Chapter I

Introduction

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INTRODUCTION AND LITERATURE SURVEY

Bedrock rivers play a key role in the evolution of erosional landscapes. They set the base level for hillslopes, transport sediment to depositional basins, and communicate changes in tectonic and climatic boundary conditions throughout the landscape (Whipple, 2004). In recent years, considerable attention has been given to bedrock channel morphology and dynamics, and to fluvial erosion processes (Howard, 1994; Wohl et al., 1994; Tinkler and Wohl, 1998; Stock and Montgomery, 1999; Whipple et al., 2000; Lavé and Avouac, 2001; Wohl and Merritt, 2001; Hartshorn et al., 2002; Van der Beek and Bishop, 2003; Snyder et al., 2003a,b; Duvall et al., 2004; Finnegan et al., 2005; Stock et al., 2005; Stark, 2006; Wobus et al., 2006a,b; Whittaker et al., 2007, Gilbert, 1877; Howard, 1980; Howard et al., 1994; Montgomery et al., 1996, Whipple 2004. Bedrock channels lack a continuous cover of alluvial sediments, even at low flow, and exist only where transport capacity exceeds sediment flux over the long term.

According to Tinkler and Wohl (1998) “bedrock channels are those reaches along which a substantial proportion of the boundary (≥50%) is an exposed bedrock, or is covered by an alluvial veneer which is largely mobilized during high flows such that underlying bedrock geometry strongly influences patterns of flow hydraulics and sediment movement.”

It is seen that bedrock channels are channel segments which lack a coherent bed of active alluvium. In mountainous region bedrock sections are seen with short riffles or waterfalls.

Evolution of bedrock channel is a function of both weathering and detachment. Resistant rocks in the channel are eroded by sediment abrasion.

Changes along the bedrock channel are usually very less and adjustment in morphology is only related to the high flows. Since bedrock channels often include gravel bed reaches, some application of gravel bed principles to bedrock channel theory may be necessary. (Tinkler and Wohl 1998).
Gravel bed rivers are those rivers which flow through very coarse material in the range of gravel, cobbles and boulders. However they also carry certain amount of fine material along with the flow. These rivers differ significantly from alluvial rivers flowing through sandy material. Some of the characteristics which differentiate gravel bed rivers from the alluvial rivers are 1) much steeper slope 2) formation of a layer of relatively coarse material on the surface known as the pavement 3) Absence of ripples and dunes commonly found in sand bed rivers but the occurrence of large bed features such as bars, riffles and pools. Relatively less information is available about hydraulic geometry, resistance and sediment transport in gravel bed rivers.

It is only in the last 3 decades that some attempts have been made to collect data on gravel bed rivers in order to study their characteristics. (Garde et al 2001).

A growing literature deals with bedrock channels, erosion processes within them, and their role in landscape evolution. Formal definitions currently in use classify channels as bedrock when alluvial cover is discontinuous or thin. This is equated with a physical property of the flow. A bedrock channel cannot substantially widen, lower or shift its bed without eroding bedrock.

Recent development in river research has substantially extended beyond the hydraulics of sediment transport, stimulated by the abundance of erosion and sedimentation problems. Much progress has been made to provide analytical methods for channel design, river morphology, and mathematical simulation of river channel changes.

Many books and research articles are available on the mechanism and hydraulics of rock bed, gravel bed and alluvial channels.

Numbers of studies have been made in last few decades on the various parameters of the river channel. Channel morphometry, role of vegetation in stream bank erosion, accretion in the channel as bars are also studied widely.

In India almost all the alluvial rivers and their environment has been observed and studied. Rock bed and gravel bed channels are the common features all over the world. Many studies are also undertaken on the rock bed and gravel
bed channels in India. Various accounts on the geometry, downstream changes of rock bed and gravel bed channels are now available.

Most of these studies have been made for the large river basins. The studies on geometry, fluvial environment, and behavioral characteristics of small basins are still limited in number.

Studies in recent years show various aspects of channel geometry. The article published in Hydrological Processes Vol. 6 pp417-433(1992) entitled ‘Channel geometry, bed material, and inferred flow conditions in ephemeral stream systems, barrier range, western N.S.W. Australia by D. L. Dunkerley examines the nature of flow and bedload transport in the ephemeral channel systems.

The article published in the Bulletin titled ‘Bed-material entrainment and hydraulic geometry of gravel-bed rivers in Colorado’ by E.D. Andrews from U.S. Geological Survey, Denver Federal Center, Denver, Colorado 8025 compared the bankfull hydraulic-geometry equations for the Colorado rivers and British gravel-bed rivers that had been divided according to the extent of bank vegetation. No significant difference between the hydraulic geometries of Colorado and British gravel-bed rivers with thick bank vegetation was found. The comparison of hydraulic-geometry equations for those rivers with thin bank vegetation determined that there was no difference in the width-versus-discharge relations. No significant difference was found for the exponents of the depth, velocity, and slope equations; however, the coefficient values were slightly different.

A paper in the Journal of Hydrology, (Sept. 2006) Volume 306, Issue 1-4, p. 97-111. titled Hydraulic geometry of stream reaches by Stewardson, Michael, extended hydraulic geometry analysis to represent the mean and variation of hydraulic characteristics along a river reach as power functions of discharge. Using 54 surveys of 17 river reaches, mostly in southeast Australia, it is shown that five reach hydraulic variables are sufficient to characterise the gross hydraulic conditions along a river reach the means and coefficients of variation of surface width and hydraulic depth, the
coefficient of variation of cross-sectional velocity, mean width and mean depth were also ascertained.

A paper published in the Earth Surface Processes and Landforms Vol. 6 Issue 6, 7 Jul 2006, ‘Drainage area and the variation of channel geometry downstream by Micha Klein, Department of Geography, University of Haifa, Israel states that the understanding of small basin dynamics provides important information for the understanding of large basin dynamics assuming that the extrapolation of small basin data to larger basins is valid. This work tests the validity of this extrapolation of data with reference to channel geometry. Another paper on ‘Drainage density and climate’ by K.J. Gregory, Exete, and V. Gardiner, Wolverhampton published in Z. Geomorphology 287-298 in Sep. 1975 summarized that drainage density can be useful for the classification of drainage basins for the special prediction of drainage basin processes and for assisting interpretations of temporal changes of drainage networks.

In the volume of Geology, October 2004; v. 32; no. 10; p. 897-900, in the article ‘Limits of downstream hydraulic geometry’ by Ellen Wohl Department of Geosciences, Colorado State University, Fort Collins, Colorado 80523, USA data sets from 10 mountain rivers in the United States, Panama, Nepal, and New Zealand are used in the study to explore the limits of downstream hydraulic geometry relationships. The study shows where the ratio of stream power to sediment size ($\frac{F}{D_{84}}$) exceeds 10,000 kg/s$^3$, downstream hydraulic geometry is well developed; where the ratio falls below 10,000 kg/s$^3$, downstream hydraulic geometry relationships are poorly developed.

The paper titled ‘Width of streams and rivers in response to vegetation, bank material, and other factors’ by Russell J. Anderson, Brian P. Blesdsoe and W. cully Hession in the Journal of the American water resources association, dated October 2004 describes the factors affecting widths of streams and rivers. Results indicated that vegetative controls on channel size are scale dependent. Author concludes that bank vegetative conditions strongly influence the width of a channel.

A paper entitled ‘Stabilization of a gravel bed channel by large streamside obstructions and bedrock bends, Jacob Creek, northwestern California’ by Thomas E. Lisle published in Geological Society of America, Bulletin p 999-1011, August
1986 is the case study of Jacoby Creek, northwestern California which contain gravel bars that have forms and positions controlled by numerous large stream side obstructions such as bedrock outcrops, large woody debris, and rooted bank projection and bedrock bends.

In Indian contest most of the studies have been carried out on the basin characteristics, Stream morphometry, channel geometry, perimeter sedimentology etc. A paper titled ‘The perimeter sedimentology of river Mosam’ by Dr. S.N. Karlekar speaks about the deposits on both the banks and on the bed which are indicator of bank stability, channel size, and channel shape. The paper describes that the main control of the shape of any river channel is its sedimentology. The channel stability can be assessed by the nature of bank material. The bank stability, the retreat of banks, resistance and erosion of banks, all are governed mainly by the nature and strength of Perimeter sediments.

A paper titled ‘Geomorphology and drainage basin characteristics of Amaravathy river basin, Tamilnadu, by T.Kavita and A. Ganesh published in the journal of Indian Journal of Geomorphology Vol. 13 & 14, Oct. 2009 pp.117-26 studies the morphometric parameters of Amaravathy basin of Tamilnadu with the help of remote sensing data. In the paper quantitative drainage analysis has been done aspect wise such as linear aspect, areal aspect and relief aspects. The study shows that drainage basin morphometry throws light on the lithologic and structural control of the drainage basin, relative runoff and recharge, erosional aspects and stage of development of the basin relief.

**Fluvial Systems in Upland Maharashtra**

Semi arid regions of upland Maharashtra are subject to wide fluctuations in water and sediment discharge. There appears a general predominance of coarse sediments in these rivers. Rivers in this region are found to respond fast to the changes in the hydraulic regime. (Rajguru et al 1993) There is a definite cut and fill sequence produced due to change in the river regime.

Channel gradients of these rivers are low with few knickpoints. Breaks in the long profiles are marked by waterfalls and pot holes. On a micro scale numerous changes in channel gradient are reported.

These rivers transport silty, sandy sediments as suspended load and coarse sediments as bed load during monsoons.
The channel size and channel configuration of these rivers depends on perimeter lithology and the maximum monsoon discharge. The bedrock reaches are narrow, deep and less sinuous. The control of perimeter lithology is evident in W/D ratio of bedrock and gravel bed cross sections. (Kale 1990)

Sections of bedrock rivers display a strong fluvial activity in the form of pot holes, polished rock surfaces and waterfalls, plunge pools and boulder berms. In confined bedrock channels the depth increases dramatically to accommodate extreme discharge (Kale 1990). Formation of pot holes and entrenched sectors in bedrock channels suggest intense erosion by floods.

The morphology and configuration of river channels in the semiarid zone of upland Maharashtra indicates their misfit form and probably suggests a paleo-flood environment in their formation.