# GOVERNMENT OF BANGLADESH
## FLOOD PLAN COORDINATION ORGANIZATION

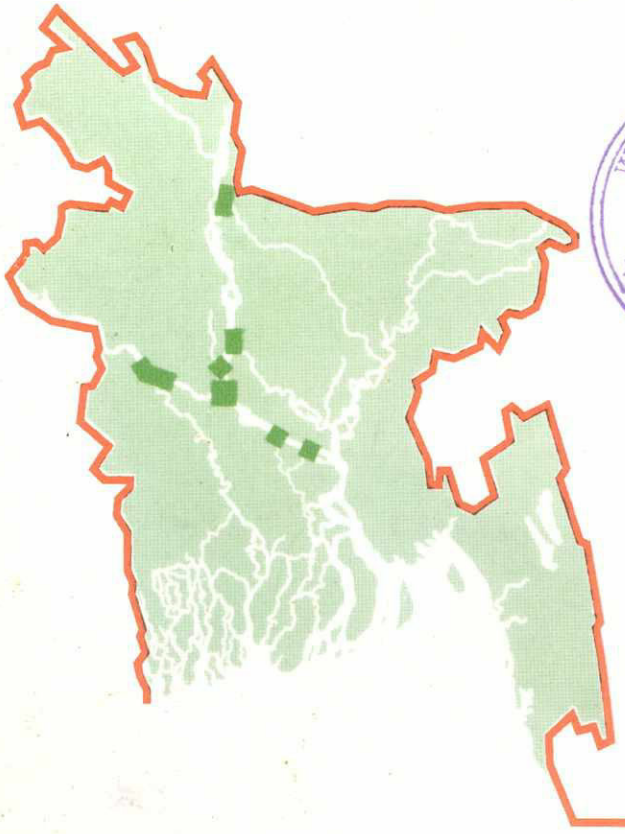
# FAP 24 RIVER SURVEY PROJECT



**SURVEY REPORT 7**

**Transfer of bench-marks levels across Jamuna River at Bahadurabad**





DELFT HYDRAULICS
DANISH HYDRAULIC INSTITUTE
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Project ALA/90/04 — Commission of the European Communities

# SURVEY REPORT 7

## Transfer of bench-marks levels across Jamuna River at Bahadurabad



December 1993



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**FAP 24 RIVER SURVEY PROJECT**

**Flood Plan Coordination Organization**

**DELFT-DHI** **Commission of the European Communities**

House No. 96,
Road No. 23,
Banani, Dhaka
Tel : 600002, 603175
Fax: 88-02-883568

December 23, 1993

Chief Engineer
Flood Plan Coordination Organization (FPCO)
7 Green Road, Dhaka.

Attention : Mr. Afzalur Rahman.
Superintending Engineer.

Subject : Survey Report 7

Our ref : RSP/9.1/703

Dear Sir,

One year ago the River Survey Project established a temporary network of bench-marks on the main char in the Jamuna River between Bahadurabad and Fulcharighat. The bench-mark heights were determined by levelling from the left bank over the char to the right bank. Since then the bench-marks are used in our survey work in the area, amongst others in water slope gauging.

Obviously the levelling results allow a check on the differences between the reference levels of the existing networks on the left bank and the right bank. As this subject is still actual, it was decided to summarize the levelling results in this report.

Thanking you.

Yours sincerely

Pieter van Groen
Team Leader

## Contents

## 1. Introduction

On the Brahmaputra/Jamuna River near Bahadurabad important survey work is to be done by the River Survey Project FAP 24. This work includes both routine measurements as well as special surveys to support certain study topics. An example is establishment of temporary staff gauges for reduction of soundings during bathymetric surveying and for measurements of water level slopes.

For these various survey tasks an accurate vertical control needs to be established in the area. This is realized by constructing a set of temporary bench-marks (TBMs) and by determining accurately their levels, which is done by levelling between the TBM's and the existing (reference) bench-marks with known levels on each side of the river. For the location of the bench-marks see Figure 1.

In between these existing bench-marks located at the left and right bank of the river respectively and supplemented with a number of TBMs in between on the central island a levelling across the complete river was carried out. Another objective to do this was also to check any differences in levels between the networks on the left bank and the right bank of the river.

The levelling across the river was done in the low water (LW) period (December 1992) when limited channel width occurs. Three methods of transferring levels across each river channel were carried out.

- Trigonometric levelling
- Hydrostatic levelling
- Levelling by GPS

## 2. Reference bench-marks used for levelling

### 2.1 Bahadurabad site

On the left bank, Finnmap BM 5244 is located at Bahadurabad ghat. This bench-mark has been used as a reference for transferring the reference level from the main land on the east side of Jamuna River to the char areas located north-west of Bahadurabad ghat.

The level of Finnmap BM 5244 has been obtained as 19.8569 meter PWD.

### 2.2 Fulcharighat site

Two temporary bench-marks were established on the right bank of Jamuna River at Fulcharighat by FAP 24 in December, 1992. Out of these two TBMs, one is located on the plinth of T&T office and the other on the plinth of Thana Parishad Office.

The elevations of these two TBMs have been determined by second order levelling from the GPS 7 bench-mark.
The elevation of the bench-mark GPS 7, which is located within the premises of the Dak-bungalow at Gaibandha, is 21.97m PWD

Levels of the two TBMs have been measured to be:

- o TBM on the plinth of T&T office : 20.521 m PWD
- o TBM on the plinth of Thana Parishad Office : 20.660 m PWD

For transferring the levels from the right bank to the char areas east of Fulcharighat the TBM located on Thana Parishad office at Fulcharighat has been used and thus GPS 7 ( Finnmap) has been used as the reference bench-mark for the main land west of Jamuna River.

When connecting the two TBMs of FAP 24 to the bench-mark Finnmap BM 5244 a discrepancy of 0.2 m was discovered. This corresponds rather good with the discrepancy found in water-levels as described in Chapter 5.

## 3. Levelling equipment and methods used

### 3.1 General

Under FAP 24 River Survey Project, all levelling works related to checking of zero values of BWDB gauges, establishment of new BMs/TBMs as well as levelling of land cross-sections over chars (as extension of bathymetric cross-sections) are required to be carried out by second order levelling.

In order to perform these works and also to obtain the specified accuracy of levelling, the following types of equipment were used:

a) Topcon Auto-level AT - G3
b) Topcon Electronic Total Station GTS - 303
c) Trimble 4000 SE receiver/dataloggers

Equipment specifications for land levelling can be found in Table 1.

In transferring the levels over the channels three different methods have been applied, as follows:

## 3.2 Trigonometric levelling

An electronic total station was used for transferring of levels by river crossing. (For an exact description of equipment see Table 2).

The vertical angle between the bench-marks on both sides of the river was measured with the theodolite (Total Station). The slope distance between the two bench-marks was also measured.

To avoid refraction errors, observations were taken from both banks and as much as possible simultaneously.

The height diference between the two bench marks was then calculated by using the following formula :

$$\Delta H = Hor.D * Tan (90 - Ver.A) + I. H - P. H.$$

where

| | | |
|---|---|---|
| ΔH | = | height difference between the two bench-marks. |
| Hor.D | = | horizontal distance |
| Ver.A | = | vertical angle |
| I.H | = | instrument height |
| P.H | = | prism height |



## 3.3 Hydrostatic levelling

For hydrostatic levelling, it has to be assumed that the flow is perpendicular to the direction of the levelling so that the water-levels at both banks of the river are nearly the same.

Two staff gauges, one at both banks were installed and connected to the bench-marks located on each bank. Simultaneous gauge readings were taken from the gauges at both banks and their differences were calculated by using the formula as indicated below :

ΔH = DHE + GRE - GRW + DHW

where

| | | |
|---|---|---|
| ΔH | = | Height difference of bench-marks at the two banks |
| DHE | = | height difference of bench-marks and zero of gauge at east bank |
| GRE | = | gauge reading at east bank |
| GRW | = | gauge reading at west bank |
| DHW | = | height difference of bench-marks and zero of gauge at west bank |

### 3.4 Levelling by GPS

For checking the performance of GPS in transferring the height from a known point to an unknown point by simultaneous GPS observations, the following three known points (pionts with know coordinates and heights) were considered :

| | | |
|---|---|---|
| Bahadurabad | : | GPS 764 |
| Bonarpara | : | GPS 765 |
| and Shaghata | : | GPS 779 |

For the discription of equipment see Table 3.

Moreover, an unknown point was selected in the mid char located between Bahadurabad and Fulcharighat and static observations were taken, extending over an hour at each station.

## 4. Establishment of additional Temporary Bench-Marks (TBM)

In the middle char area between Bahadurabad and Fulcharighat, 5(five) nos. of TBMs have been established.

Details of these TBMs are as follows :

- TBM01 - G.I pipe embedded and located in the village Char Parulia
- TBM02 - G.I pipe embedded and located in the village Char Burul
- TBM03 - G.I pipe embedded and located in the village Uttar Khatiamari
- TBM04 - Located on the plinth of Angaridah Primary School
- TBM05 - G.I pipe embedded and located in the village Char Kristomoni.

Approximate location of TBMs have been shown in Figure 1

## 5. Measurement Results

### 5.1 Accuracies

Under FAP 24 River Survey Project it is specified that all levelling works are to be executed by second order levelling, which means that the maximum acceptable error shall be in the order of $\pm$ 5 mm x$\sqrt{k}$, where k is the measured distance in kilometers. During actual levelling all sections were closed.

The measured deviations are noted as follows:

| | | Measure-ment Distance (km) | Acceptable error (mm) | Closing error (mm) |
|---|---|---|---|---|
| (a) | Levelling from right bank<br>From GPS 7 at Gaibandha to TBM 01 in Middle island | 29.5 | ±27.2 | +17.8 |
| (b) | Levelling from left bank<br>From FMBM 5244 to TBM 01 in middle island | 10.30 | ±16.1 | -8.3 |
| (c) | Levelling in middle island<br>For establishment of several TBMs TBM 01, 02, 03, 04 & 05 | 31.3 | ±27.9 | +4.6 |

## 5.2 Difference in water-levels as measured at Bahadurabad and Fulcharighat

Differences in water-levels at left and right bank (considering the zero value of gauges used by BWDB and zero value measured by FAP24) are found as follows:

| | | |
|---|---|---|
| **At Bahadurabad** | | |
| Zero value of gauge on 14.12.92 at 1620 hrs. | as used by BWDB | 13.00m PWD |
| | as measured by FAP 24 | 12.96m PWD |
| Water-level on 14.12.92 at 1620 hrs. | by using zero value of BWDB | 14.34m PWD |
| | by using zero value of FAP 24 | 14.30m PWD |
| **At Fulcharighat** | | |
| Zero value of gauge on 14.12.92 at 1620 hrs. | as used by BWDB | 13.00m PWD |
| | an measured by FAP 24 | 13.63m PWD |
| Water level on 14.12.92 at 1620 hrs. | by using zero value of BWDB | 13.44m PWD |
| | by using zero value of FAP 24 | 14.07m PWD |

## 5.3 Differences in networks at right and left bank

When connecting the Finnmap levelling networks at the right and left bank some discrepancy was discovered.

In connection with establishing a number of gauges and for execution of bathymetric surveying in the left channel of Jamuna River at Bahadurabad, a temporary bench-mark (TBM 01) has been established by FAP 24, at Char Parulia (see Figure 1).

The TBM 01 has been connected by second order levelling from the Finnmap Bench Mark GPS 7 at Gaibandha as well as from Finnmap BM 5244 on the left Bank of Jamuna near Bahadurabad using their respective official levels.

Comparison of the two surveys has given the following results :

| By levelling from : | Value of TBM 01 in m PWD |
|---|---|
| Finnmap BM 5244 (left bank near Bahadurabad) | 20.075 |
| Finnmap BM GPS 7 (right bank at Gaibandha) | 19.784 |
| | Measured difference : 00.291 m |

## 5.4 Tentative choice

The water level slope measurements and the bathymetric pilot surveys take place in the left main channel at Bahadurabad. Therefore as a tentative choice, the River Survey Project has taken FMBM 5244 for their (levelling) work near Bahadurabad. This means for instance that the FAP 24 staff gauges in this area are all referred to the reduced level of 20.075 meter PWD for TBM 01 on Char Parulia as obtained in relation to Finnmap BM 5244.

There shall not be any difficulty on the part of FAP 24 to make necessary correction with retrospective effect as soon as the values are finally resolved in mutual agreement with the Client.

## 5.5 Levels of TBM

The levels/heights measured for the TBMs are :

| Location | TBM No. | Levels/heights in m PWD |
|---|---|---|
| Char Parulia | TBM 01 | 20.075 |
| Char Burul | TBM 02 | 20.778 |
| Uttar Khatiamari | TBM 03 | 20.920 |
| Angaridah Primary School | TBM 04 | 20.334 |
| Choumohoni (Char Kristomoni) | TBM 05 | 21.228 |

## 6. Conclusions

Out of the three methods, the results of levelling obtained by GPS observations and Hydrostatic levelling are found not to be within an acceptable accuracy.

As such, the results of Trigonometric levelling are considered the only method to be taken into account at this moment for transfer of levels.

It is certainly questionable whether hydrostatic levelling is relevant at all in very wide and braided rivers like the Jamuna.

The method of levelling by GPS is in the process of being highly improved and it is therefore recommended to follow closely the future technical development.

It is recommended that the measured differences in reference levels between the right and left river bank respectively should be finally resolved in mutual agreement with the Client including Survey of Bangladesh (SOB).

| Land levelling | | | |
|---|---|---|---|
| Model | Topcon Auto-level AT-G3 | | |
| Specifications | Telescope | Length | 230 mm |
| | | Image | Erect |
| | | Field of view | 1° 30' |
| | | Effective objective diameter | 40 mm |
| | | Resolving power | 3" |
| | | Minimum focus | 0.5 m |
| | | Stadia ratio | 100 |
| | Horizontal circle | Diameter | 117 mm |
| | | Minimum reading | 1° or 1' |
| | Automatic Levelling Mechanism | Setting accuracy | 0.3" |
| | | Compensating range | ± 15' |
| | Accuracy in 1 Km Double Run levelling | Without optical micrometer | 1.5 mm |
| | | With optical micrometer | 1 mm |
| | Weight | Instrument | 1.8 Kgs |
| | | Plastic carrying case | 1.3 Kgs |

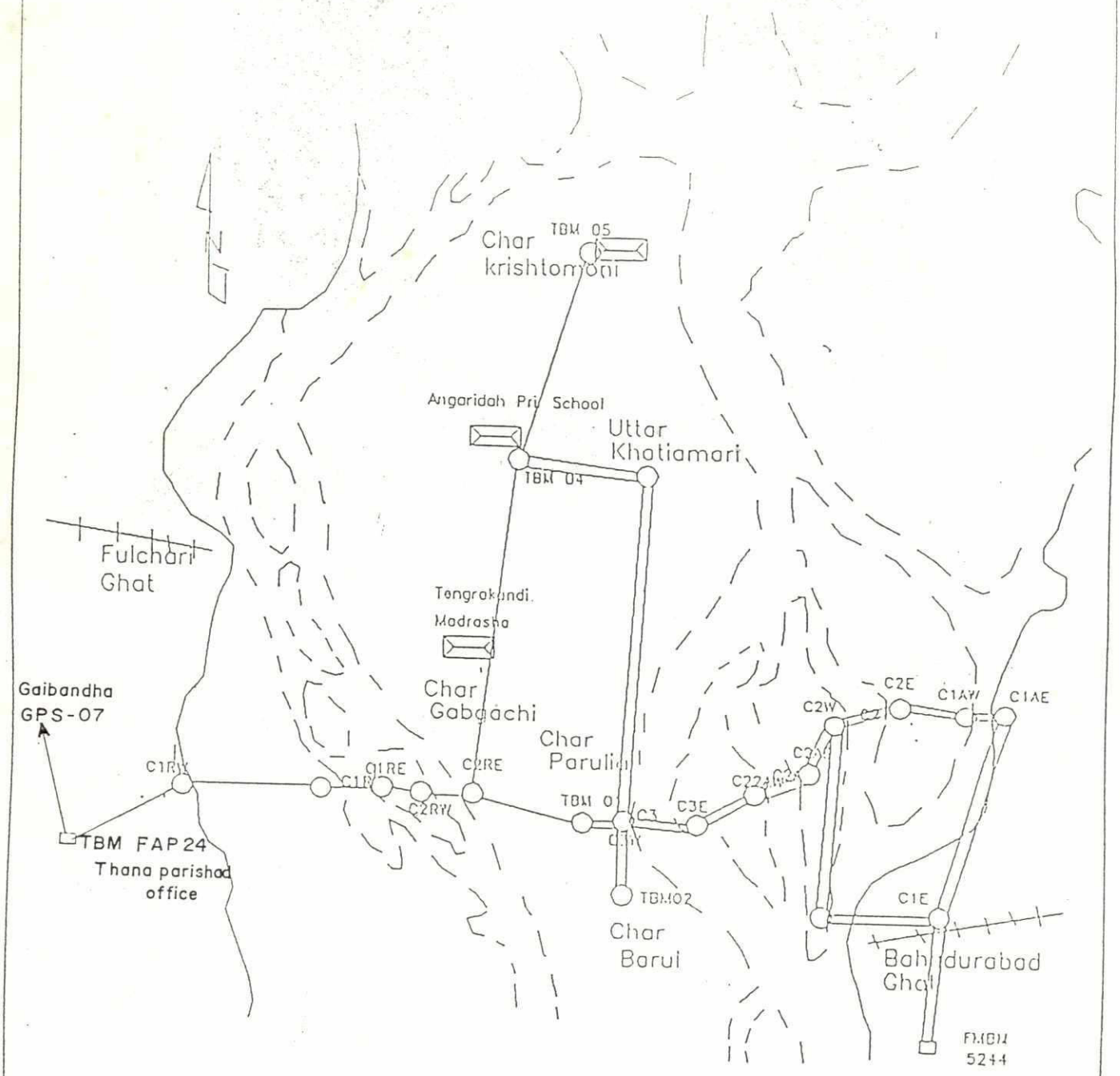
Table 1 : Equipment used for land levelling.

| River Crossing | | | |
|---|---|---|---|
| Model | Topcon Electronic Total Station | | GTS 303 |
| Specifications | Telescope | Length | 150 mm |
| | | Objective lens diameter | 45 mm (EDM 50 mm) |
| | | Image | Erect |
| | | Field of view (at 1000m) | 1°30' |
| | | Resolving power | 2.5" |
| | | Minimum focusing distance | 1.3m |
| | Destance Measurements | 1 Prism | 1200 ~ 1400m |
| | | 3 Prism | 2000-2200m |
| | | Measurement accuracy | ±(3mm+2ppm) m.s.e |
| | Angle Measurement | Accuracy | 5" |
| | | Minimum reading | 1" |
| | | Instrument height | 176 mm |
| | Weight | Instrument | 5.2 Kgs |
| | | Plastic carrying case | 3.7 Kgs |

Table 2 : Equipment used for River Crossing

| Levelling by GPS | |
|---|---|
| Model | Trimble 4000 SE receiver/dataloggers |
| Specifications | 9 Channels of L1 C/A code and carrier GPS survey software suite, TRIMVEC plus TM |
| | 1 cm + 2 ppm accuracy |
| | Size 9.8 (24.8cm)W x 11" (28cm)D x 4"(10.2cm)H |
| | Weight 10 lbs. (4.5 Kg) static receiver with tripod |

Table 3 : Equipment used for levelling by GPS




Legend:

- Levelling lines From left bank
- Levelling lines From right bank
- Reference Bench-marks
- Temporary Bench-marks (TBM)

Not to scale

| | | | |
|---|---|---|---|
| FAP 24 RIVER SURVEY PROJECT<br>DELFT-DHI<br>Delft Hydraulics Danish Hydraulic Institute in association with Ohm/Appolonia Hydroland | | Transfer of bench-marks Levels | |
| | | Location : Jamuna River at Bahadurabad | |
| File: | Date: | Principle sketch of Levelling sections from Left bank to Right bank | Fig. No. 1 |
| Scale: | Init: | | |