GeoAmericas2020
4th PAN AMERICAN CONFERENCE ON GEOSYNTHETICS
26-29 APRIL 2020 • RIO DE JANEIRO • BRAZIL

Design of Check Dam with Geocells – Case Study

P.V. Guda, Strata Geosystems (India) Pvt Ltd, Mumbai, India,
Y.R. Patil, Strata Geosystems (India) Pvt Ltd, Mumbai, India,
S.D. Vedpathak, Strata Geosystems (India) Pvt Ltd, Mumbai, India,
S.P. Bagli, Strata Geosystems (India) Pvt Ltd, Mumbai, India,
G.N. Dalmia, Strata Geosystems (India) Pvt Ltd, Mumbai, India

ABSTRACT

Geocells have several applications. This paper presents an innovative view of the geocells to construct a small check dam for the first time in South Asia. The check dam discussed in this case study is near Satpara, Madhya Pradesh, India. The check dam was constructed as “Corporate Social Responsibility (CSR)” by a corporate entity to enhance ground water recharge for the nearby farmlands. The height of the dam is 3.8m from stream bed up to the crest. The spillway comprises a series of pipes below the crest, supplemented by a trapezoidal opening at one end. The site is remote and almost inaccessible for construction vehicles. It was therefore proposed to construct the check dam with HDPE geocells. Geocells which are easily carried as manual load to the site. The geocells were infilled with locally available non-plastic granular material and the outermost cells on the upstream and downstream sides were infilled with concrete to avoid erosion of material from the outer cells and to restrict ingress of water into the body of the check dam. To relieve any possible build-up of pore water pressures within the body, suitable weep hole pipes have been provided thorough the downstream side. With the use of geocells, the work was carried out with minimum manpower and equipment. Construction commenced in mid-May 2018 and was completed by end-June 2018, well in time before the onset of the South West monsoons.

1. INTRODUCTION

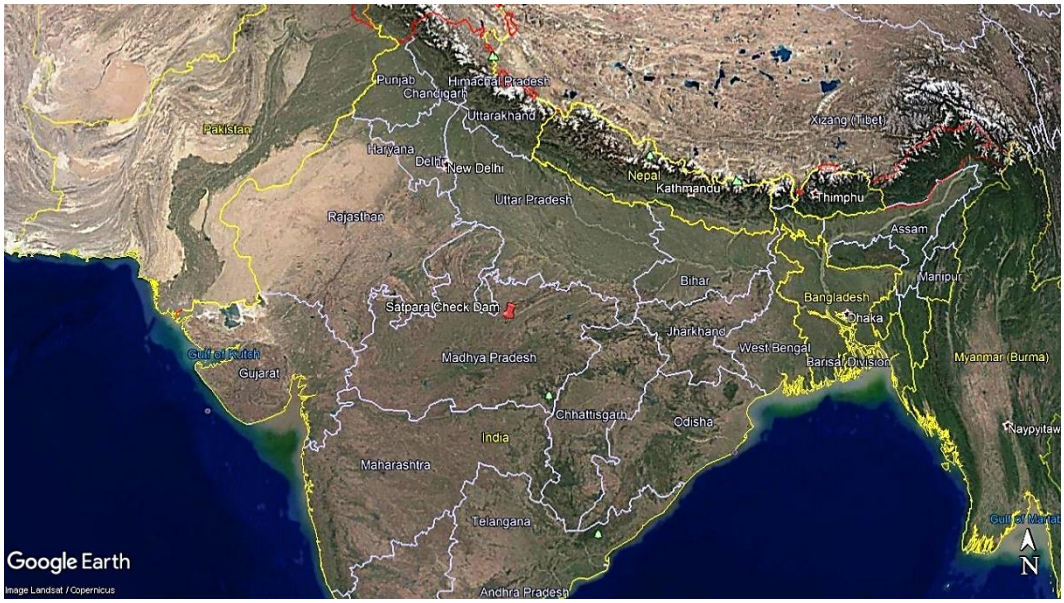
Check dams are small dams constructed across a stream or minor waterway to counteract erosion by reducing the water flow velocity. Check dams have been used ever since ancient times in India to replenish the ground waters and wells. Conventionally such check dams are constructed as earth or masonry (rubble or concrete) gravity retaining structures. This Paper illustrates a different approach for construction of the check dam using geocells infilled with locally available non-plastic granular soil and the outer sides of the check dam are provided with concrete veneer, both upstream and downstream.

2. OVERVIEW

The check dam was constructed as a Corporate Social Responsibility (CSR) activity of a corporate body to enhance the ground water recharge for nearby farmlands. The check dam, constructed of geocells, is locatednear Satpara, Madhya Pradesh, India (Figure 1a). Prior to the proposal of installing the check dam, rainwater was allowed to flow through the stream without any attempts at ground water recharge. Figure 1b shows the arid landscape, highlighting the paucity of water.

In view of submergence of adjoining properties, the check dam was restricted to a height 3.8m from stream bed, with the spillway invert at 2.8m above the stream bed. The spillway comprised of a series of heavy-duty concrete pipes, 250mm nominal diameter were located below the crest with their invert at 2.8m above the stream bed. These pipes were supplemented by a trapezoidal channel at one end. The longitudinal length of the check dam is about an average 20m from abutment to abutment along the stream cross section profile.

The subsoil comprises essentially of plastic silt.



a) Location of the site (Satpara Check Dam in Madhya Pradesh)

b) Satellite imagery of the proposed site before the construction of check dam

Figure 1. Imageries of the site (Courtesy: Google Earth)

3. PROJECT REQUIREMENT

Conventional method of construction of check dam (earth fill, masonry) was either uneconomical or not viable. Besides, there were constraints of construction time (2 to 3 months for the onset of the monsoons) and remoteness of the site. Construction of the check dam using geocells as building blocks proved to be the optimum solution.

Figure 2 indicates the profile of the stream cross section which required dressing prior to construction of check dam using geocells.

Figure 2. Profile of the stream cross section prior to construction of check dam

4. PROPOSAL

In view of the constraints with the conventional methods, the Client approached Strata Geosystems (India) Pvt. Ltd. for a geosynthetic solution. A check dam of geocells as building blocks was recommended. Geocells are strong and lightweight three-dimensional cellular systems, which are manufactured by welding HDPE straps and expanded to form three dimensional panels. The geocell cell walls are perforated in order to release any pore water pressure developed within the infill material. Geocells are filled with locally available non-plastic material except outer cells on upstream side which are filled with concrete to confine the material within the cells and limit the ingress of water.

5. ANALYSIS

The proposed geocell check dam is designed similar to conventional gravity structures. The check dam is basically constructed by placing interconnected geocell panels on top of each other. The orientation of the geocells is such that the geocell straps are perpendicular to the direction flow of water. The geocells proposed consists of weld spacing of 660mm and depth of 200mm. The number of cells in each layer along the cross section of the wall are based on the design computations by evaluating internal and external stability of the structure.

Design analysis is carried out for static and seismic conditions as per Indian Standard IS 6512. Minimum safety factors considered in the analysis of the dam for sliding and overturning are 1.5 and 2.0 respectively. Seismic analysis of the structure has been carried out for horizontal acceleration coefficient corresponding to zone III. The cross-sections through the width of the check dam and longitudinal cross-section profile of the geocell check dam with geocells are shown in Figure 3 and Figure 4 respectively.

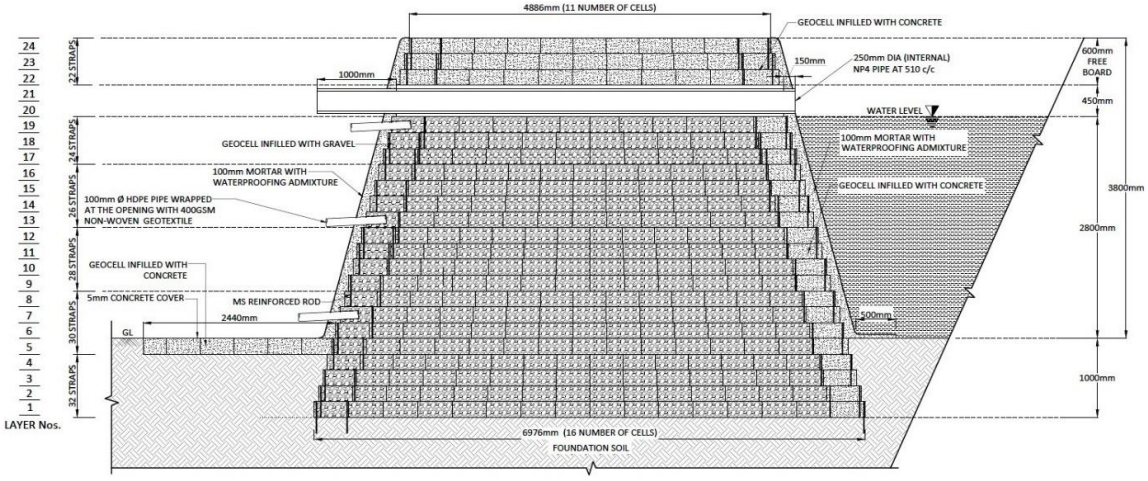


Figure 3. Cross-section through the width of the check dam

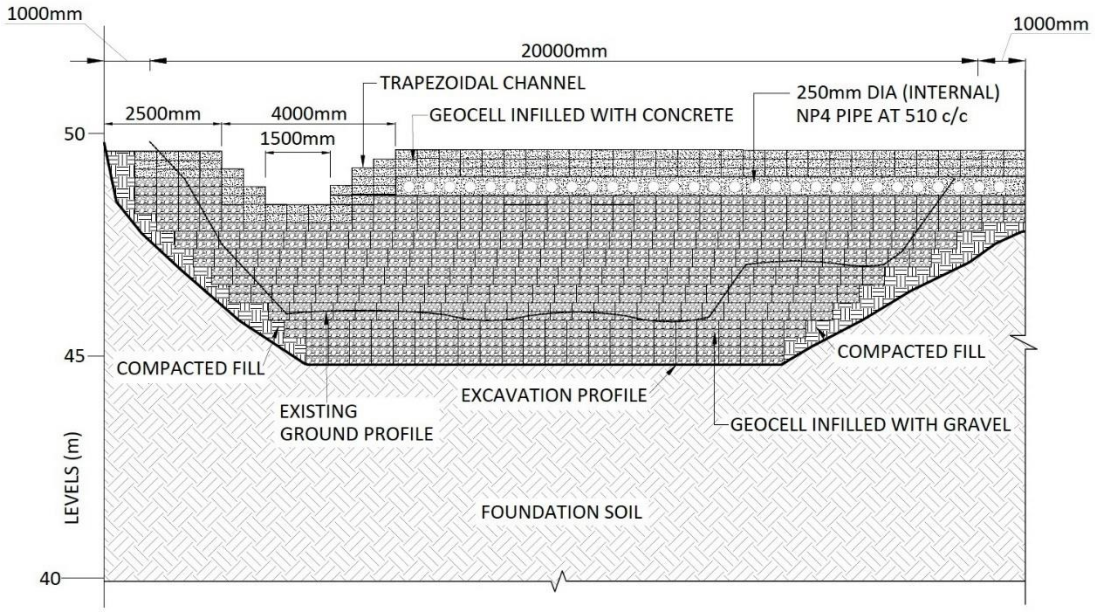


Figure 4. Longitudinal cross-section of the check dam from the upstream side

6. CONSTRUCTION METHODOLOGY

Construction sequence is as follows:

i. The check dam is embedded 1m into the dressed bed and 1m on either side of the slopes to maintain the overall stability of the dam.
ii. The check dam is constructed such that a trapezoidal geometry of the dam is formed. In order to form a trapezoidal geometry an offset (batter) of 50mm is provided on both the faces of the dam between each lower and upper layer of geocell panels by relaxing the expansion of the panels as required.
iii. The bottom width of the check dam is 6.9m and the top width of the dam is 4.9m. These dimensions are based on the requirements of stability.
iv. 8mm diameter, 400mm long MS rods are placed in the outer cells of each layer on the upstream and downstream side so as to hold the geocell panels in position during the compaction of infill material.
v. The outermost cells on the upstream side are filled with the concrete to prevent ingress of water within the dam and remaining cells are infilled with locally available non-plastic material.
vi. In order to create a smooth profile of the upstream and downstream surfaces of the check dam, additional veneers concreting was done on both the faces.
vii. 100mm diameter PVC pipes as weep holes are provided at 1.5m vertically and horizontally on the downstream side of the check dam to release pore water pressure (Figure 7).
viii. Spillways in the form of heavy-duty pipes of internal diameter 250mm are placed at a center to center distance of 510mm and a trapezoidal channel with a bottom width of 1500mm is provided at one end of the check dam. The invert level of the heavy-duty pipe spillway and the bottom of trapezoidal channel is 1000mm from the top of the check dam.
ix. The top three layers of geocells, i.e. layers above the heavy-duty pipe spillway are infilled with concrete to prevent ingress of water into the body of the check dam.

Figure 5 and Figure 6 show details of construction.

Figure 5. Infilling of geocells with non-plastic material

Figure 6. Construction of check dam up to spillway level

Figure 7. Provision of weep holes on downstream side of check dam

Photographs of the completed geocell check after first monsoon (6 months post construction) and second monsoon season (1.5 years post construction) are shown in Figure 8 and Figure 9 respectively. Construction of check dam using geocells has helped in water storage capacity and increased ground water recharge as seen in satellite imagery of the site during non-monsoon season (November-2018) (Figure 10).

a) Upstream of check dam after the first monsoon - 2018 (6 months post construction)

b) Reservoir behind the check dam after the first monsoon - 2018 (6 months post construction)

Figure 8. Check dam, first monsoon after construction (2018)

a) Upstream of check dam after the second monsoon - 2019 (1.5 years post construction)

b) Reservoir behind the check dam after the second monsoon - 2019 (1.5 years post construction)

Figure 9. Check dam, second monsoon after construction (2019)

Figure 10. Satellite imagery of the Site after the construction of check dam (November 2018)

7. CONCLUSIONS

i. Considering the success of the check dam at Satpara, it may be concluded that geocells (three dimensional geosynthetics) facilitate rapid construction of gravity structures including check dams.
ii. Geocells being light-weight material, handling is easy and neither mechanized equipment nor skilled workers are required for construction.
iii. The check dam has been provided with adequate pore water relief systems in the form of pipes.
iv. Heavy duty concrete pipes and the trapezoidal channel have been provided as spillways to prevent overtopping of the structure.
v. Use of geocells infilled with locally available soil has drastically reduced the consumption of the concrete to a great extent.

8. ACKNOWLEDGEMENT

Authors of this paper express their gratitude to Strata Geosystems (India) Pvt. Ltd and its Client for granting permission to publish this Case Study.

REFERENCES

IS:6512 - Criteria for Design of Solid Gravity Dams (Second Revision)