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IMPACT ASSESSMENT OF KHAN JAHAN ALI BRIDGE ON RUPSHA RIVER

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ABSTRACT

In this study, the impact of the Khan Jahan Ali Bridge (in Khulna, Bangladesh) on the Rupsha River was assessed. The amount of flow path of the river occupied by the bridge pier was calculated about 15.75%. Since the River is a tidal river, the flow is unsteady for which discharge is changed frequently. To calculate the discharge of this river, the river flow velocity data (current meter readings) was collected at a certain date (November 19, 2013) from Bangladesh Water Development Board (BWDB), Khulna. From this data, the river discharge was calculated as 4047 m3/s using area velocity method. To assess the impact of the bridge on the river geometry, the cross section of the river at 2km and 7km upstream of the bridge was collected from BWDB, Dhaka and the data of water level (1978-2013) were collected at 7km upstream of the bridge from BWDB, Khulna. It was observed that from 2003 the maximum water level was rising and the minimum water level initially increased and thereafter decreased (2009-2013) after the construction of the bridge (2004-2008). It was seen that at 2km u/s of the bridge, scouring has occurred at the right bank and deposition was occurred at the left bank from the very beginning of the construction of the bridge. On the other hand, at 7km u/s of the bridge, scouring has occurred at both banks from the very beginning of the construction of the bridge and then the river bed level was increased for both banks.

Keywords: *Khan Jahan Ali Bridge, Rupsha River, river discharge, river geometry, water level*

1. INTRODUCTION

Bangladesh is located in a delta region facing the Bay of Bengal in South Asia and its territory is divided by many rivers. The Rupsa River is a major river in southwestern Bangladesh and a distributary of the Ganges. Its entire length is affected by tides. It flows by the side of Khulna and connects to the Bay of Bengal through the Pasur River at Mongla channel. Khan Jahan Ali Bridge was constructed over the river Rupsha at Labonchara in the Khulna city. It is also known as the Rupsha Bridge. The Port of Mongla, the second biggest port in Bangladesh in terms of cargo handling tonnage, is located approximately 40km south from the largest city in the southwest region Khulna.

At the beginning of the 2000s, a ferry service was used for river crossing at the Rupsha River and this was a major factor in preventing the smooth flow of traffic to the port. As a bridge over the Rupsha River would enable land transport from the Capital city Dhaka to Mongla Port via the Jamuna Bridge and the Paksey Bridge, it was expected that this would improve the convenience of the port. This is the background to the plan for a bridge over the Rupsha River.

The purpose of bridge construction is to ensure and facilitate the communication over the flow of waterways conveniently. The construction of bridge may require placement of bridge piers in the channel or floodplain of natural waterways. However, these structures have detrimental effects on the hydrology and morphology of the adjacent area of the streams as the waterway is constricted. Piers will obstruct the flow and cause an increase in water levels upstream of the bridge (Biswas, 2010). A significant amount of waterways is occupied by bridge pier in the Rupsha River. In this study, impact assessment of the Khan Jahan Ali Bridge on the Rupsha River was investigated.

2. METHODOLOGY

The main concern of this study is to analyze the effect of bridge on stream flow, water level and channel geometry. To accomplish the objectives of this study, the water level data and cross section data at two points of upstream of the bridge were collected. The river discharge was measured by area velocity method. The collected data was then analyzed and from the output of the analysis the effects of the bridge on river water level and geometry were obtained. The steps in this study are shown in below:

- Selection of study area.
- Collection of historical data.
- Data analysis.
- Comparison of conditions before and after construction of the bridge.
- Conclusion.

2.1 Study Area

The Rupsha-Pasur River System (RS) is one of the biggest and important river systems in the Sundarbans estuarine ecosystem. It is the largest fresh water supplier into this mangrove forest. In Khulna of Bangladesh, the Rupsha-Bhairab is a major tidal river system flowing on the east of the city. Khan Jahan Ali Bridge was constructed over the river Rupsha at Labonchara. The study area covers the river flow from 7 km upstream to the Khan Jahan Ali Bridge.

The construction was started on 30 May 2001 and inaugurated on the 21st May 2005. The Length of the bridge is 1,360m while the width is 16.65m. At bridge section the river width is 476 m. The bridge has 7 spans on 8 piers and 5 piers are on the river with 15m width of each pier. About 15.75% flow-path is occupied by bridge pier. There are special security measures in the 8 piers of the bridge. According to the Project manager, the piers are well fortified to prevent any errant watercraft to hit the piers. This is the first protection system installation in any bridge in the country. Seismic prevention has also been set in the bridge which is 80m above the sea level. The vast infrastructure of the bridge is built on the concrete beneath 70m to 72m in the 50ft. deep the Rupsha River (Kobayashi, 2011). Figure 1 shows the satellite view of the Khan Jahan Ali Bridge and Figure 2 shows the basement of Bridge pier.

Figure 1: Satellite view of the Khan Jahan Ali Bridge

Figure 2: Basement of Bridge pier

2.2 Data Collection

To accomplish this study water level, velocity and cross-section data of the Rupsha River were collected. Data were collected from Bangladesh Water Development Board (BWDB), Khulna and Dhaka. Water level and current meter data were collected for the Station 241 (Station Name: Rupsha-Pasur), which is situated about 7 km upstream from the bridge. The water level data were collected from BWDB, Khulna. The data length varied from 1978 to 2013 i.e. 35 years. The cross-section data at 2 km & 7 km u/s of the bridge for the year 1995, 2002, 2006 and 2009 were collected from BWDB, Dhaka. Current meter readings on 19.11.2013 at Station 241 were collected from BWDB, Khulna. Table 1 shows the information for the collected data types. The value of water level data represents how much the river is lower or upper with respect to sea level. The maximum water level data are collected generally in the month of August to November and the minimum water level data are collected from January to April.

Table 1: List of collected data

Data Type	Data Period	Data Length	Location
Maximum &Minimum Water Level	1978-1995 & 2010-2013	19 years	Station 241
Daily Water Level	1995-2010	16 years	
Cross-Section (two points)	May 1995	8 nos.	2 km & 7 km u/s of the bridge
	May 2002		
	April 2006		
	January 2009		
Current meter readings	19.11.2013	1	Station 241

3. DATA ANALYSIS

3.1 Water Level Comparison

The maximum and minimum water level data for the Station 241 are calculated. Table 2 shows the maximum and minimum Water Level at 7 km upstream of the Rupsha bridge (Station ID-241).

Table 2: Maximum and minimum water level at u/s of the Rupsha Bridge (Station No. 241)

	Maximum Water Level		Minimum Water Level	
Year	**Date**	**Value (m PWD)**	**Date**	**Value (m PWD)**
1978	September	2.72	March	-0.64
1979	August	2.76	February	-0.62
1980	August	2.76	March	-0.65
1981	August	2.79	March	-0.64
1982	September	2.79	March	-0.67
1983	September	2.92	February	-0.65
1984	August	3.28	February	-0.59
1985	August	3.00	April	-0.92
1986	August	2.94	February	-0.72
1987	8-9-1987	3.12	2-3-1987	-0.73
1988	28-8-1988	3.41	19-3-1988	-0.59
1989	17-9-89	2.90	9-2-1989	-0.45
1990	22-8-90	3.15	12-3-1990	-0.59
1991	12-9-1991	3.15	18-3-1991	-0.74
1992	30-8-1992	3.10	20-2-1992	-0.72
1993	18-9-1993	3.25	9-3-1993	-0.72
1994	23-8-1994	3.22	27-4-1994	-0.67
1995	28-8-1995	3.15	18-3-1995	-0.73
1996	31-8-1996	3.25	22-1-1996	-0.82
1997	19-8-1997	3.21	10-3-1997	-0.76
1998	7-9-1998	3.46	31-1-1998	-0.75
1999	14-7-1999	3.44	19-7-1999	-0.62
2000	2-8-2000	3.26	21-3-2000	-1.47
2001	18-9-2001	3.24	10-3-2001	-0.71
2002	13-8-2002	3.27	27-3-2002	-0.70
2003	8-10-2003	3.98	21-3-2003	-0.69
2004	19-9-2004	3.34	1-3-2004	-0.15
2005	28-6-2005	3.74	6-2-2005	-0.01
2006	12-6-2006	3.19	1-3-2006	-0.04
2007	20-6-2007	3.55	27-4-2007	-0.07
2008	19-9-2008	3.22	21-2-2008	-0.08
2009	25-8-2009	3.2	20-3-2009	-0.47
2010	7-11-2010	4.14	2-3-2010	-1.23
2011	25-11-2011	3.92	20-2-2011	-1.20
2012	18-9-2012	3.42	11-3-2012	-1.12
2013	22-8-2013	3.75	29-3-2013	-0.96

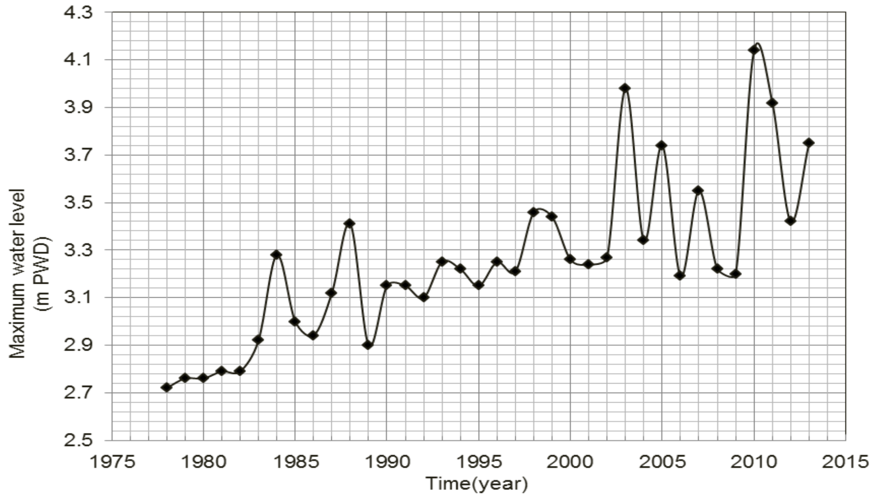

Figure 3: Maximum water level (m PWD) variation with respect to time (year)

Figures 3 and 4 show the maximum and minimum water level (m PWD) variation respectively for the station-241 (near to bridge). The construction of the bridge was started in 2001 and finished in 2005. It is observed from the Figure 3 that from 2003 the water level is rising than the previous time. From the Figure 4, it is seen that the minimum water level initially has increased after the construction of the bridge (2004-2008) and thereafter decreased (2009-2013).

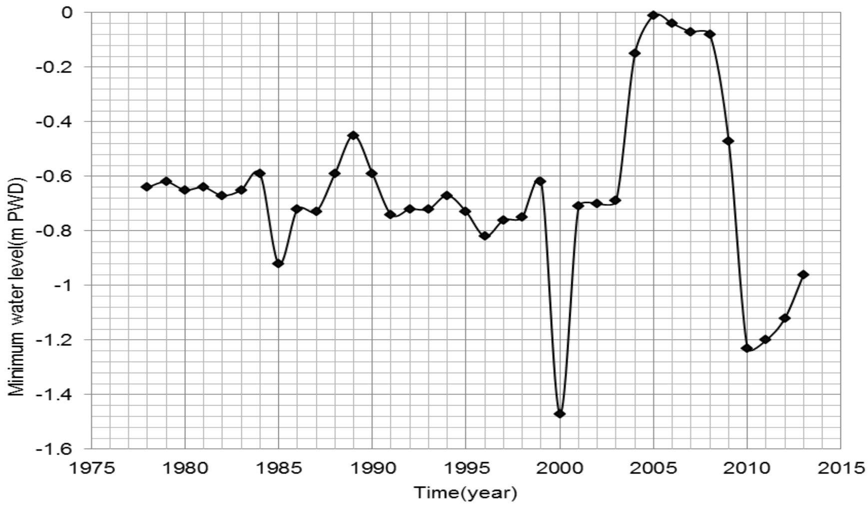

Figure 4: Minimum water level (m PWD) variation with respect to time (year)

3.2 Discharge of Rupsha River at U/S of the Khan Jahan Ali Bridge

Table 3: Discharge calculation by area velocity method (November 19, 2013)

Vertical	Distance from left edge (m)	Average Width (m)	Depth d (m)	Current meter reading N (Rev/sec)	Velocity V (m/s)	Segmental Discharge ΔQ (m^3/sec)
I	0	9.40	0			0
	4.70	9.40	2.19	0.34	0.09	2.00
	10.85	9.40	7.68	1.20	0.32	23.66
	13.20	9.40	7.41	1.16	0.31	22.04
	24.74	9.40	7.68	1.20	0.32	23.66
	37.28	9.40	7.93	1.24	0.33	25.22
	41.61	9.40	8.23	1.29	0.35	27.15
	47.08	9.40	8.93	1.40	0.38	31.92
	50.24	9.40	9.30	1.45	0.39	34.60
	55.57	9.40	10.21	1.60	0.43	41.66
	65.00	9.40	10.52	1.64	0.44	44.21
	70.15	9.40	10.97	1.71	0.46	48.05
	77.36	9.40	11.13	1.74	0.47	49.45
	80.36	9.40	12.01	1.88	0.51	57.54
	87.20	9.40	11.68	1.83	0.49	54.43
	92.54	9.40	11.13	1.74	0.47	49.45
	101.15	9.40	11.77	1.84	0.49	55.27
	106.42	9.40	12.80	2.00	0.54	65.31
	108.77	9.40	12.90	2.02	0.54	66.33
	120.08	9.40	13.47	2.11	0.57	72.30
	122.40	9.40	13.96	2.18	0.59	77.63
II	128.56	9.40	13.75	2.15	0.58	75.32
	136.45	9.40	14.48	4.86	1.11	151.37
	142.94	9.40	14.39	4.83	1.10	149.51
	150.78	9.40	14.64	4.92	1.12	154.72
	156.25	9.40	14.54	4.88	1.11	152.62
	165.31	9.40	14.78	4.96	1.13	157.68
	172.32	9.40	15.18	5.10	1.16	166.28
	178.48	9.40	15.85	5.32	1.21	181.20
	183.03	9.40	15.00	5.04	1.15	162.38
	191.53	9.40	14.70	4.94	1.12	155.98
	199.47	9.40	14.91	5.01	1.14	160.45
	206.01	9.40	15.09	5.07	1.15	164.32
	213.77	9.40	15.33	5.15	1.17	169.56
	232.99	9.40	15.58	5.23	1.19	175.11
	245.28	9.40	16.19	5.44	1.24	189.01
III	252.83	9.40	15.55	2.39	0.64	94.44
	262.92	9.40	15.55	2.39	0.64	94.44
	270.62	9.40	15.55	2.39	0.64	94.44
	282.78	9.40	15.03	2.31	0.62	88.26
	294.42	9.40	14.72	2.26	0.61	84.67
	304.35	9.40	14.85	2.28	0.61	86.16
	309.80	9.40	15.09	2.32	0.62	88.96
	322.14	9.40	14.33	2.20	0.59	80.26
	335.60	9.40	13.11	2.01	0.54	67.23
	348.41	9.40	7.47	1.14	0.31	21.98
	358.96	9.40	3.60	0.55	0.15	5.20
	373.90	9.40	1.98	0.30	0.08	2.99
	395.32	9.40	0			0
					Total=	4046.70 m^3/sec

In the tidal river like Rupsha, the authority (BWDB) does not measure the river discharge regularly. To calculate the discharge of this river, the river flow velocity data (current meter readings) is collected at a certain date (November 19, 2013). From this data, the river discharge is calculated using area velocity method as 4047 m^3/s. Table 3 shows the discharge calculation by area velocity method (Subramanya, 2013). To calculate the velocity along verticals, following calibration equations are used. The equation 1, 2 and 3 are formulated by the authority (BWDB).

$$Vertical-I : V = 0.26257N + 0.01707 m/\sec \quad (1)$$
$$Vertical-II : V = 0.22600N + 0.01251 m/\sec \quad (2)$$
$$Vertical-III : V = 0.26805N + 0.00532 m/\sec \quad (3)$$

3.3 Change in River Cross-Section

The river cross-section data at two points (2 and 7 km u/s of the Rupsha Bridge) were collected for four different times i.e. at May 1995, May 2002, April 2006 and January 2009. From this data, cross-sections of the river were plotted.

Cross-section at 2km u/s of the bridge:
Figures 5 to 8 show the cross-sections which were taken 2km apart from u/s of the bridge in May 1995, May 2002, April 2006 and January 2009 respectively. The alignment of the river is almost straight at 2 km and 7km u/s of the bridge. It is seen from the Figures 5 and 6 that the depth is increased at right bank, whereas decreased at left bank. It clearly indicates that the scouring is occurred at the right bank and deposition is occurred at the left bank from very beginning of the construction of the bridge.

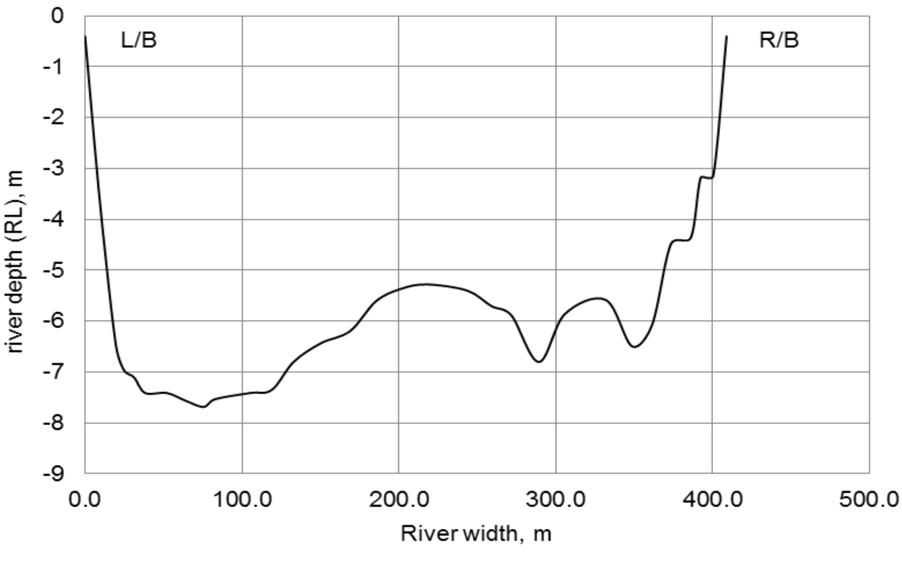

Figure 5: Cross-section at 2 km u/s from the bridge (at May, 1995)

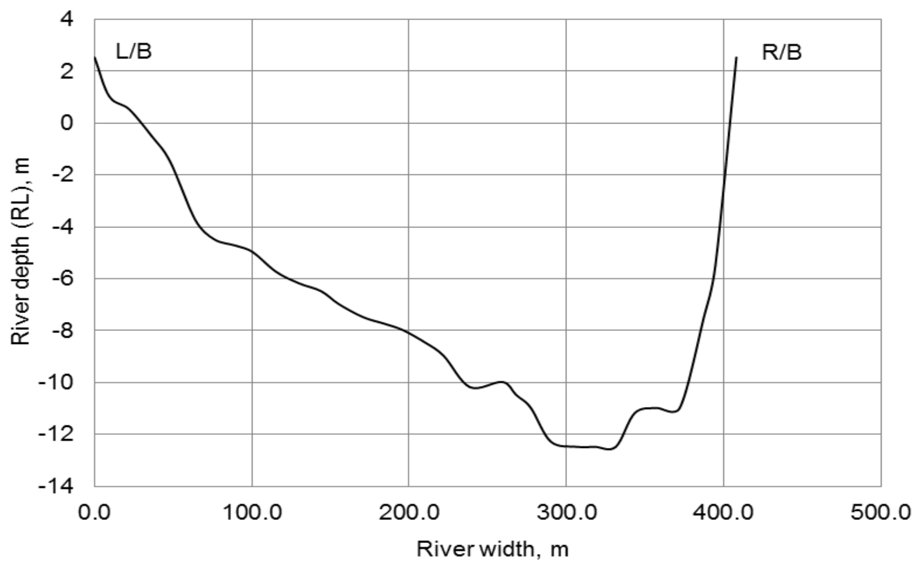

Figure 6: Cross-section at 2 km u/s from the bridge (at May, 2002)

Figures 7 and 8 show the cross-sections of the river which were taken at 2km u/s of the bridge and those were after completion of the bridge construction. It is seen that the left bank is slightly eroded after the construction but the right bank remain almost same. Hence, it is concluded that the river cross section has been changed due to the construction of the bridge at 2km u/s of the bridge.

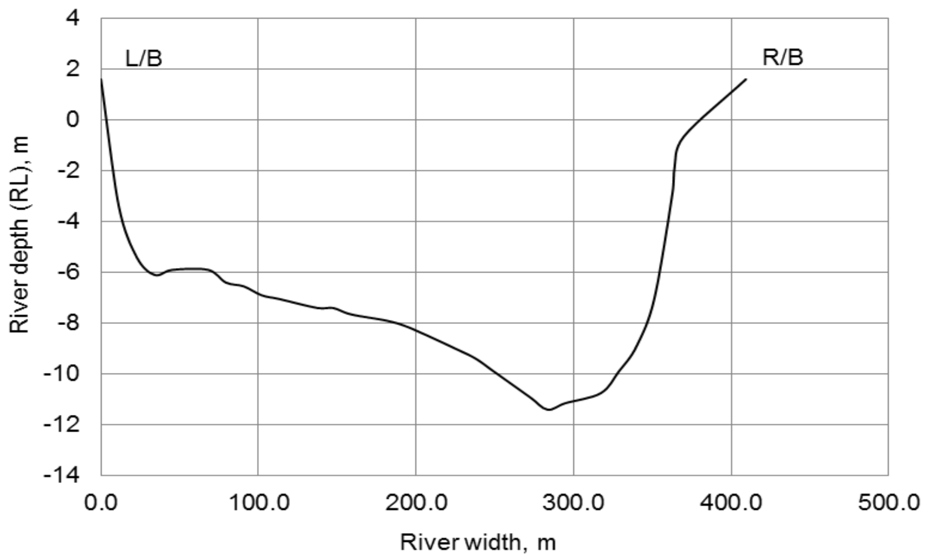

Figure 7: Cross-section at 2 km u/s from the bridge (at April, 2006)

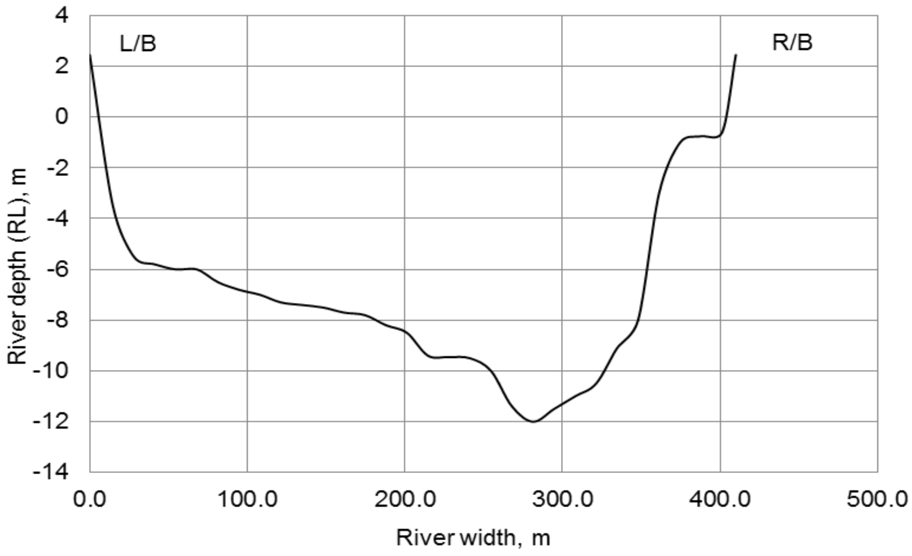

Figure 8: Cross-section at 2 km u/s from the bridge (at January, 2009)

Cross-section at 7km u/s of the bridge:

Figures 9 to 12 show the cross-sections at 7km u/s of the bridge in May 1995, May 2002, April 2006 and January 2009, respectively. It is seen from the Figure 9 and 10 that the depths are increased at both banks in which increasing rate is higher for the left bank. It clearly indicates that the scouring is occurred at both banks from very beginning of the construction of the bridge.

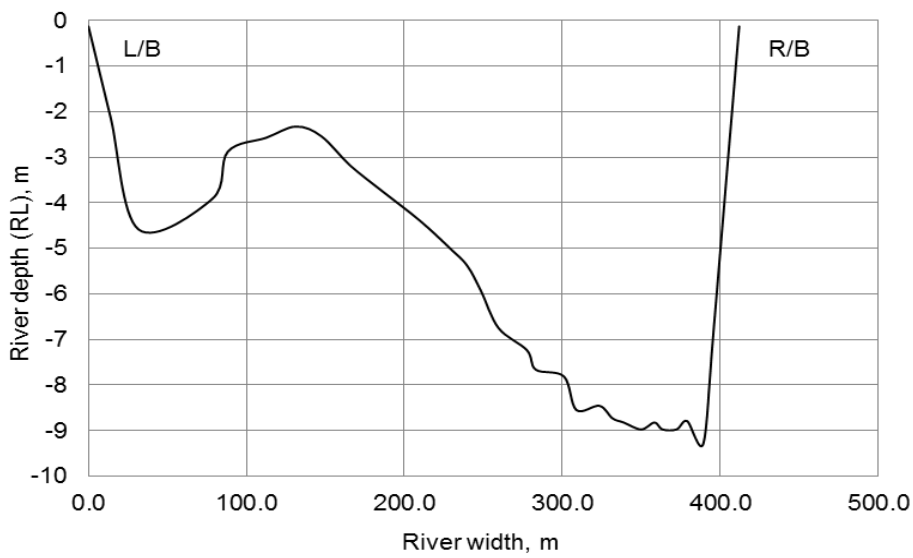

Figure 9: Cross-section at 7 km u/s from the bridge (at May, 1995)

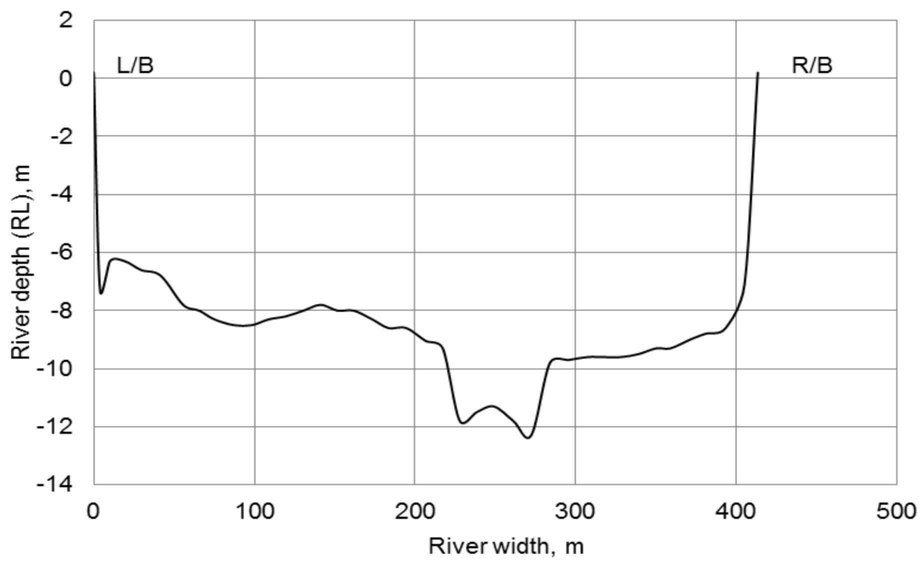

Figure 10: Cross-section at 7 km u/s from the bridge (at May, 2002)

Figures 11 and 12 show the cross-section of the river at 7km u/s of the bridge after completion of the bridge. It is seen that the river bed level increases for both banks in which increasing rate is higher at the right bank that clearly indicates that deposition has been happened. Hence, it is concluded that the river cross section has been changed due to the construction of the bridge at 7km u/s of the bridge.

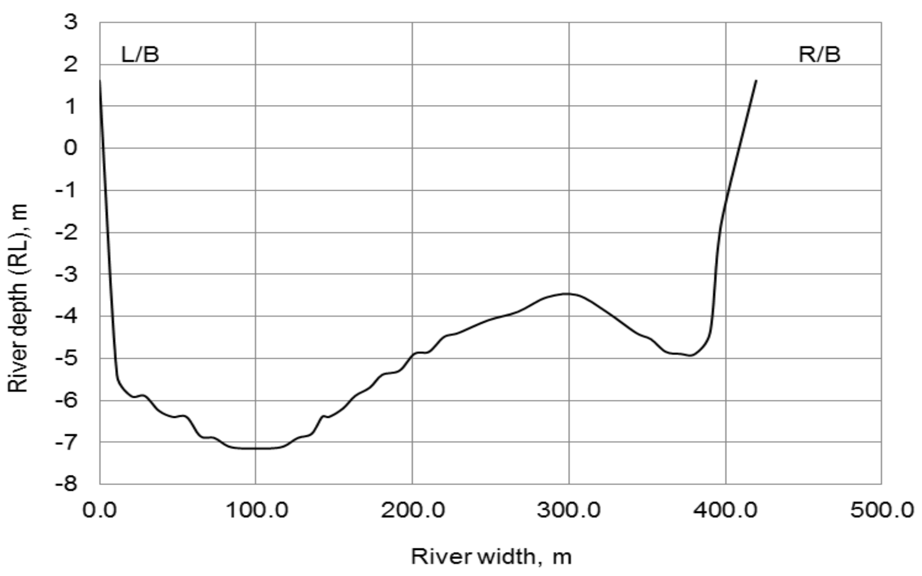

Figure 11: Cross-section at 7 km u/s from the bridge (at April, 2006)

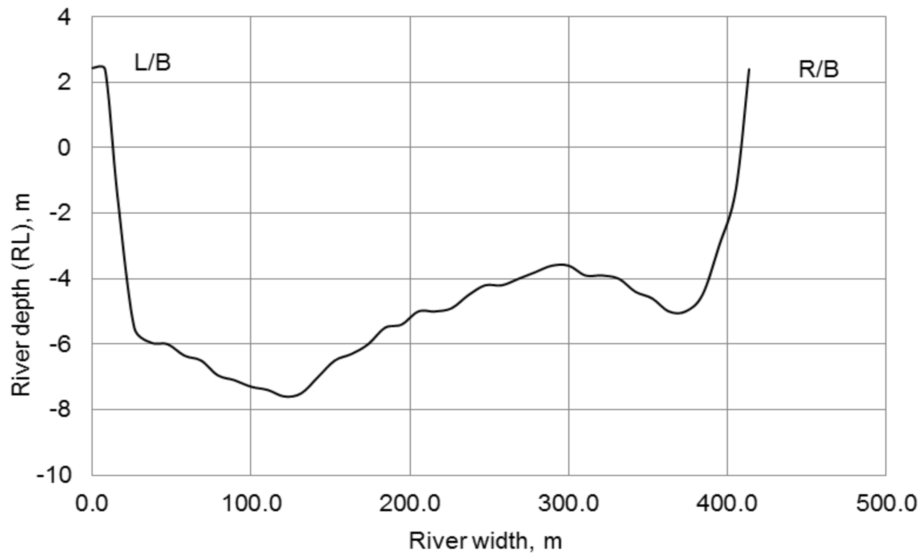

Figure 12: Cross-section at 7 km u/s from the bridge (at January, 2009)

4. CONCLUSIONS

The main purpose of this study was to assess the impact of the Khan Jahan Ali Bridge on water level, stream flow and channel geometry of the Rupsha River. It was calculated that about 15.75% flow path was obstructed by bridge pier. It was observed that from 2003 the maximum water level was rising than the previous time and the minimum water level initially increased after the construction of the bridge and then decreased. It was seen that near the bridge, the scouring was occurred at the right bank and deposition was occurred at the left bank from very beginning of the construction of the bridge. On the other hand, at far distance from the bridge, the scouring was occurred at both banks from very beginning of the construction of the bridge. It is concluded that the water level both minimum and maximum is rising as well as the river geometry is also changed after the construction of the bridge.

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