CHAPTER 1: INTRODUCTION

1.1 GENERAL INTRODUCTION

Ganga is a holy, mythological and historical river of India and extends well into Bangladesh with a vast area nurtured by flow. It rises in the western Himalayas from the Gangotri and flows south and east through the Gangetic Plains of North India and merges into the Bay of Bengal through Bangladesh. The Ganga is the longest river of India and is the second greatest river in the world by water discharge. The Ganga comes into being at Devprayag where the Bhagirathi river joins the Alaknanda river. The Bhagirathi flows at the foot of the Gangotri Glacier at Gaumukh, at an elevation of 3,892 m. The Bhagirathi is considered to be the true source in Hindu culture and the Alaknanda is its left tributary.

At Varanasi, the Ganga River has the narrowest valley which is just 1–2 km wide, and the active channel is about 1 km wide and is totally confined between the cliff walls (Shukla 2006). Because of incision, the river shows entrenched meanders of 8–10 km wavelength. Varanasi is located on the concave side of the river on an escarpment which is 8–17 m high. At this spot, the Ganga's flow meanders NNW and shows development of a huge pointbar (2 km long and 0.70 km wide) attached to the eastern bank represented by10–20 m high cliff. The drainage system of Varanasi environs is mainly controlled by Varuna River and Assi Nala (Khan et al 1988). Both of the Ganga tributaries join it from the city side on the concave bank. Varuna river valley is less than 0.5 km wide and the banks are moderately high and scoured on either side. Because of encroachment, the Assi Nala is now modified

into a drain though the valley at places is more than 100 m wide. At Varanasi, the Ganga River carries a combined sediment load of Himalaya and peninsular craton including Vindhyan rocks.

.The city of Varanasi is unique in the architectural, artistic and religious expressions of traditional Indian culture and is, even today, a living example of this culture. The city has two main historic remnants of a holy past: the first one being Sarnath where Buddha gave his first sermon, "Turning the wheel of law" in ca 528 BCE, and the second one being the Rajghat Plateau, where the archaeological findings and the C14 dating of some of the wares excavated from the earliest level (upper part of IA layer, sample No. TF-293) confirm the existence of urban settlements in the period during 800-500 BCE. Both these sites have been included in the heritage zones identified for nomination to the UNESCO heritage list. Archaeological investigations, supported by Eidt (1977) on the basis of scientific analysis of the chronosequence of non-occluded/occluded phosphate ratios of the vertical profile of anthrosols in the Rajghat area of Varanasi, confirm the existence of the city from 800 BCE to CE 800, and further the continuity of residential settlement. The archaeological remains (e.g. pottery, terracotta, iron implements, artefacts, seals, etc) found in the area are datable to the ca. 9th century BCE, and include evidence of Black Slipped Ware Culture. Since at least 8th century CE, the city started growing as a pilgrimage site and by 12th century, it became the most popular holy centre for the Hindus. During this period, various deities and their images were established. Their number at present reached over 3000 Hindu shrines and a few Buddhist, Jain and Sikh shrines. Later Muslim shrines also became prominent and now their number has reached over 1350. Varanasi owes its existence to the Ganga River (misspelled as Ganges is the West) considered to be the most holy river for the Hindu people and especially sacred in Varanasi where its flow from south to north refers to the life cycle from death (south, the realm of death, Yama) to life (north, the realm of life, Shiva, i.e. Kailash). This unique

directional change of the river course led to the development of the ancient city, Kashi, on the west banks of the river, facing the rising of the sun and making thus the ghats of Varanasi sacred for all Hindu rituals. The Varanasi Development Authority has already drawn out a Master Development Plan of the City (1991-2011) and has identified heritage zones in the city therein. Although the architectural heritage of the city is still preserved, its existence is seriously threatened by immense pressures from increasing population, modernisation, economic development and tourism. The Varanasi Development Authority (VDA) has, with the aim of achieving a sustainable development of the city based on its architectural preservation and the conservation of its cultural landscape, recently undertaken the creditable and immense task of documentation of the vast architectural and intangible cultural heritage of the city and its surrounding region and of formulating a legislative framework to protect the same. The proposed and identified "The Ganga River and Riverfront & Old City Heritage Zone of Varanasi" satisfies the UNESCO Cultural Heritage Criteria as set out in Article 1 of the Convention, and as set out in the Operational Guidelines- Cultural Criteria Para 24 (a). i, ii, iii, iv, v, vi, and para 27. ii, and the Cultural Landscape Criteria para 39.ii. and iii.

1.2 BACKGROUND

Meandering is one of the most common patterns followed by large rivers. A lot of research work has completed by researchers for the study of bankfull discharge and bankfull velocity of river, but there is a lack of research about the natural flow and natural velocity of river. As it is clear to understand that the discharge of river is a direct function of river meandering wavelength and amplitude, as higher the value of river meandering wavelength and amplitude higher will be the discharge and the vice versa. This clear understanding gives a way to go forward with this research

in the direction that the river parameters must be naturally having a relationship with each other. For developing a correlation between the river parameters which are directly related to the physical parameters of river i.e. discharge, depth and velocity.

Water flows on the surface under gravity force the drag forces which plays the important role into defining velocity vector, for mild slope of the length. It is a fractional force which defines the direction of fluid movement but this frictional force is function of space and time as the stage of flow changes, the frictional force is modified and form the drag forces come into picture. The new geomorphology of river system with the more advancement in the flow the friction and form drag force give birth to pressure drag forces under this condition the geomorphology of river system gets indirectly modified and sinuosity gets developed. The origination and growth of the sinuosity is the function of space and time as such the river bed is also a compound curve link together with the segment of the bends, having different sinuosities, under the condition of compound curve with complex geomorphology. This complex fashion is responsible for stream lines conversion and diversion, development growth magnification and decay of stream in transverse cells, over and above this variation in boundary shear stresses takes place which is responsible for erosion and sedimentation of different materials at different location. Stage variation and discharge condition as such momentum of one segment of sinuosity is transfer to another segment of the curve having different sinuosity. But as they are interested in transferring the momentum from one to another and changing geomorphology from one to other, therefore, the energy transmission from one segment to another segment with changes in morphology and dynamics are of great interest for the hydraulic engineers in general for river engineer particular.

1.3 DEFINITION OF THE PROBLEM

Ganga river basin is the largest basin extending over the states of Uttarakhand, Uttar Pradesh, Haryana, Himachal Pradesh, Delhi, Bihar, Jharkhand, Rajasthan, Madhya Pradesh, Chhattisgarh and West Bengal. Rapidly increasing population, rising standards of living and exponential growth of industrialization and urbanisation have exposed the water resources, in general, and rivers, in particular, to various forms of degradation. Many Indian rivers, including the Ganga in several stretches, particularly during lean flows, have become unfit even for bathing.

The Ganga at Varanasi is almost stable since ages; therefore, it is essential to know what are the guiding parameter and the boundary condition for the stability of Ganga course to Varanasi. The river Assi and Varuna flowing at the upstream and downstream of the river at Varanasi imparts with transfer of their momentum of flows in guiding the stream lines of the Ganga. However, in general erosion and deposition phenomenon vary from the Ganga bend having one sinuosity. It is essential to know the size of sediment at concave, middle and convex site of sinuosity.

Sinuosity of the River Ganga at the Varanasi is fixed since ages, the fundamentals behind this has not been investigated till date. The boundary condition of the Ganga site at the Varanasi is being guided by natural confluence of Assi and Varuna rivers. Moreover, the Ramnagar fort is situated on the concave side of the upstream bend is causing and guiding the streamlines in the flow of Ganga entering into Varanasi bend. In spite of these boundary conditions the sedimentation process of the sand bed is continuous; therefore, sedimentation and erosion process in the flood plain and in the mainstream adjacent to the flood plain is continuous and causing continuous sedimentation and change in cross-sectional shape of the river bank adjacent to the sand bed.

1.4 RESEARCH OBJECTIVES

The main objectives of Research work are given below:

1. To measure Discharge, Velocity & Depth of River Ganga at Varanasi Bend by using ADCP
2. To prepare 14-Cross-sections of River Ganga from Ramnagar (upstream) to Rajghat (downstream)
3. To do the River Modelling with measured discharge, velocity & depth data
4. To generate rating curve for River Ganga with measured data
5. To perform the grain-size analysis of sediments
6. To study the impact of discharge, velocity, depth and grain-size analysis on erosion, sedimentation and River sinuosity

1.5 OUTLINE OF THE THESIS

Chapter I, The present introductory chapter sketched the wider context and the growing relevance of studying the flowing pattern of River Ganga at Varanasi bend. Finally, the research parameters and the objectives of the research were categorised in the following chapters, the targets listed above are achieved by incorporating material and methodology to each of the specific object.

Chapter II, Gives an overview of relevant literature regarding the mathematical modelling of the alluvial channels. It begins from the brief literature review of the ADCP and ends with Grain size analysis of the various rivers in the chapter.

Chapter III, complete data collection procedure of river Ganga at Varanasi bend i.e. discharge, velocity, depth and marking of the cross-sections of the Varanasi bends with the help of various instruments.

Chapter IV, the complete measured data analysed broadly and formation of a linear mathematical model in terms of discharge as dependent variable and taken depth and velocity as independent variables, finally the validation of the model is done in the same chapter.

Chapter V, the complete measurement done at the last section during five months (Nov-2012 to March-2013) listed and a rating curve for River Ganga is generated within certain boundary conditions, this curve is also validated in the same chapter.

Chapter VI, grain size analysis of the complete bend is done in the chapter, its effect on erosion and sedimentation very useful for the people residing near the bank of the River Ganga.

Chapter VII, impact of the discharge, velocity and depth on erosion and sedimentation broadly discussed.

Chapter VIII, the summary and conclusions of this research are provided, in which the technique developed and knowledge acquired from this research are described and evaluated together with some comments.