of the reinforced section

LAYER	BC	DBM	BASE	SUB-BASE
Thickness (mm)	25	60	150	210

The computed tensile strain at the bottom of the asphalt layer for geocell reinforced section is lesser than the conventional section's strain. Hence, the section is structurally better in Fatigue resistance.

Computed stress & strain by IITPAVE Software for 225mm base layer Conventional approach

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   No. of layers                 4
 E values (MPa)          1700.00  145.78  134.78   60.75
 Mu values                  0.350.400.400.40
 thicknesses (mm)          85.00  250.00  210.00
 single wheel load (N) 20000.00
 tyre pressure (MPa)        0.56
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Table 5 Computed stress & strain by IITPAVE Software for 225mm base layer Conventional approach

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Dual  Wheel
   Z         R       SigmaZ       SigmaT      SigmaR      TaoRZ       DispZ       epZ         epT         epR
  85.00     0.00-0.2241E+00 0.9841E+00 0.7993E+00-0.1657E-01 0.6729E+00-0.4990E-03 0.4605E-03 0.3137E-03
  85.00L    0.00-0.2241E+00-0.4770E-01-0.6299E-01-0.1657E-01 0.6729E+00-0.1233E-02 0.4605E-03 0.3137E-03
  85.00   155.00-0.1574E+00 0.6468E+00-0.4653E-01-0.9068E-01 0.6748E+00-0.2162E-03 0.4225E-03-0.1281E-03
  85.00L  155.00-0.1574E+00-0.4052E-01-0.9785E-01-0.9068E-01 0.6748E+00-0.7001E-03 0.4225E-03-0.1281E-03
 335.00     0.00-0.6417E-01 0.1183E-01 0.2565E-02-0.1527E-01 0.4804E+00-0.4796E-03 0.2501E-03 0.1612E-03
 335.00L    0.00-0.6417E-01 0.7700E-02-0.8553E-03-0.1527E-01 0.4804E+00-0.4964E-03 0.2501E-03 0.1612E-03
 335.00   155.00-0.7083E-01 0.1264E-01 0.3485E-02-0.2943E-01 0.5033E+00-0.5301E-03 0.2715E-03 0.1836E-03
 335.00L  155.00-0.7083E-01 0.8125E-02-0.3400E-03-0.2943E-01 0.5033E+00-0.5486E-03 0.2715E-03 0.1836E-03
 545.00     0.00-0.2937E-01 0.2724E-01 0.2218E-01-0.5185E-02 0.3965E+00-0.3646E-03 0.2234E-03 0.1709E-03
 545.00L    0.00-0.2939E-01 0.1519E-02-0.7484E-03-0.5184E-02 0.3964E+00-0.4889E-03 0.2235E-03 0.1712E-03
 545.00   155.00-0.3192E-01 0.2954E-01 0.2594E-01-0.7437E-02 0.4104E+00-0.4015E-03 0.2370E-03 0.1995E-03
 545.00L  155.00-0.3192E-01 0.1631E-02 0.2082E-05-0.7417E-02 0.4104E+00-0.5362E-03 0.2370E-03 0.1995E-03
```

Computed stress & strain by IITPAVE Software for 150mm Geocell reinforced base layer

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 No. of layers                4
E values (MPa)          1700.00  240.53  134.78   60.75
Mu values                  0.350.400.400.40
thicknesses (mm)          85.00  150.00  210.00
single wheel load (N) 20000.00
tyre pressure (MPa)        0.56
```

Table 6 Computed stress & strain by IITPAVE Software for 150mm Geocell reinforced base layer

Dual Wheel

Z	R	SigmaZ	SigmaT	SigmaR	TaoRZ	DispZ	epZ	epT	epR
85.00	0.00	-0.2557E+00	0.7266E+00	0.5938E+00	-0.2353E-01	0.6444E+00	-0.4223E-03	0.3578E-03	0.2524E-03
85.00L	0.00	-0.2557E+00	-0.3914E-01	-0.5725E-01	-0.2353E-01	0.6444E+00	-0.9030E-03	0.3578E-03	0.2524E-03
85.00	155.00	-0.1511E+00	0.4478E+00	-0.1187E+00	-0.1272E+00	0.6457E+00	-0.1566E-03	0.3190E-03	-0.1309E-03
85.00L	155.00	-0.1511E+00	-0.2438E-01	-0.1017E+00	-0.1272E+00	0.6457E+00	-0.4184E-03	0.3190E-03	-0.1309E-03
235.00	0.00	-0.8884E-01	0.6507E-01	0.4222E-01	-0.1864E-01	0.5447E+00	-0.5477E-03	0.3480E-03	0.2151E-03
235.00L	0.00	-0.8884E-01	0.1042E-01	-0.2380E-02	-0.1864E-01	0.5447E+00	-0.6830E-03	0.3480E-03	0.2151E-03
235.00	155.00	-0.9063E-01	0.6789E-01	0.3553E-01	-0.4776E-01	0.5698E+00	-0.5488E-03	0.3739E-03	0.1855E-03
235.00L	155.00	-0.9063E-01	0.1148E-01	-0.6656E-02	-0.4776E-01	0.5698E+00	-0.6868E-03	0.3739E-03	0.1855E-03
445.00	0.00	-0.3526E-01	0.3294E-01	0.2587E-01	-0.6428E-02	0.4388E+00	-0.4362E-03	0.2723E-03	0.1988E-03
445.00L	0.00	-0.3527E-01	0.1941E-02	-0.1239E-02	-0.6429E-02	0.4388E+00	-0.5851E-03	0.2723E-03	0.1990E-03
445.00	155.00	-0.3844E-01	0.3602E-01	0.3021E-01	-0.1019E-01	0.4560E+00	-0.4817E-03	0.2917E-03	0.2313E-03
445.00L	155.00	-0.3844E-01	0.2165E-02	-0.4520E-03	-0.1020E-01	0.4560E+00	-0.6440E-03	0.2917E-03	0.2314E-03

If the strain is higher than the conventional section's strain the design has to be revised by increasing the thickness of the base layer by trial and error method.

The fatigue resistance (N_f) and the rutting resistance (N_R) are obtained as per the formulas given in IRC: 37 (2012)

$$N_f=2.21*10^{-4}*[1/\varepsilon_t]^{3.89}*[1/E_R]^{0.854}$$

Where,
N_f = fatigue life in number of standard axles,
ε_t= Maximum Tensile strain at the bottom of the bituminous layer, and
E_R = Elastic modulus of the bituminous layer.

$$N_R=4.1656*10^{-8}*[1/\varepsilon_v]^{4.5337}$$

Where,
N = Number of cumulative standard axles, and
ε_v = Vertical strain in the subgrade

According to traffic 2.92 MSA, the allowable maximum Tensile strain at the bottom of the bituminous layer (ε_t) & allowable Vertical strain in the subgrade (ε_v) are

$$\varepsilon_t= 0.00048865=0.4887*10^{-3}$$
$$\varepsilon_v = 0.00088318=0.8832*10^{-3}$$

The computed maximum Tensile strain at the bottom of the bituminous layer (ε_t) & Vertical strain in the subgrade (ε_v) are

$\varepsilon_t = 0.3578*10^{-3}<0.4887*10^{-3}$ **Hence Ok**
$\varepsilon_v = 0.6440*10^{-3}<0.8832*10^{-3}$ **Hence Ok**

VI. RESULTS DISCUSSION AND RECOMMENDATION

6.1 RESULTS DISCUSSION

As per Solid Waste Management Rules, 2016, all the ULBs are responsible for the Solid Waste Management activities within their respective jurisdiction. Bhopal Municipal Corporation (BMC) looks after the Solid Waste Management activities within its jurisdiction. Solid Waste Management activities of BMC comprises of the following activities:

PRIMARY COLLECTION

The door to door collection to include all government office complexes, non- government office complex, authorized colonies, unauthorized regularized colonies, all market commercial/ institutional places, slums and even from undesignated points by means of deployment of suitable vehicles. This shall also include by-lanes, lanes and streets. The bidder shall be responsible for collection of waste from road side litterbins, horticulture waste etc. The wastes generated from household and commercial establishment shall be brought under systematic intervention for high efficiency at ground level. The Solid Waste Management function involves monitoring and management of the activities of Door-to-Door Collection of Municipal Solid Waste, Dead Animal, Street sweeping, Cleaning of open drains, Transporting of Waste, Scientific Treatment & Disposal of MSW, Maintenance of Waste Collection vehicles and other utilities such as Public toilets/complexes, etc., The process also involves keeping track of the amount of waste treated /disposed at the Processing/Disposal site as the case may be.

SECONDARY COLLECTION

The collection of the wastes dumped into the bin-points and transported to the site falls under this category of collection. The Secondary Collection and Transportation (C&T) is being handled by a fleet of modern compactors, tippers, etc by GMC. This is looked after by Zonal Engineers, JTOs and Supervisors with a fleet of hand carters and sweepers. The collected primary garbage through primary vehicles would be transferred at the concerned Mini Transfer stations. There would be Mini transfer stations with parking station.

PROCESSING

Mass Burn with energy recovery results in the least tripping fee for the project considering the capital cost, capacity of the plant, PLF and operation cost, over the project period. Hence after considering pros and cons of various W2E technologies, mass burn with energy recovery has been selected as the MSW treatment technology for the current project.

Generation of solid waste in Bhopal

Amount of un-segregated MSW and waste for feeding to the boiler and characteristics of MSW: We wish to confirm that the proposed Waste to Energy power plant is designed to fire processed waste and not un-segregated waste. The plant is designed with an installed range to fire 1050TPD of processed waste of 1650 kcal/kg Net Calorific Value (NCV) to produce 21MW of gross electric power by firing processed waste. Since, it's difficult to come up with a single boiler capable of firing 1050TPD of processed waste, we shall be providing two lines/numbers of boilers with an installed capacity of 750TPD (15MW) and 300TPD (6MW). The steam from both the boilers shall be combined together and same shall be sustain to a common 21MW steam turbine. Generator will also be of 21MW capacity. Please see details of waste projection from Bhopal city and adjoining cluster areas as given by Bhopal Corporation in the Project Information document (PIM), in the table attached below. Please also see the summary table which is based on the waste generation is attached below.

Table 7 Generation of solid waste in Bhopal

Year	Bhopal	Mandide ep	Obaidulla hganj	Berasia	Sehore	Ichhawar	Kothri	Ashta	Total mixed	Total processed	Old legacy waste fired	Total Waste Fired	Gross power
													generated, MW
	TPD	**TPD**	**TPD**	**TPD**	**TPD**	**TPD**	**TPD**	**TPD**	**TPD**	**TPD**	**TPD**	**TPD**	**@1650kcal/kg NCV**
2018	1033	19	7	9	38	4	3	16	1129	790	0	0	Plant yet to be commissioned
2019	1055	19	7	9	40	4	3	17	1154	808	0	0	Plant yet to be commissioned
2020	1077	20	7	10	41	5	3	18	1181	827	223	1050	21
2021	1100	21	7	10	42	5	4	19	1208	846	204	1050	21
2022	1123	22	8	10	44	5	4	19	1235	865	185	1050	21
2023	1147	22	8	11	45	5	4	20	1262	883	167	1050	21
2024	1171	23	8	11	47	5	4	21	1290	903	147	1050	21
2025	1195	24	8	11	48	5	4	22	1317	922	128	1050	21
2026	1220	25	9	12	50	5	4	23	1348	944	106	1050	21
2027	1246	26	9	12	52	6	4	24	1379	965	85	1050	21
2028	1272	27	9	12	53	6	5	25	1409	986	64	1050	21
2029	1299	28	9	13	55	6	5	26	1441	1009	41	1050	21
2030	1326	29	10	13	57	6	5	27	1473	1031	19	1050	21
2031	1354	30	10	13	58	6	5	29	1505	1054	0	1054	21
2032	1382	31	10	13	61	6	5	30	1538	1077	0	1077	21
2033	1411	32	11	13	63	6	5	31	1572	1100	0	1100	22
2034	1441	33	11	13	65	7	5	33	1609	1126	0	1126	22
2035	1471	34	11	13	67	7	5	34	1645	1152	0	1152	23

(***Source:****City MITCON Consultancy & Engineering Services Ltd.)*

Table 8 Total Waste generation in 2016

Urban local bodies(ULB)	Wards	Population 2016	Total waste generation (TPD)
Bhopal	85	2411972	909
Mandideep	26	87676	17

Obaidullaganj	15	25286	8
Berasia	18	34370	10
Sehore	35	121453	32
Ichhawar	15	16539	4
Kothri	15	11988	4
Ashta	18	61286	16
Total			**1000**

*(**Source:** MITCON Consultancy & Engineering Services Ltd.)*

Serviceability of the approach road

Geocells are suggested to use for the construction of the approach road to the Adampur chhawani landfill site. In normal construction method, the approach road is to be designed according to traffic and soil of road. It is found out that traffic of 2.92 MSA according to traffic on approach road and soil of 6.93 CBR during earlier survey. So, according to that Sub-base of 210mm, base of 250mm, DBM of 60mm & BC of 25mm has to be designed. But by using Geocells the BMC would manage to save 100mm of base course and designed thickness of each layer are Sub-base of 210mm, base of 250mm which is with use of 150mm geocell is reduced to 150mm, DBM of 60mm & BC of 25mm. The installation of Geocell will be completed in 3 days time whereas the total road will be completed in less than 40 days. The installation of Geocell not only saves natural resources and time but also saves money.

6.2 RECOMMENDATION

During the collection of data of these sites. It is seen that till today only few cities practicing proper disposal of solid waste although it is devastating to know that they are so careless about it. It is an important matter to lookout but unless it became a big loss to us we would never notice it. In Guwahati also until its alarming condition nobody take precautions. Then finally a fully designed & operational landfill was raised. Already there are many techniques available to dispose solid waste appropriately. In Bhanpur case the locality complains made it possible to shift the location to Adampur chhawani but here we are again, there is same mistake there is no proper disposal of waste. Proposal of WTE plant for Bhopal is passed in 2018 and the WTE plant is going to be installed soon which generates 21MW energy in 2020 and it will generate about 23MW in the year 2035 according to the amount of waste generated. In Guwahati, the approach road condition is also so bad that it is difficult and time taking to dump the waste to destination. It is recommended to use geocell in approach road of Adampur chhawani and areas where required.

VII. CONCLUSIONS

- It concludes that increase in bearing capacity and decrease in the deformation of the embankments is noted in geocell reinforced pavement.
- The installation of Geocell not only saves natural resources and time, it also saves money.
- The overall thickness reduction is very less (18.35 % only). But since this thickness reduction is costly in base layer hence geocell technology provides significant initial construction costs saving.
- The thickness of Base layer is reduced by 100 mm (40.00 %).
- These materials are normally less expensive to purchase, transport and install as compare to soils and aggregates.
- The study concludes that the Government should allow proper disposal of collected waste in order to ensure a clean environment friendly Bhopal till the WTE plant is equipped.
- Generation of 21MW of power is viable when the WTE plant is equipped.
- Maintenance charges of garbage dumpers will be reduced.
- Time to reach the site will be reduced.

The comparison of the thickness of both the pavement is tabulated in table 9.

Table 9 comparison of the thickness of both the pavement

LAYER	BC	DBM	BASE	SUB-BASE	TOTAL THICKNESS(mm)
Conventional pavement	25	60	250	210	545
Geocell Reinforced pavement	25	60	150	210	445

7.1 SCOPE OF FUTURE RESEARCH

- Case study and analysis on Slopes of landfill with Geocell for steeper slopes in prime area where limited availability of land is factor can be done.
- Case study and analysis on areas under cyclic loading condition with Geocell can be done.
- Case study and analysis on soil having low bearing capacity like black cotton soil with Geocell can be done.

VIII. REFERENCES

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