Proceedings of the 6th International Conference on Civil Engineering for Sustainable Development (ICCESD 2022), 10~12 February 2022, KUET, Khulna, Bangladesh (ISBN-978-984-35-1972-6)

GEO-BAGS EFFECTS ON MEANDERING SECTION AGAINAST BANK EROSION: A CASE STUDY OF DHARLA RIVER

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ABSTRACT

The objective of the study was to verify the effectiveness of geo-bags as river bank erosion control when it was used at the meandering section of Dharla (Flashy river). In this regard, geo-bags (250 kg) were dumped at the meandering section of Mogalbasha union when the water level started to touch the flood level during rainy season (after June 25th,2020) and river bank erosion started. The quantity of geo-bags dumped were 60 nos. per meter against cement concrete blocks (according to Bangladesh Water Development Board design, dumping volume was 10 cum per meter). The photographic images of river bank shifting and water flow path of the river were collected. The Reduced level (RL) data were measured and reconnaissance survey was also done. When river bank erosion started at Mogalbasha union, geo-bags were dumped 60 nos. per meter in launching apron and maintaining a slope of 1: 2.5 (geo-textile filter cloth was used below geo-bags on slope) as emergency bank protection work. The river bank erosion was stopped after dumping the geo-bags. At the end of December 2020, it was noticed that sedimentation occurred due to the dramatical decrease of the velocity of water and and the sediment being transported was dropped on the floodplain. Before dumping of geo-bags, the river was flowing towards the right bank. But after dumping, the river also changed its flow path direction due to the developement of new char and chute channel which caused morphological change of the river. During dry season, initially the RL of two meandering section was measured before dumping of geo-bags. After dumping the geo-bags, the RL of those sections was measured again during the dry season. Therefore, a lowering of RL was noticed adjacent to the right bank. Based on the field observations, RL data, image analysis and information from various sources it can be concluded that- at every meandering section of Dharla river, if the river depth remains within 0 to 10m, then it will be possible to protect river bank erosion of Dharla river within low cost using geo-bags dumping and thus land reclamation can be possible.

Keywords: *River bank erosion, Meandering section, Geo-bags, Low cost, Bank protection.*

1. INTRODUCTION

River bank erosion has been a perpetual issue in Bangladesh and exceptionally alarming to the individuals particularly who are living in the riparian territory. Dharla is one of the trans-boundary Rivers at Kurigram district in Bangladesh which originates in the Himalayas. It flows from the upstream of India having a stretch of 62 km inside Bangladesh. Due to the onrush of water from the upstream catchment in monsoon, erosion by Dharla takes a sharp turn, causing the collapse of embankments and rendering a thousand of people homeless with massive loss of crops and poultries (Bose et al., 2017). In Kurigram district, every monsoon significant amount of riverside land is being eroded which makes people displaced, destitute and ultimately affecting the country's socio-economic structure (Hossain et al., 2016). Geo-bags dumping can be a protective measure for protection against river bank erosion. When river bank erosion starts at

monsoon, dumping of geo-bags in the meandering section of Dharla river will be both cost effective and immediate measure rather than concrete blocks dumping.

In Bangladesh, both cement concrete (CC) blocks and geo-bags are used as river bank protective measures. For long term river bank protection work CC block are suitable. When river bank erosion starts, dumping of geo-bags is suitable for immediate bank protective measures. It takes 28 days for casting of CC blocks. On the other hand, preparation of geo-bags takes shorter time. If empty geo-bags are stored in a place, when river bank erosion starts, immediately they can be used by filling sand in it. The FM of sand is generally kept 1.0-1.5. Moreover, geo-bags are low cost bank protective measures with respect to CC blocks (Source: BWDB).

There are some disadvantages of using geo-bags in river bank protection work. Failure of geo-bags can be occurred by pull out, deformation/ slump, dislodgement, sliding, physical damage and partial filling. But CC blocks (Hossain et al., 2016). Korkut et al. (2007) showed that geo-bags can't protect local scouring but they are flexible to adopt in placing as protection material. Wahed et al. (2011) showed a comparison between geo-bags and CC blocks about their impact in river bank erosion protection work and concluded that geo-bags are more eco-friendly with respect to CC blocks. Hossain et al. (2016) stated that very limited works are carried out to assess the effectiveness of geo-bags in river bank erosion protection works for the rivers in Bangladesh. However, this research will help to evaluate the effectiveness of geo-bags in river bank erosion protection works.

In Kurigram district, at Mogalbasha union, there exists three primary schools, bazar, union parishad, temple, shashan ghat, mosques, madrasa etc. Therefore, a typical meandering section of Dharla river at Mogalbasha union has been selected as the study area for its socio-economic importance.

2. METHODOLOGY

2.1 Study area

Figure 1(a) shows the LGED map (Landsat TM 1998) of Kurigram district. It's at Rangpur division in Bangladesh. Kurigram district is bordered by the Cooch Behar and Gaibandha districts of India to the north and east respectively, and the Lalmonirhat and Rangpur districts of Bangladesh to the west. The district consists of 9 upazilas, 72 unions, and 1872 villages. Figure 1(b) shows Google earth map of Mogalbasha union at Kurigram district. The Mogalbasha union is located in the northern part of Bangladesh. It's located in between 25°45'25.57" and 25°46'31.04" north latitudes and in between 89°39'23.00" and 89°40'40.34" east latitudes. Several rivers flow through center of Kurigram district. Among them Dharla river is one of the major rivers (source: Wikipedia).

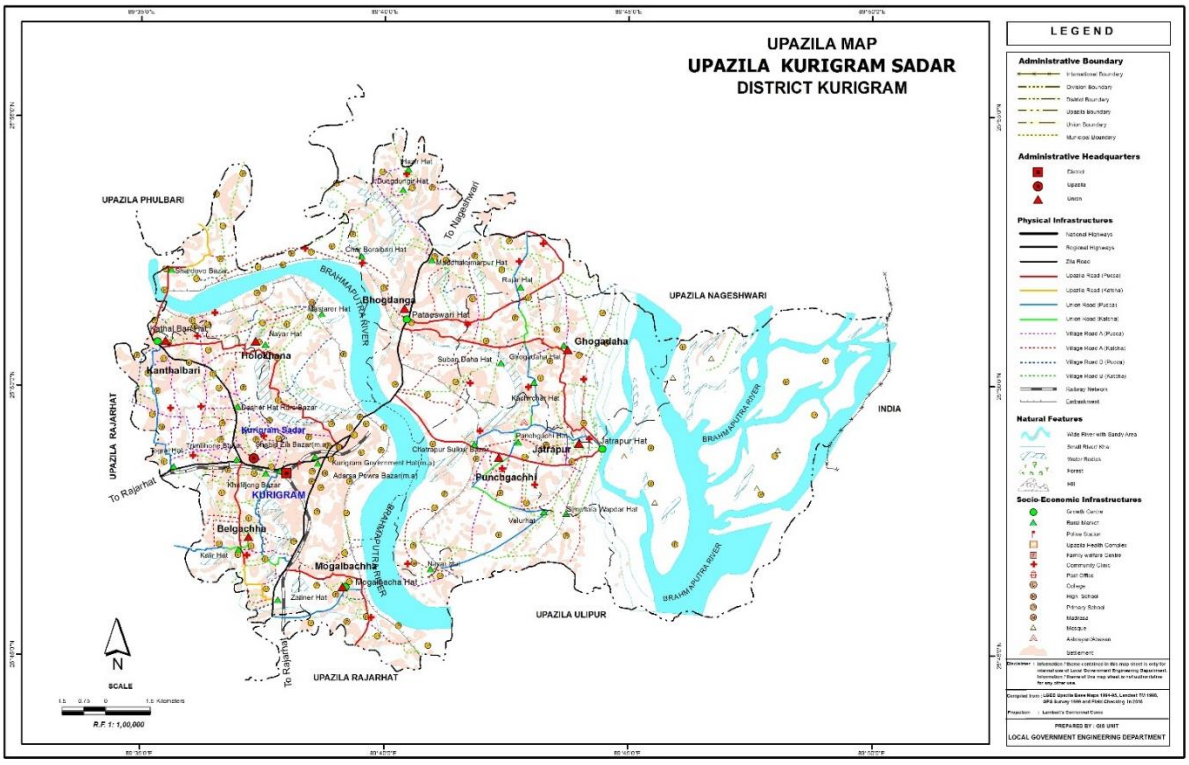

Figure 1 (a): Kurigram Sadar Map (Source: LGED Upazila Base Maps 1994-95, Landsat TM 1998)

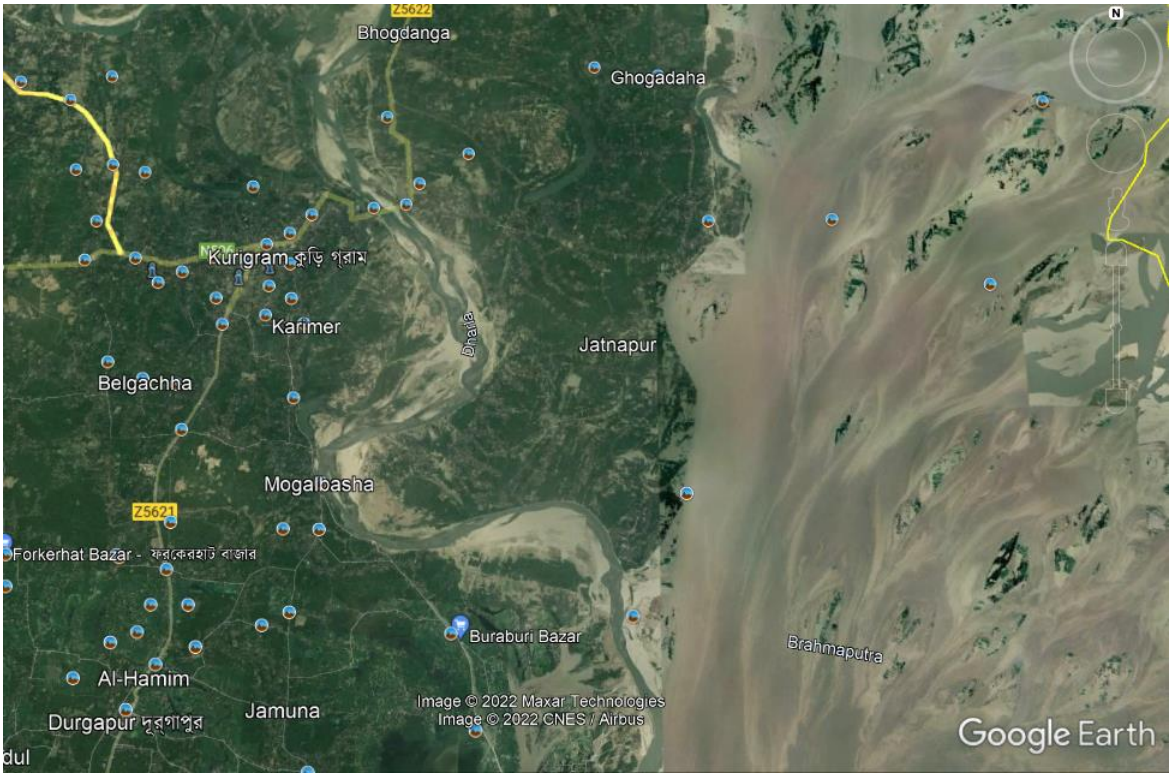

Figure 1(b): Satellite image of Mogalbasha union, Kurigram

2.1.1 Cross-sectional division of the study area

Figure 2 shows the cross-sectional division of the study area. A total of 3.5 km (from 39.00km to 42.50 km) along the right bank of the river was divided into 25 cross-sectional areas at Mogalbasha union, Kurigram district (Source: BWDB). In this Figure, the pink line, green line, blue line and red line represents pucca road, embankment, bank line and proposed work respectively. The section Ch 39+850 km is a major meandering section of Dharla river at Mogalbasha union.

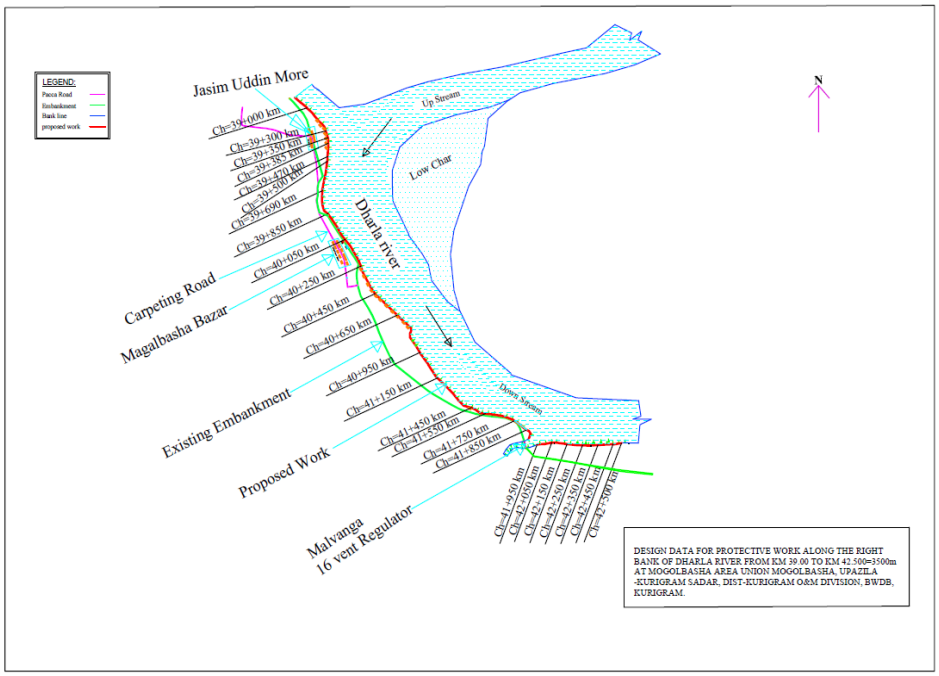

Figure 2: Cross-sectional division of study area

2.2 Preparation of Geo-bags

Empty geo-bags of different sizes and capacity were supplied at work site, making the bag with standard geo-textile fabric (97% Polypropylene fabric with 3% additives, mass: 400gm/m², unit weight: 855 Kg/m^3 to 946 Kg/m^3). Figure 3 shows that empty geo-bags were stored in a place before dumping of geo-bags on the launching apron. The inner size of each geo-bag was 1200mm x 950mm and the outer size was 1250mm x 1000mm. The geo-fabric thickness was greater than 3 mm. Filling volume of geo-bag was 0.1664 cum and the weight capacity was 250 kg.

Figure 3: Empty geo-bags

2.2.1 Dumping of geo-bags

Geo-bags (250 kg) were dumped in the launching apron when the water level started to touch the flood level (after June 25th, 2020) and river bank erosion started. Figure 4 shows the river bank erosion situation when the water level of the river was started rising. Figure 5 (a) shows the sloping procedure. A slope of 1:2.5 was maintained. Geo-filter cloth was used before dumping of geo-bags (Figure 5 (b)). Figure 6 shows dumping of geo-bags. Empty geo-bags were filled with sand having FM 1-1.5. The quantity of geo-bags dumped were 60 nos. per meter according to Bangladesh Water Development Board (BWDB) design requirements.

Figure 4: River bank erosion images

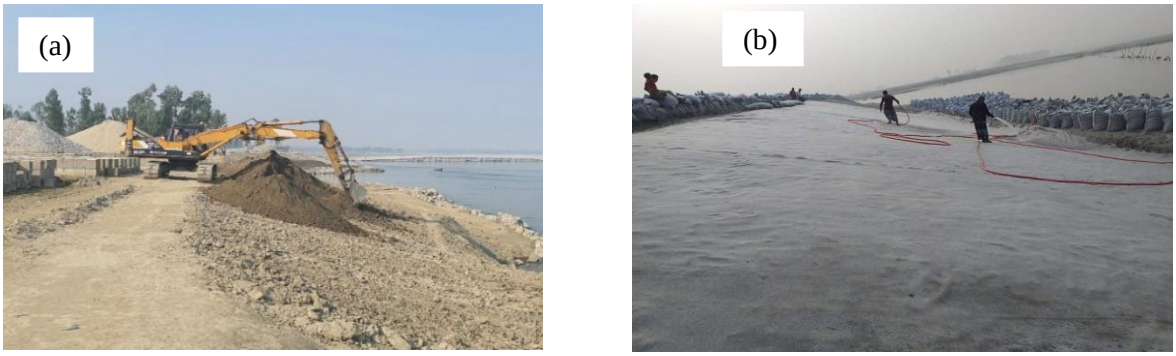

Figure 5: (a) Sloping procedure and (b) Geo-filter cloth for dumping of geo-bag

Figure 6: Dumping of geo-bags

2.2.2 Measurement of Reduced Level (RL) data and Reconnaissance survey

In this study, RL was measured at the section Ch 39+850 km and Ch 40+050 km (Figure 2). The RL of the water surface was taken at those sections before geo-bag dumping (after 15th March, 2020) and after geo-bag dumping (after December 15th ,2020). Figure 7 shows the procedure of taking RL value which was taken after 15th December, 2020. Moreover, reconnaissance survey was also conducted for getting overview about the morphological change of the river.

Figure 7: Measurement of RL from the study area

3. RESULTS AND DISCUSSION

3.1 Change in Reduced Level (RL)

When river bank erosion started at Mogalbasha union, geo-bags were dumped 60 nos. per meter in lunching apron maintaining a slope of 1: 2.5 (geo-textile filter cloth was used below geo-bags on slope). The river

bank erosion in the right bank of the river was reduced after dumping the geo-bags. Dumping of geo-bags worked as an emergency bank protection work.

Table 1 and Table 2 shows the change in RL value at the sections Ch 39+850 km and Ch 40+050 km due to dumping of geo-bags. In the both tables, 1st column represents the distance along the cross-section of the river, 2nd and 3rd column represents the value of RL before and after dumping of geo-bags. In Table 1, at Ch 39+850 km, before dumping of geo-bags water level was at a distance of 27.69m and the RL value of that point was 22.41m. After dumping of geo-bags water level was found at a distance of 28.60m and the RL value of that point was 20.00m. From the distance 0 to 44.94m the RL value was lowered at post-work. The RL value was started rising from the distance 48.30m up to 66.68m. This increase in RL value indicated that there was a development of 'char' due to dumping of geo-bags. Before dumping of geo-bags the river depth was found 9.55m and after dumping of geo-bags the depth was found 10.4m. In Table 2, at Ch 40+050 km, before dumping of geo-bags water level was at a distance of 27.69m and the RL of that point was 21.63m. After dumping of geo-bags water level was found at a distance of 28.60m and the RL of that point was 19.22m. From the distance 0 to 40.06m the RL value was lowered at post-work. The RL value was started rising from the distance 44.94m up to 66.68m. This increase in RL value indicated that there was a development of 'char' due to dumping of geo-bags. Here, river depth was found 9.7m at pre-work and 9.95m at post-work. Figures 8 and 9 are the graphical representation of the RL values which are stated in table 1 and table 2. In Figure 8, the distance 0 to 10m indicates ground level and the RL value was 28.45m. Due to dumping of geo-bags the RL value was lowered adjacent to the right bank and from 48.30m the RL value was started rising. Highest 'char' was developed at the distance of 58.18m. The RL value at that point was 21.56m in pre-work and 22.68m in post-work. Therefore, a char of 1.12m was developed at that section. In Figure 9, the distance 0 to 10m indicates the ground level and the RL value was 27.23m. Due to dumping of geo-bags the RL value was lowered adjacent to the right bank and from 44.94m the RL value was started rising. Highest 'char' was developed at the distance of 58.18m. The RL value at that point was 20.78m in pre-work and 21.91m in post-work. Therefore, a char of 1.13m was developed at that section due to dumping of geo-bags. Figure 10 shows the visual presentation of the whole work at the section Ch 39+850km. In figure 10, the oval shaped elements represent geo-bags. The red line indicates surface before dumping of geo-bags and the green line indicates the surface after dumping of geo-bags.

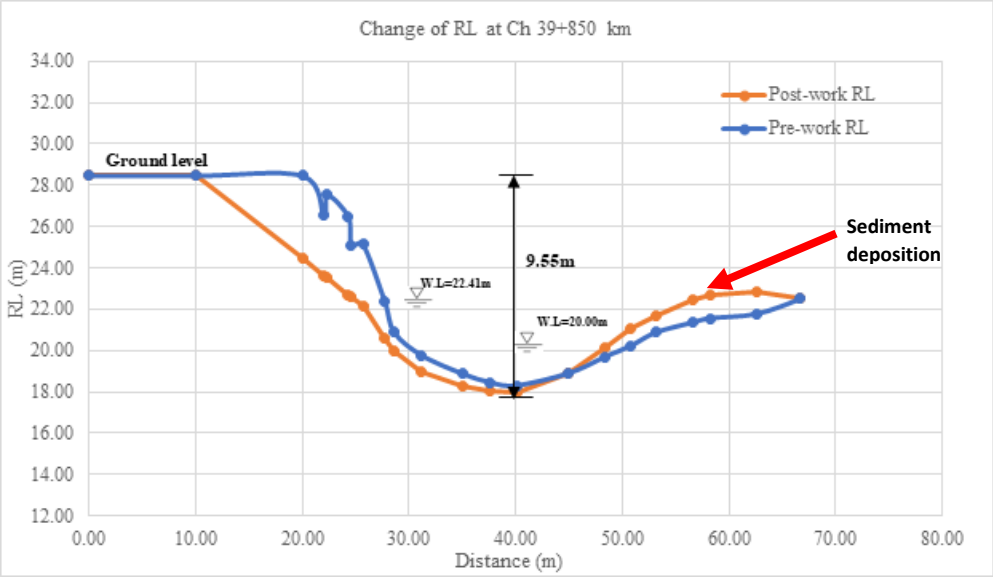

Figure 8: Change of RL due to dumping of geo-bags at the section Ch 39+850 km

Table 1: RL data at Ch 39+850 km

Distance (m)	Pre-work RL (m PWD)	Post-work RL (m PWD)
0.00	28.45	28.45
10.00	28.45	28.45
20.00	28.45	24.45
22.01	26.53	23.63
22.35	27.52	23.5
24.30	26.47	22.72
24.58	25.08	22.59
25.68	25.13	22.17
27.69	**22.41 (WL)**	20.56
28.60	20.88	**20.00 (WL)**
31.16	19.77	19.00
35.00	18.88	18.25
37.63	18.45	18.05
40.06	18.31	18.00
44.94	18.90	18.89
48.30	**19.68**	**20.13**
50.81	**20.24**	**21.03**
53.15	**20.88**	**21.69**
56.59	**21.36**	**22.45**
58.18	**21.56**	**22.68**
62.57	**21.77**	**22.83**
66.68	**22.49**	**22.49**

Table 2: RL data at Ch 40+050 km

Distance (m)	Pre-work RL (m PWD)	Post-work RL (m PWD)
0.00	27.23	27.23
10.00	27.23	27.23
20.00	27.23	23.68
22.01	25.75	22.85
22.35	26.74	22.72
24.30	25.69	21.94
24.58	24.30	21.81
25.68	24.35	21.39
27.69	**21.63 (WL)**	19.78
28.60	20.10	**19.22 (WL)**
31.16	18.99	18.23
35.00	18.10	17.48
37.63	17.67	17.28
40.06	17.53	17.23
44.94	**18.12**	**18.14**
48.30	**18.90**	**19.36**
50.81	**19.46**	**20.26**
53.15	**20.10**	**20.92**
56.59	**20.58**	**21.68**
58.18	**20.78**	**21.91**
62.57	**20.99**	**22.06**
66.68	**21.71**	**21.72**

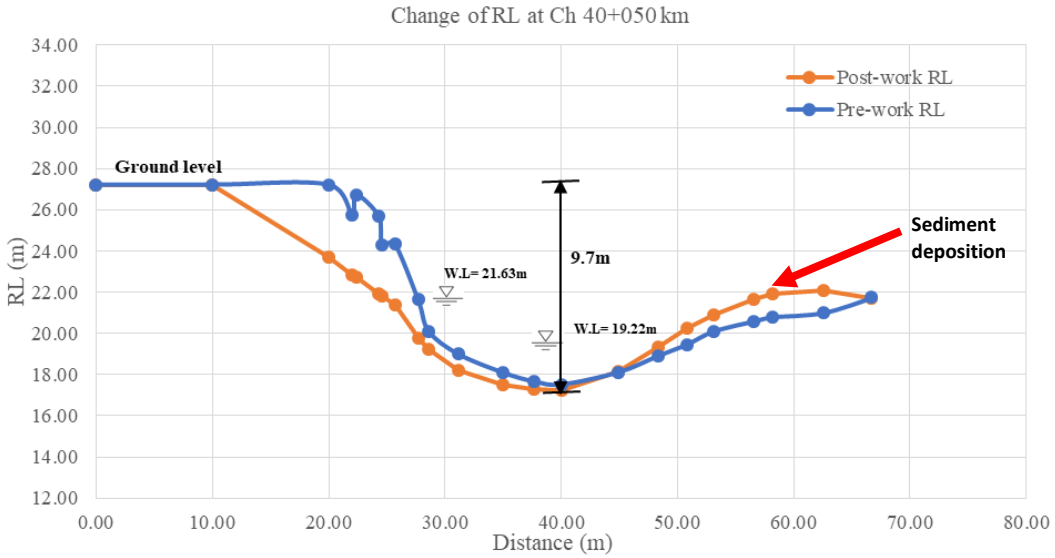

Figure 9: Change of RL due to dumping of geo-bags at the section Ch 40+050 km

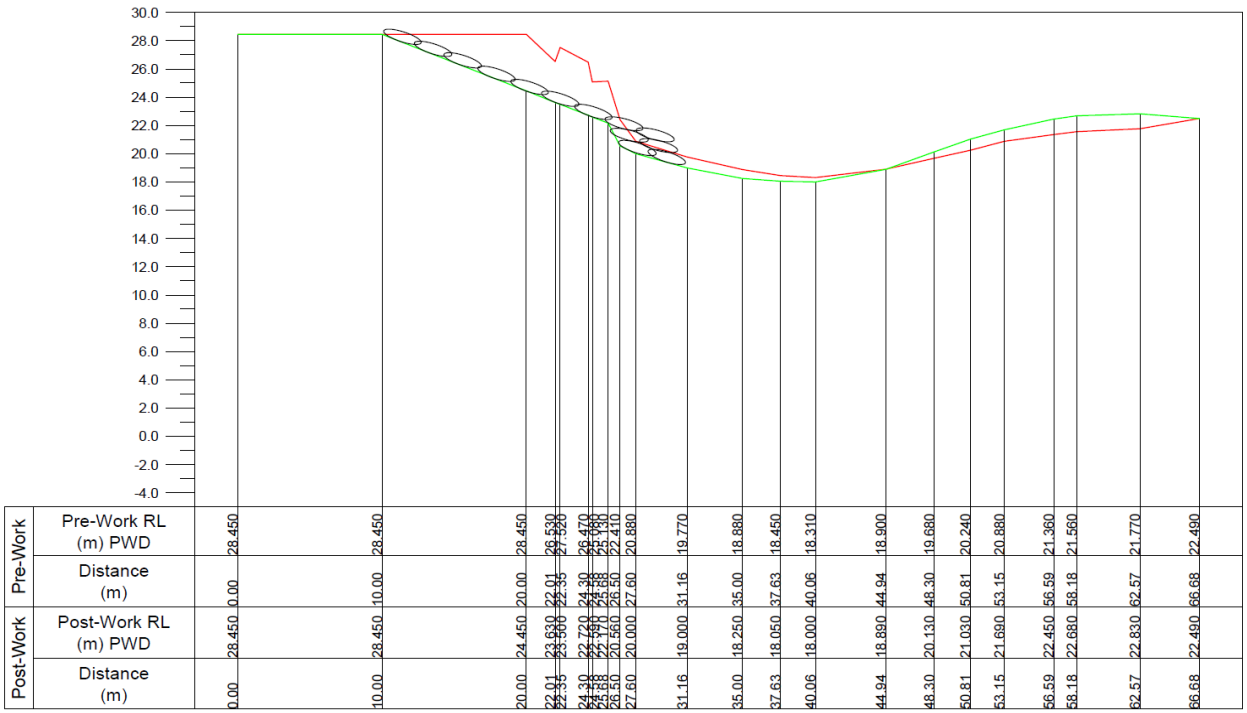

Figure 10: Visual presentation of the work at the section Ch 39+850 km

3.2 Development of new Char and Chute Channel

At the end of December 2020, the water level started lowering and it was noticed that sediment particles were settled down at the middle of the river section due to the effect of geo bag dumping. When the velocity of water dramatically decreased, the sediment particles were settled down. Thus, a new 'Char' was developed which was a first stage of reclaimed land. Figure 11 shows the development of low char. Turning back to Tables 1-2, and Figures 8-9, it was shown that a maximum of 1.12m and 1.13m char was developed. When the char was developed, the flow of water was deviated towards two directions and thus chute channel was formed.

Figure 11: Development of 'low char'

3.3 Change in River Morphology

Due to the development of new char and chute channel, the flow path of river was deviated and a change in the river morphology was noticed. To get a clear sight about the morphological change of the river, satellite images of Dharla river in Mogalbasha union were collected from google earth in the year of 2001, 2014 and 2020. Figures 12, 13 and 14 shows the satellite images of the river in the year of 2001, 2014 and 2020 respectively. In both the three figures, the black line represents pucca road. Apparently, from the Figures 12, 13 and 14, it has been noticed that the river morphology is changing over the years.

Figure 12: Satellite image of Dharla river in Mogalbasha union in the year 2001

Figure 13: Satellite image of Dharla river in Mogalbasha union in the year 2014

Figure 14: Satellite image of Dharla river in Mogalbasha union in the year 2020

3.4 Cost comparison between Geo-bags and CC blocks

Table 3 and Table 4 shows the manufacturing cost of geo-bags and CC blocks including some of their specifications. The coverage area (1.14 m2) 250kg sand filled geo-bags was 7 times higher than the coverage area of largest size (40cm x 40cm x 40cm) CC blocks used on the launching apron of Dharla river at Mogalbasha union and also the volume capacity of geo-bags was 2.6 times higher than largest size CC blocks. The manufacturing cost of largest size CC blocks (40cm x 40cm x 40cm) was 57% higher than the manufacturing cost of 250kg sand filled geo-bags.

Table 3: Manufacturing cost of geo-bags (Source: BWDB)

Weight (Kg)	Volume (m^3)	Coverage Area (mm^2)	Thickness (mm)	Manufacturing Cost (BDT)
250	0.1664	1200 x 950	3.00	358.09

Table 4: Manufacturing cost of CC blocks (Source: BWDB)

Size (cm^3)	Volume (m^3)	Coverage Area (m^2)	Mixing Ratio	Manufacturing Cost (BDT)
40 x 40 x 20	0.032	0.16	1:3:6	436.73
40 x 40 x 40	0.064	0.16	1:3:6	850.05
35 x 35 x 35	0.042875	0.1225	1:3:6	572.11

4. CONCLUSION

According to BWDB design, in Dharla river generally 10 cum/m dumping material is used (when river depth is not greater than 10 m and a slope of 1:2.5) for launching apron. Among them 5 cum/m CC blocks and 5 cum/m geo-bags are used. Since the effectiveness of geo-bags was satisfactory in this research, hence geo-bags can be used instead of that 5 cum/m CC blocks for river bank protection work in Dharla river. For a trial, geo-bags were dumped at a section where the river depth was greater than 10m but the result was not satisfactory. From the above results obtained from this analysis, it can be concluded that at every meandering section of Dharla river, if the river depth remains within 10m, then it will be possible to protect river bank at meandering section of Dharla river within low cost using geo-bags dumping. Land reclamation is possible.

REFERENCES

A. Reza and T. Islam, "Assessment of Fluvial Channel Dynamics of Padma River in Northwestern Bangladesh," vol. 2016, no. 2, pp. 41-49, 2016.

A. Akter, M. Crapper, G. Pender, G. Wright, and W.S. Wong, "Modelling the failure modes in geobag revetments," Water. Sci. Technol., vol. 65, no. 3, pp. 418-425, 2012.

Bose, I. and Navera, U. K. (2017). Flood Maps and Bank Shifting of Dharla River in Bangladesh. Journal of Geoscience and Environment Protection, 5, 109-122.

Das, U. K. (2016). A Case Study on Performance of Jia Bharali River Bank Protection Measure Using Geotextile Bags. Int. J. of Geosynth. And Ground Eng. (2016) 2:12 DOI 10.1007/s40891-016-0052-8.

G. Li, Y. Chen, and X. Tang, "Geosynthetics in Civil and Environmental Geosynthetics in Civil and Environmental Engineering." 2008.

Hossain, M. M. and Hasan, M. Z. (2016). Performance Comparison between Geo-Bag and Cement Concrete block in River Bank Protection Works. International Journal of Engineering Technology, Management and Applied Sciences, Vol. 4, Issue 12, ISSN 2349-4476.

M. S. Wahed, M. S. Sadik, and S. M. Muhit, "Environmental Impacts of Using Sand Filled Geo-Bag Technology Under Water In River Erosion Protection of Major Rivers in Bangladesh," in International Conference on Environmental Technology and Construction Engineering for Sustainable Development ICETCESD-2011, 2011.

R. Korkut, E. J. Martinez, R. Morales, R. Ettema, and B. Barkdoll, "Geobag Performance as Scour Countermeasure for Bridge Abutments," Journal of Hydraulic Engineering, vol.133, no. April. pp. 431-439, 2007.