CENTRE OF EXCELLENCE IN WATER RESOUCES ENGINEERING

UNIVESITY OF ENGINEERING AND TECHNOLOGY, LAHORE

Research Study for Calibration of Acoustic Doppler Current Profiler (ADCP)

In Collaboration with

PREFACE

Project entitled "Rapid Assessment of Stream Data for Flood and Drought Management" isis funded by Japan International Cooperation Agency (JICA) and implemented by University of Engineering and Technology (UET) Lahore. Centre of Excellence in Water Resources Engineering (CEWRE) was entrusted by UET Lahore, in collaboration with project Management and Implementation Unit (PMIU) of Punjab Irrigation Department (PID), to carry out the validation of Acoustic Doppler Current Profiler (ADCP) results in its unique facility namely; Current Meter Calibration Channel at CEWRE Model Tray Hall. The purpose of this study was to assess the accuracy of ADCP used by PMIU.

It is pertinent to mention here that the investigations were carried out by the officials of PMIU and CEWRE in Model Tray Hall by using the procedure adopted for current meter calibration as suggested by USGS. The detail of the activities is contained in the subsequent sections of this report for guidance.

DIRECTOR CEWRE

RESEARCH TEAM

This assignment has been accomplished by a team of Professors, Researchers and Technical staff as mentioned below**:**

University of Engineering & Technology, Lahore		
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Sr. No.	**Name**	**Designation**
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PMIU, Irrigation Department Lahore		
Sr. No.	**Name**	**Designation**
1.	Dr. Muhammad Riaz	Director PMIU
2.	Zia-ul-Hassan	Assistant Director Monitoring, PMIU

EXECUTIVE SUMMARY

This investigation study was carried out to assess the accuracy of ADCP used by PMIU, irrigation department at Model Tray Hall of Centre of Excellence in water Resources Engineering (CEWRE). For this purpose, current meter calibration setup was used. Calibration of ADCP was carried out at three different depths in water channel; 0.37m, 0.46 m and 0.60 m depth. ADCP was rated by towing it with the trolley at five different velocities; 0.25, 0.50, 1.00, 1.50 and 2 m/s, at each of the water depth.

The equation derived from ADCP calibration can be used to measure the flow velocity after incorporating the ADCP measured velocity in equation. Results showed that the velocity measured by ADCP is slightly more than trolley, which means higher value of measured discharge.

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LIST OF SYMBOLS AND ABBREVIATIONS

JICA	=	Japan International Cooperation Agency
UNESCO	=	United Nations Education Scientific and Cultural Organization
UET	=	University of Engineering and Technology
IRI	=	Irrigation Research Institute
CEWRE	=	Centre of Excellence in Water Resources Engineering
PMIU	=	Project Monitoring and Implementation Unit
ADCP	=	Acoustic Doppler Current Profiler

1. AUTHORITY

The investigation work on the subject project was carried out on the request of the Prof. Dr. Habib ur Rehman, Dean Faculty of Civil Engineering UET, Lahore/National Expert of the Project entitled “Rapid Assessment of Stream Data for Flood and Drought Management” funded by JICA through UNESCO and being implemented by UET Lahore.

2. BACKGROUND

An MOU was signed between UET, PMIU and CEWRE under the project titled “Rapid Assessment of Stream Data for Flood and Drought Management” funded by JICA through UNESCO and being implemented by UET Lahore. The MOU has following objectives:

i. Assess the accuracy of ADCP owned /used by PMIU of Punjab Irrigation Department by calibration of ADCP at Model Tray Hall of Centre of Excellence in Water Resources Engineering (CEWRE).
ii. To make a correlation between the velocity measured by PMIU from ADCP and Trolley velocity in current meter channel measured at CEWRE’s Model Tray Hall.

This report describe the salient features and operating procedure of the Current meter Calibration Channel of CEWRE in detail. Moreover, calibration procedure of ADCP and its results are also discussed.

3. Current Meter Calibration Facility at CEWRE

Model Tray Hall of Centre of Excellence is equipped with current meter calibration setup. It consists of PLC control panel, electrically driven trolley and water channel. The trolley moves on rails mounted on side walls of water channel. Maximum speed limit of trolley has been restricted to 2 m/s. Trolley covers a distance of 25m in each run. The total length of water channel is 44 meter. Water channel’s maximum depth is 1.2m and its width is 1m. Four photoelectric sensors are installed on each end of rail track to stop the movement of trolley as soon as the trolly reaches the sensors, automatically. Rope buffers on each end of rail track are also provided to stop the movement of trolley in case of failure of trolley breaks and sensors.

Figure 1: Channel and rail track of trolley

Figure 2: View of the Trolley on rail track of calibration channel and the control room

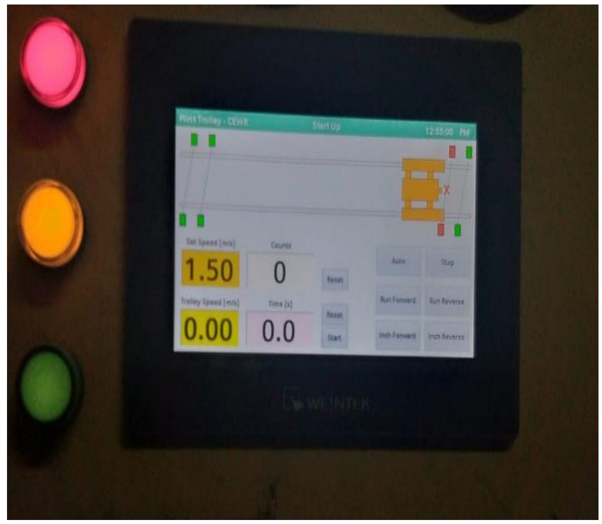
4. Trolley Operation Procedure

Following stepwise procedure is adopted to operate the trolley:

1. To activate the power supply to trolley, motor power button of green color is pressed form trolley drive control panel.
2. Before operating the trolley, check that track is clear and no person on trolley. Now press the green “Drive Power” start button providing power to the thyristor drive.
3. Note that the “Emergency Set” red lamp will be lit, indicating that the emergency trip circuit is not reset.
4. Place the key in the “Emergency Reset” switch and turn clockwise, the set lamp will be extinguished indicating that the emergency trip circuit is now reset. The key cannot be removed until it return to vertical.
5. The key can now be positioned in the “Enable” switch, turning the key will enable the trolley controls to be operational.
6. Before moving the trolley, switch the “Trolley Auxiliary Power” on, this activate the rail brush motors.
7. Select the desired running speed from “Speed Set Knob”. PLC panel will indicate the selected speed of trolley.
8. “Run Forward” or “Run Reverse” buttons on PLC panel will cause the trolley to move to the desired nominal set speed in the direction selected.
9. The trolley may stopped at any point of the operation by pushing the “Stop” button.
10. The trolley will automatically stop at the end of track by utilizing the photo-electric sensors. When this occurs the “Run” buttons will not operate for same direction as trolley was originally travelling. However the “Inch” buttons will enable trolley movement within these restricted regions to allow for maximum utilization of channel length.

5. Description of Control Panel

Control panel consist of “Trolley Drive Control”. It has motor power button, drive power button and emergency set and reset switches with red and green lights. Trolley speed is adjusted by using a black color “Knob”. The movement of trolley on track is controlled through “PLC Panel”. Moreover, data regarding adjusted speed of trolley, constant speed of trolley, revolution counter, working of photoelectric sensors and time of travel are also acquired from “PLC Panel”.



(b)

(a)

Figure 3: (a) Control panel of Trolley (b) PLC panel

6. Calibration Procedure of Current Meter

In order to find out the velocity of water from revolutions of rotor of a current meter, a relation must be established between angular velocity of rotor and velocity of water turning it. The establishment of this relation is known as ‘rating the current meter’. The relationship between flow velocity and rotational speed of rotor of current meter is shown below.

$$V = a + KN \quad (1)$$

In above relation ‘V’ denotes the flow velocity while ‘N’ denotes the revolution per unit of time. Whereas ‘a’ and ‘N’ are constants.

At CEWRE current meter calibration is carried out in 44m long, 1m wide and 1.2m deep channel. The trolley carries the current meter at a constant speed through stationary water in channel. The average velocity of moving trolley is determined for each run by making a measurement of distance it travels during the time that the revolutions ‘N’ of the rotor of current meter counted through counter. United States Geological Survey (USGS) recommends that current meter is rated by towing it through trolley at eight different velocities (0.25, 0.50, 0.75, 1.10, 1.50, 2.20, 5.00 and 8.00 ft/sec). A pair of run is made for each velocity. The data thus consist of 16 observations of the velocity of trolley (V) and revolutions (N) per unit of the time of rotor. The meter rating is determined form these data and expressed in form of linear equation.

7. Calibration Procedure of ADCP

In order to assess the accuracy of ADCP, its calibration was carried out in model tray hall of CEWRE on current meter calibration setup. As the trolly is built for calibration of current meter, thus special coupling arrangement had to be made to attach ADCP with the trolly. The ADCP was coupled with current meter trolley through specially manufactured coupling arrangement as shown in figures below. In addition to the coupling arrangement, the trolly was provided with new set of digital camera, led lights, and led screen (in control room) for live streaming of the ADCP and the boat while calibration run is in progress.

Due to restricted width of the channel, the outer floats of the ADCP boat were removed, and only the middle float of the ADCP boat were used.

Figure 4: Specially manufactured hanging rod for coupling of ADCP with Trolley

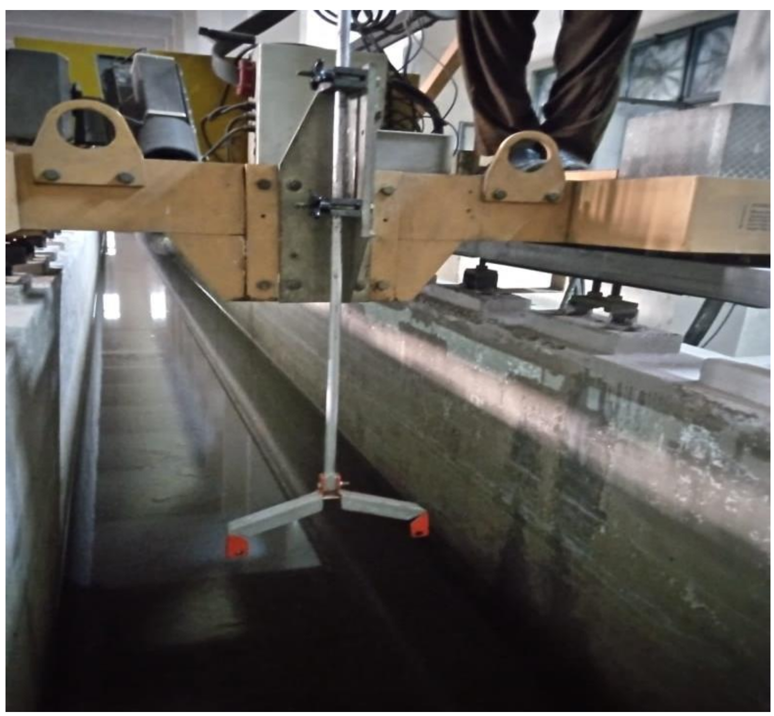


Figure 5: ADCP coupling rod attached with Trolley

Figure 6: View of ADCP boat coupled with trolley

Calibration of ADCP was carried out at three different depths in water channel; 0.37m, 0.46 m and 0.60 m depth. ADCP was rated by towing it with the trolley at five different velocities; 0.25, 0.50, 1.00, 1.50 and 2 m/s, at each of the water depth. At each velocity of trolley, 4 transects (runs) of ADCP boat were performed and average of four transects was taken as average velocity of ADCP. The same procedure was adopted for all water depths (0.37m, 0.46 m and 0.60 m) in water channel. Results indicate that observed velocity of ADCP is almost same as that of current meter trolley which indicates the ADCP accurately measures the flow velocity. Observed values of ADCP velocity and trolley speed are shown in Table 1, 2, 3 below. Correlation developed between average velocity of trolley and ADCP velocity is shown in figure 7.

Table 1: Observed ADCP velocities against current meter Trolley speed at 0.37m water depth

Depth of water in channel = 0.37m						
Set #	**Transect #**	**Distance covered**	**Trolley velocity**	**Average Trolley Velocity**	**ADCP Velocity**	**Average ADCP Velocity**
		m	**m/s**	**m/s**	**m/s**	**m/s**
1	1	24.732	0.25	0.25	0.259	0.257
	2	23.651	0.25		0.257	
	3	23.594	0.25		0.254	
	4	23.542	0.25		0.257	
2	1	23.284	0.5	0.5	0.51	0.510
	2	23.877	0.5		0.511	
	3	23.509	0.5		0.509	
	4	23.002	0.5		0.51	
3	1	23.687	1	1	1.019	1.025
	2	23.984	1		1.03	
	3	23.433	1		1.024	
	4	23.238	1		1.028	
4	1	20.245	1.5	1.5	1.512	1.514
	2	22.343	1.5		1.527	
	3	23.335	1.5		1.5	
	4	21.16	1.5		1.515	
5	1	25.516	2	2	2.061	2.046
	2	23.252	2		2.024	
	3	25.481	2		2.052	

Table 2: Observed ADCP velocities against current meter Trolley speed at 0.46m water depth

Depth of water in channel = 0.46m						
Set #	**Transect #**	**Distance covered**	**Trolley velocity**	**Average Trolley Velocity**	**ADCP Velocity**	**Average ADCP Velocity**
		m	m/s	m/s	m/s	m/s
1	1	23.514	0.25	0.25	0.25	0.251
	2	23.514	0.25		0.25	
	3	14.946	0.25		0.25	
	4	22.846	0.25		0.252	
2	1	22.972	0.5	0.5	0.504	0.504
	2	23.466	0.5		0.503	
	3	23.512	0.5		0.503	
	4	23.354	0.5		0.505	
3	1	24.248	1	1	1.022	1.020
	2	24.254	1		1.017	
	3	21.975	1		1.019	
	4	24.504	1		1.023	
4	1	24.777	1.5	1.5	1.537	1.525
	2	24.695	1.5		1.519	
	3	24.692	1.5		1.519	
	4	24.759	1.5		1.525	
5	1	21.001	2	2	2.063	2.046
	2	26.042	2		2.04	
	3	25.767	2		2.035	

Table 3: Observed ADCP velocities against current meter Trolley speed at 0. 60m water depth

Depth of water in channel = 0.60m						
Set #	**Transect #**	**Distance covered**	**Trolley velocity**	**Average Trolley Velocity**	**ADCP Velocity**	**Average ADCP Velocity**
		m	m/s	m/s	m/s	m/s
1	1	23.402	0.25	0.25	0.251	0.252
	2	23.561	0.25		0.253	
	3	23.252	0.25		0.251	
	4	4.242	0.25		0.252	
2	1	23.362	0.5	0.5	0.502	0.504
	2	23.789	0.5		0.503	
	3	22.935	0.5		0.506	
	4	23.856	0.5		0.503	
3	1	24.127	1	1	1.02	1.020
	2	24.712	1		1.022	
	3	23.084	1		1.02	
	4	23.562	1		1.016	
4	1	22.476	1.5	1.5	1.524	1.518
	2	21.203	1.5		1.513	
	3	22.185	1.5		1.522	
	4	24.213	1.5		1.513	
5	1	23.647	2	2	2.076	2.056
	2	26.252	2		2.045	
	3	24.944	2		2.047	

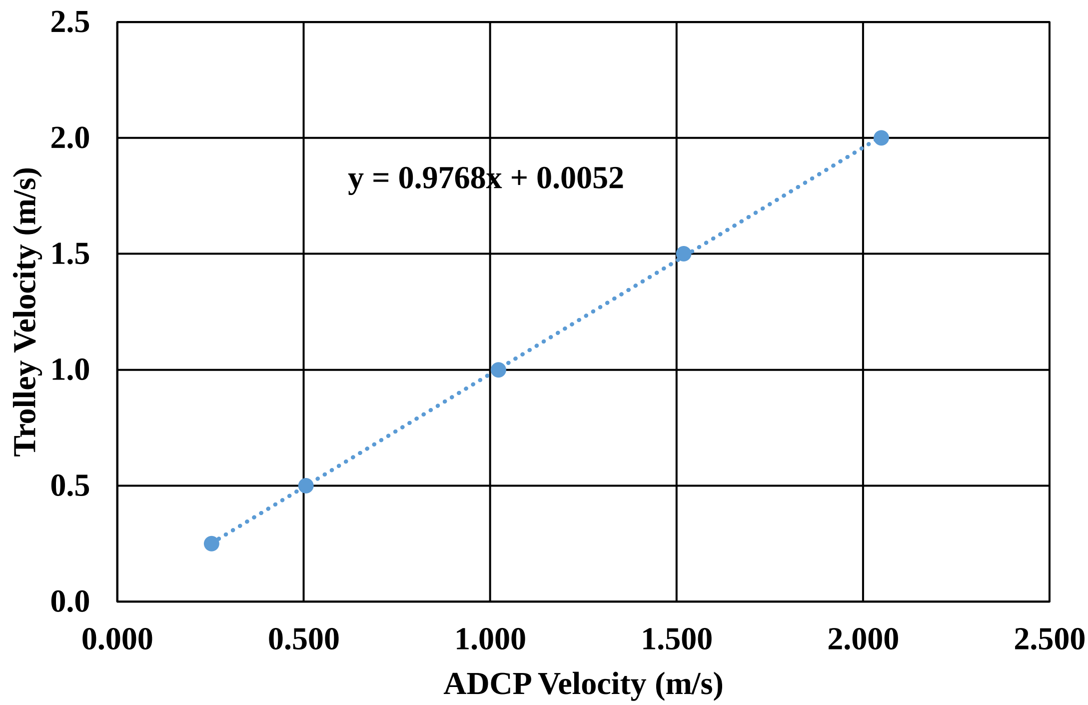


Figure 7: Relationship between ADCP velocity vs Trolley Velocity

From correlation between ADCP velocity and Trolley velocity (shown in figure 7), a calibration equation for ADCP is achieved as mentioned below.

$$V_{trolley} = 0.9768V_{ADCP} + 0.0052 \quad (2)$$

Where,

V= Velocity in m/s

The above equation indicates that if velocity is observed using ADCP instrument then the actual velocity of flow can be estimated using the above linear equation. This equation also indicates that velocity observed by ADCP is slightly more (1.65%) than trolley velocity (actual velocity), thus computing more discharge.

8. Conclusion and Recommendations

From the set of the experiments following conclusions can be drawn:

- Acoustic Doppler Current Profiler is a reliable method of measurement of flow rate in channels, and the difference of velocity measured is just 1.65%age.

- Current Meter Calibration Channel can be used affectively to validate/calibrate modern flow measurement equipment such as ADCP.

- It is recommended that the ADCP capability to perform in field like environment should also be explored by testing it in more sever conditions with respect to temperature, sediments and channel bed conditions.

- It is also recommended that the ADCP capability to estimate the bed load should also be investigated in the LAB environment in future projects.

9. ACKNOWLEDGEMENT

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