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Soil and Environment Conservation with Geogrid in the Arid Area (Chandab Basin-Iran)

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Abstract. This paper is derived from a research on soil conservation and slope stabilization using Geogrid in the Quaternary alluvial sediments of Chandab region in southeast of Tehran. The objective was to study the efficiency of geogrid materials in technical and economical aspects for high slope stabilization and decrease of soil erosion. To determine geogrid works, plots of 12×2 meters were constructed. They were enclosed with steep plates; runoff and sediments gathered and were led to gathering plots. Different treatments were considered for the research. Two slope (85% & 110%) and their replication were among the treatments from which 9 events were recorded. The recoded data has been analyzed with Spss program. The effect of slope and soil covering of plots, also their reciprocal effects on amount of sediment concentration has been evaluated with two way on variance analysis. This investigation and other studies suggest that the use of geogrid to issue in soil conservation and soil stability in the steep slopes (road trench and railway lines) and prevent erosion of rivers and dam borders.

Keywords: Erosion control, Geogrid, Slope stability, Soil conservation, Arid and semi arid area.

1. Introduction

Geogrids provide stability to the top soil layer through confinement: once extended to their full open size and filled with lightly compacted top soil, a stable and inextensible planting medium is achieved. Slopes with different length, inclination and soil characteristics, can be properly protected against erosion by the choice of the most suitable kind of geogrid. Geogrids have junctions that allow the passage of water between adjacent cells [1] and [2]. Some cases in soil stability are pointed as following:

At Iserlohn a 19 m high, 215 m long, geosynthetic reinforced earth structure was built for Lobbe Holding GmbH & Co. The construction is located adjacent to the A46 motorway and has a maximum free height of 16.70 m with a width of 11.20 m at the base. Both planning and the design calculations were carried out by Geokunststoff GbR [3], located in Weimar, Germany. The design was strictly in accordance with the Empfehlungen für Bewehrungen aus Geokunststoffen –EBGEO. The completed wall has a slope angle of 80° without berms whilst the slope face has been completely vegetated. This paper describes both the design approach and the construction details including construction time, installation sequence and details of the face vegetation. The results of deformation measurements over a period of 2 years are also included [3]. The soil or aggregate infilled by providing lateral confinement. In this situation the infiltration of the water is facilitated and the runoff is decreased both in volume and in speed, with a consequent reduction of the water erosivity. Rills and gullies are therefore prevented.

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The combined use of geogrids, for stabilizing a thick top soil layer, and geomats, for surface protection, provides the most effective erosion control system in heavy situations Maccaferri Pty Ltd [4] assisted in the design of reinforced soil wall using Maccaferri gabions and RockGX geogrids. This system was chosen because of its ability to blend into its natural environment. For the critical section, measuring approximately 5 m in height, soil reinforcement in the form of polyester geogrids was used to create a stable reinforced soil block mass. The Rock GX geogrids were laced between adjacent gabion baskets, providing superior long-term design strengths. Eden Gardens garden & nursery centre have provided their customers and workers an environmentally friendly and naturally looking environment. Revegetation and landscaping of the gabion garden walls was simple and effective.

The above mentioned projects have been fulfilled in wet area and it has obtained good results. So this method was applied in the arid and semiarid areas in order to study its result.

2. Materials and Methods

2.1. Study area

The Chandab basin is situated in the 60 km south eastern of Tehran province in the northern part of Iran, in the latitude 35º 24′ 31″ N and Longitude 51º 55′ E situation (Fig. 1).

Fig. 1: Location of the study area.

The topography of the study area varies from plain to mountainous and includes old to young geological formations. The climate of the Chandab catchments is arid to semi arid, although locally the climate varies based on the altitude. There are four kinds of meteorological stations; rain gauge and evaporation station. The amount of precipitation, air temperature, relative humidity and amount of evaporation from class A pans were recordedat all of stations. The mean of annual precipitation rate is 185.7. Mean maximum temperatures during 1990-1997 range from 29.9 to 39.9 Cº and mean minimum ranges from -1 to 6.6 Cº January is the coldest month while August is the warmest month in the study area. The mean of annual temperature is 16.1 Cº. Temperature regime of area is thermic.

Area has no soil cover because the project has accomplished in the Quaternary alluvial fan with high slopes, the soil is classified to Course loam with Ap (platy) structure and brown inclined to clear yellow in color and with sandy texture and mass structure with calcareous fiber. There is a thin layer of soil, which is classified as: lithic leptosols, calcaric regosols and gypsic regosols. In the studied area due to non-existence layer of soil, the vegetation covering is weak and predominate vegetal species are: *Salsola kali* and *Pteropyrom olivieri*.

In the study area the drainage network consists of ephemeral and perennial streams. Because of the arid climate, most streams are ephemeral. Runoff flow after each rain falls largely disappears in the Quaternary surface depositions. There are some perennial rivers in the study area with North-South directions.

2.2. Method

The geogrid soil reinforced structure has to be designed taking into consideration the characteristics of the backfill, subgrade and reinforced soil. The maximum particle dimension of the aggregate shall be 125 mm and the use of swelling plastic clays, due to their low compactability shall be avoid.

To determine geogrid works, plots of 12X2 m were chosen in this research. At the end of plots, runoff is caught and measured and sediment amount in the runoff was measured. Different treatments along with replications were chosen (Table 1).

In order to select the geogrid characteristics, several different solutions were discussed and designs and calculations were carried out and the most economic solution was to use the locally available recycled material with a pH value of 11.5 and integral geogrids. Reinforcement with high resistant to chemicals with a low factor of safety against installation damage was needed to be used with recycled material.

In this study the geogrid with below characteristics to soil conservation and soil stability (Table. 2) has been used. To place of the geogrid panels, geogrid panels shall be expanded to the full open dimension, parallel to the flow direction. Initially each panel shall be anchored at the top of the slope in a trench with dimensions determined by design. If it is possible, the anchorage trench at the top can be filled with concrete (to reduce the embedded length).

Table 1: Different chosen treatments

A	Geogrid with natural grassland covering
B	Geogrid with seeding aboriginal grassland species
C	Without geogrid and with natural grassland covering
D	Without geogrid with seeding aboriginal grassland species

Along the slope the geogrid shall be anchored with pins. The spacing between the pins shall be determined by the design engineer.

Pins have shape and length depending on the soil characteristics. Pin diameter shall be 8 mm minimum. Each pin shall be placed at the junctions of the panels. The geogrids can accommodate infill and finishes such as soil/grass, gravel.

Table 2: Characteristics of used geogrid

Aspect	nets or grids in rolls or boxes
Solubility in water	Insoluble
Polymer	Polypropylene-HDPE
Ecotoxicity	Non toxic.
Measure	690 g/m^2
Measure of gates	27×27 mm.
Tensile strength	8.5 Kn/m
Applications	Stabilization and reinforcement of weakly soils

2.3. Data Analysis

Nine events were measured. The data were analyzed with the Spss program. In this investigation has been measured geogrid function to soil stability and conservation. Geogrid efficacy in aspects of technique and economic in soil stability and decrease of soil erosion in the steep slope has been measured and collected data has been analyzed.

3. Results and Discussion

The intensity of this problem was different in diverse areas. In the study area, the erosion situation in the alluvial soils has been evaluated. The least rain event 4.5 mm had been related to second event. Least runoff event belongs to second event. Table 3 shows the quantity of measured sediment concentration in each plot. The receipted data has been analyzed with Spss program. The effect of slope and soil covering of plots and their reciprocal effects to amount sediment concentration has been evaluated (Table 4) in two ways on variance analysis.

Table 3: The results of sediment concentration analysis (gr/Liter)

Order	**Plots sign**	**(gr/liter)**								
1	**BB1**	0.9	2.6122	1.2767	0.9625	0.4994	0	2.21	2.868	0.625
2	**AA1**	0.0649	0.462	0.4591	2.228	0	0	0	0	0
3	**DD1**	0.9522	12.1928	1.5122	0.7991	0.1606	0	0	0.844	0.44
4	**CC1**	0.1428	1.7194	0.1967	0.8046	0.1412	0	0.088	1.389	0.20

5	**AA2**	0.0962	0.4102	0.2206	0.2294	0.0629	0	5.25	0.55	0.04
6	**CC2**	22.0858	0.2076	0.1785	1.598	6..644	0	0.255	98.395	0
7	**DD2**	0.1127	58.86	2.276	2.2571	0.1627	0	1.46	27.147	0.104
8	**BB2**	0.2804	1.0062	0.6845	0.4821	0.2675	0	0	1.172	0.239
9	**BB3**	0.1875	1.0212	0.7162	1.114	0.4642	0	0.39	0.804	0.166
10	**CC3**	14.1724	16.9815	6.2261	0	0.1765	0	14.33	8.365	0.308
11	**AA3**	1.4816	0	4.0619	0	0	0	0	0.813	0.347
12	**DD3**	0.2656	1.2111	5.2185	2.7424	0.1649	0	8.65	9.44	0.103
13	**A1**	0.1074	1.7348	1.6643	2.018	0.2679	0	0	3.56	0.119
14	**B1**	0.1422	0	0.1415	0	0	0	0	0.478	0
15	**C1**	0.2754	0.2411	0.1244	0.4661	0.0702	0	0.53	5.79	0.403
16	**D1**	0.0658	0.229	0.4281	0.7864	0.1121	0	0.27	1.186	0
17	**A2**	0.2528	0.2626	0.1175	0.1069	0.0055	0	0.55	0.325	0.759
18	**C2**	0.8177	0.4625	2.6275	0	0.2987	0	8.96	3.08	0.69
19	**D2**	0.6644	0.5892	1.1002	2.6976	0.1642	0	9.436	4.58	0.636
20	**B2**	2.0144	2.821	0	0	0.4627	0	7.726	1.175	0.29
21	**A3**	0.2629	0.2125	0.1069	0.9189	0.4253	0	1.55	1.73	0.236
22	**B3**	0.225	0.2188	0.1422	1.2491	0.1183	0	0.91	1.003	0.146
23	**D3**	0.2419	0.1875	0.0861	0.5059	0.2472	26.3	8.1	12.50	0.011
24	**C3**	0.2262	0.2222	1.6852	0.2221	0.0544	10.59	1.8	0.596	0.127

Table 4 indicates that slope has no effect on the amount of sediment concentration with % 95 probabilities but difference of sediment concentration logarithm quantity in different soil covering has been significant in the surface of %3. It means that the type of soil covering has influenced on sediment quantity (Table 5, LSD test with 95% confidence). This difference pertains to soil covering B type (with sediment concentration average of 0.78g/l) and soil covering D type (with sediment concentration average of 3.9 g/l). This indicates that the sediment concentration in the B plots is less and in the D plot is more than other plots.

Table 4: Two way variance analysis

Tests of Between-Subjects Effects

Dependent Variable: log of s   Dependent Variable: LOG

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3.014(a)	7	.431	1.992	.120
Intercept	.101	1	.101	.468	.504
SLOPE	.426	1	.426	1.971	.179
COVER	2.442	3	.814	3.766	.032
SL * CO	.146	3	.49	.226	.877
Error	3.458	16	.216		
Total	6.574	24			
Corrected Total	6.472	23			

a R Squared = .446 (Adjusted R Squared = .204)

Table 5 also shows the influence of slope and soil covering type with %95 probability is not significant. For evaluation of amount soil losses for Hectare, produced sediments has been extended to hectare. Importance of this subject for this reason is important that erosion and soil losses evaluation in the each area explain erosion situation and sensitivity to erosion of the area. In table 6, the quantity of sediments that each treatment can produce per Hectare has been presented. The most of produced sediments were related to plots without geogrid with with natural pasture covering in two types of slopes. In the two another treatments: A and B (Geogrid with natural grassland covering and Geogrid seeding aboriginal grassland species) the quantity of soil losses was much less than the others.

Table 5: Multiple comparisons between different groups

Post Hoc Tests

Multiple Comparisons

Dependent Variable: log of s
LSD

(I) covered with geogrid	(J) covered with geogrid	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
A	B	.0303	.25915	.908	-.5103	.5708
	C	-.5981(*)	.25915	.032	-1.1387	-.0575

	D	-.6436(*)	.25915	.022	-1.1842	-.1030
B	A	-.0303	.25915	.908	-.5708	.5103
	C	-.6283(*)	.25915	.025	-1.1689	-.0877
	D	-.6738(*)	.25915	.017	-1.2144	-.1333
C	A	.5981(*)	.25915	.032	.0575	1.1387
	B	.6283(*)	.25915	.025	.0877	1.1689
	D	-.0455	.25915	.862	-.5861	.4951
D	A	.6436(*)	.25915	.022	.1030	1.1842
	B	.6738(*)	.25915	.017	.1333	1.2144
	C	.0455	.25915	.862	-.4951	.5861

*The mean difference is significant at the .05 level.

The results could be used for stabilization of slopes next to dam reservoirs or trenches resulted by road construction. Regarding to this study and other researches, successful implication of geosynthetic in soil stabilization 9road trench and railway lines) and erosion prevention in the steep slopes (rivers and dam borders), the usage of geosynthetic in non structural manner in the soil and slope stabilization (Fig. 2) has been suggested. The computation results show that the lands with 110% slope have the erosion rate of 37.17 kg/ha./yr if stabilized with Geogrids and 1384.6 kg/ha./yr if not stabilized. For the land with the slope of 85% the above rates are 11.37 kg/ha./yr and 129.1 kg/ha./yr respectively [2].

Table 6: The value of annual soil losses in the studied area.

Treatments	**Rate of mean annual soil losses in the 110% slopes (kg/ hectare)**	**Rate of mean annual soil losses in the 85% slopes (kg/ hectare)**
Geogrid with natural grassland covering	41.26	11.72
Without geogrid and with natural grassland covering	1004.9	115.17
Geogrid with seeding aboriginal grassland species	33.08	11.036
Without geogrid with seeding aboriginal grassland species	1764.33	142. 5

Based on obtain results, soil conservation in the steep slope soils with geogrid in comparison with other protective methods like to gabion, retaining wall, pitching and terracing decreased the expenses by 450, 490 and 219 percent to hectare, respectively.

On the other hand during the operation of project is shows variations in the vegetation covering in the different plots. The percentage of vegetation covering is variable in the different seasons. Vegetation covering in the slopes of 85% has been increased more than the other slopes. The quantity of vegetation covering has increased from 1 to 6.5% in the first treatment as far as season concerned, there is high fluctuation in third and forth (witness) treatments of the above 110% slope plots and it has increased from 1 to 8.5% in the second treatment. The rainfall seasons accompanies increasing and the drying seasons with falling of vegetation covering. The quantity of vegetation covering in the first treatment of 85% of slope plots shows ascending procedures but other plots accompanies high fluctuation.

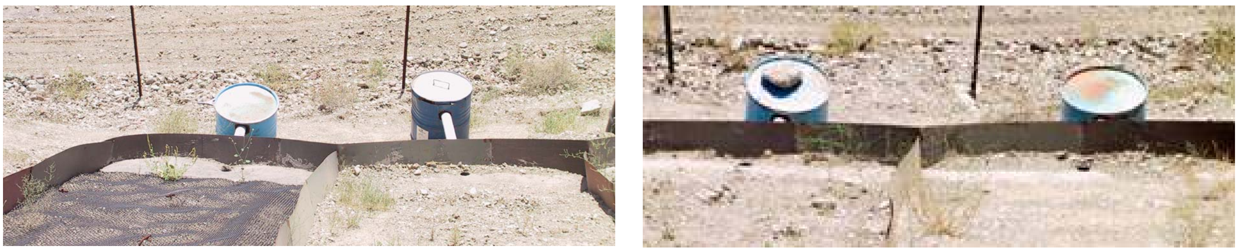

Fig. 2: Sediments produced related to plots with and without geogrid

4. Conclusion

The data were analyzed with the Spss program. The results in both slope types showed that in the 110% slope the erosion was much more than the 85% slope and the treatment plots which were stabilized with geogrids indicated a lesser to no erosion. Geogrids are made of polypropylene resistant materials. In order to environment and soil prevention the usage of geogrid is suggested due to its low price, high resistance, longevity and compatible with environment. These days geosynthetic reinforced soil structures belong to the most economically attractive construction methods due to their flexibility and versatility. Also from the ecological point of view, as e.g. CO_2 reduction, further positive impulses for this type of application can be expected in future [5]. This investigation and other studies suggest that the use of geogrid to issue in soil conservation and soil stability in the steep slopes (road trench and railway lines) and prevent erosion of rivers and dam borders.

Different types of geosynthetics can be used, because of low costs, high durability, high resistance and high suitability to environmental conditions. The polymer products are completely recyclable. The growing attention to the problems of Environment Impact has allowed a fast development of the geosynthetics used for erosion control and revegetation of arid areas, slopes, road embankments, etc. Also soil conservation can be very important regarding to production factors. Soils in deep slopes are very sensitive to degradation. That is why it should be considered of great importance. An effective and cheap way to preserve valuable soil is using up geogrid (geosynthetics). Conclusions and analysis proved that it is very economic compared to other treatments.

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6. References

[1] Khaksar, K. & Farboodi, M. Soil protection and increasing vegetation with geogrid application, *Proc. of 13th Congress of Soil Science*-Pakistan, March 24-27 (2010).

[2] Khaksar, K. & Rahmati, M. Economic evaluation of geogrid application for steep slope stability, *Proc. of 5th international congress of the European Society for Soil Conservation*, Palermo, Italy, June, 25-30, (2007) 103-106.

[3] Herold, A. One of Europe's tallest green faced geosynthtic reinforced retaining structures, *Geokunststoff GbR Herold & Khler*, Weimar, Germany (2003) Case study.

[4] Maccaferri PtyLtd, Gabion & Rock GX Geogrid Reinforced Soil Wall- Environmental Solutions, Eden Gardens, NSW, *Eden Gardens, NSW,* Australia, (2005), Case study.

[5] Khaksar, K. Study of geogrid applicability for erosion control, *Proc. of X, Congress of Croatian Society of Soil Science*, Sibenik, 14-17, lipanj, (2006).