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Influence of Variation of Shear Stress, Turbulence, Resistance in Flow Predictions of Compound Channels -A Review

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Abstract:
A compound channel is channel whose law is governed which mainly occurs in rainy season. In a Compound channel with main channel and flood plains have been considered where exchange of momentum occurs, due to the presence of different vegetation in the bed channel, examples:- rivers. In this paper all the research works has been reviewed with all the searched papers are of flows in compound channel. Such a review will help in enhancing the understanding for improving different conveyance and flow resistance in the field. Vegetation exists on the floodplains of almost all natural channels. Researchers have suggested equations for estimating composite roughness of an open channel flow which are good for simple channels and do not incorporate the interaction mechanisms that exist in a compound channel.

Keywords: Compound channel, composite resistance, turbulence of flow, momentum exchange.

I. INTRODUCTION

River floods are one of the most dangerous natural disasters and the study of compound channels is very important to understand the behaviour of the flows. A compound channel is the rise of depth of water level in the main channel area with the flood water due to heavy rainfall and the flood plains area is also effected that is called compound channel. It includes peculiar features induced by the velocity gradient between the floodplain and the main channel flow. These mechanisms integrate the marked tridimensional features and turbulent flow structure in compound channels. Because of the mentioned velocity gradient, there exists a significant lateral momentum transfer between the main channel and the floodplain. In recent studies in the Flood Channel Facility vegetation density, leads to a decrease of flow discharge. They observed that the lateral distributions of boundary shear stress follow the distributions of the depth-averaged velocities. Near the shrub area, the boundary shear stress decreases. The authors observed also a significant difference between the case with shrubs in the floodplain edge and the case with no shrubs. The differences between relative depths are almost insignificant. Characterizing the flow in compound channels is very important to study flood events in low land rivers.

Figure.1. Siang River

There are many more flow mechanisms in compound channels than in single open channels. Often, floodplains are covered with vegetation, easily submerged by the flow during floods, which renders them significantly rougher than the main channel. Observations of river banks reveal that lined vegetation, growing along the edge of floodplain, is very common.

II. RELATED LITERATURE REVIEW

LITERATURE RELATED TO THECOMPOUND CHANNEL HAVE BEEN CATEGORISED IN THE FOLLOW- ING LITERATURE BASED ON

i) Discharge capacity i.e. flow prediction
ii) Influence of vegetation in flow in compound channel
iii) Variations of Bed Shear stress in compound channel
iv) Turbulence of flow in compound channels
v) The effects of reforestation on the hydraulic characteristics of overbank flow.
vi) Momentum exchange between main channel and flood plains.
vii) Compound Channel composite resistance

2.1 Literature Related to discharge capacity of flow prediction

Many practical problems in river engineering require accurate prediction of discharge capacity in compound channels as it is extremely essential to imply in flood mitigation schemes. (Sellin, 1964) showed that Large-scale turbulence associated with significant momentum transfer leads to the decrease in total conveyance of the section. Many attempts have been made at quantifying the interaction between the main channel and floodplain .Myers (1978) Rajaratnam and Ahmadi (1979) Knight and Demetriou (1983) Van Prooijen (2005) noted experimental studies indicating that lateral momentum transfer occurs between the main channel and flood plain and generally slows down the flow in the main channel while accelerating the flow into the flood plain. Knight and Brown, (1999) Lyness et al., (2001), have focused on discharge prediction in straight mobile bed compound channels, examining the impact of sediment movement in the main channel on the discharge capacity of the main channel and floodplain.

2.2 Literature related to influence of vegetation in compound channel

Usman Ghani et. al (2013) they made experiment on Impact of Vegetation Density on Flow Characteristics in a Straight Compound Channel. This vegetation results in a number of changes in flow features of open channel flows. This paper presents a numerical study in which the impact of vegetation density on different flow features has been considered. The variables investigated included velocity profiles, bed shear stresses, Reynolds stresses and side wall shear stresses. The Reynolds stresses were also influenced considerably in the lower regions of the channel. Similar patterns were observed in case of bed shear stresses. Knight and Hamed (1984) and Knight et al. (1994) focused on the interaction between the floodplain and the main channel flows including the distribution of the Reynolds stresses. A single line of riparian vegetation may be used for bank stabilisation, to promote environmental diversity or landscape amenity purposes (Hubble et al., 2009). In this type of channels, there is also a mixing layer that stabilizes the velocity in the lateral direction of the channel. Dr. Mimi Das Saikia and Jarmina Nake(2016) studied on the detailed investigation of velocity distribution in compouns channel for both the main channel and flood plain.

2.3 Literature related to shear stress

Issam A Al-Khatib & Mustafa Gogus (2015) they used the equations of shear stress distributions across the bottoms of the main channel and floodplain interfaces were analyzed and tested for various types of asymmetric compound channels and their flow conditions. A series of nine experiments was performed in a physical model of an asymmetric compound channel to quantify the boundary shear stress at the interface of the bed of a main channel and floodplain. Knight D et al., (1983) presented experimental results concerning the discharge characteristics, the boundary shear stress and boundary shear force distributions in a compound section comprising of one rectangular main channel and two symmetrically disposed flood plains. Also presented equations giving the sheer force on the flood plains as a percentage of the total shear force in terms of two dimensionless parameters. The reduced hydraulic radius of the floodplain and the often higher hydraulic roughness results in lower velocities on the floodplains than in the main channel.

2.4 Literature related to turbulence of flow

Wilson and Shaw (1977), who modeled atmospheric flows over plant canopies. A modified k-ε model was used, introducing drag related sink terms into the momentum as well as into the turbulent transport equations. Laboratory experiments, conducted at the Hydraulic Laboratory, Kanazawa University, Japan Tsujimoto et al.,(1991) were used to validate the model. Shimizu et al. calibrated their model by the modification of two of the five universal turbulence constants of the two-equation closure to reproduce observed mean velocities and Reynolds stresses. An experimental study of shear stress distribution in a compound meandering channel has been done by Abdullah Al Amin1et. Al. S.(2013) Studies of shear zones above submerged vegetation have shown intermittent organized vortices and maximum values of turbulence intensity. The introduction of vegetation results in additional drag forces, turbulent energy and anisotropy of turbulence (Naot et al., 1996). Consequently, many researchers have numerically described the channel–floodplain interface as an imaginary vertical wall to facilitate modeling techniques, Pasche and Rouve (1985) and Naot et al., (1996)

2.5 Literature related to the effect of reforestation on hydraulic characteristics of overbank flow

Reforestation of riparian areas is a common phenomenon due both to restoration efforts and passive reforestation. Stream restoration programs typically include riparian reforestation to benefit stream ecosystems by filtering pollutants, regulating light and temperature regimes, and providing physical habitat and a food/energy base (Gregory et al.,(1991) Sweeney, (1992)Sweeney et al., (2004)). Yunjun Yao et. Al. (2014) studied deforestation and climate variability on terrestrial evapotranspiration in Subarctic China. Some riparian areas have passively reforested in response to changes in land use, especially in areas where agricultural uses are in decline. Studies from different geographic locations indicate that stream reaches with riparian forests are wider than those with adjacent grassy vegetation (Zimmerman et al., 1967; Murgatroyd and Ternan (1983), Sweeney (1992) Davies-Colley (1997) Trimble 1997; Hession et al., (2000) Sweeney et al.,(2004) Allmendinger et al., (2005). Other studies suggest that widths of streams through grassland are generally greater than those through forest (Charlton et al., 1978, Hey and Thorne, 1986, Gregory and Gurnell, 1988, Rosgen, 1996). It is noted that studies have categorized riparian vegetation in a multitude of ways, so it can be difficult to compare findings or make generalized conclusions. These apparently contrary findings may also be partially explained by a scale-dependent effect of riparian vegetation, such that in catchments greater than 10–100 km2 widths are narrower when thick woody vegetation is present and in smaller catchments the opposite effect is observed (Anderson et al., 2004). An understanding of channel processes is also essential to properly guide stream-restoration activities (Hession, 2001). The driving mechanisms that create these differences in channel size likely operate on a timescale greater than the length of a typical research study; therefore, field-based research opportunities are limited. Long-term channel change in response to riparian vegetation change has been documented in a couple of cases (Parkyn et al., (2003) McBride et al., (2005).

2.6 Literature related to momentum exchange

Experimental studies indicates the lateral momentum transfer occurs between floodplains and main channel and generally slows down the flow in the main channel while acceleration the flow into the flood plain , sellin (1964) and Zheleznyakov (1965). Prinos and Townsend (1984) have described the lateral momentum transfer by introducing an interface shear stress between adjacent compartments parameterized in terms of the velocity difference between main channel and floodplains and the channel dimensions. Dr. Mimi Das Saikia and Jarmina Nake have been review on Flow Prediction, Resistance, Momentum Exchange and Sediments in Compound Channels. They studied that the main channel flow is faster than the floodplain flow is comparatively. Although several studies have being carried out in the past, accurate prediction of compound channel flow parameters remains a difficult issue. Experimental studies indicate that between the main channel and floodplain lateral momentum transfer occurs.

2.7 Literature related to channel resistance

Shiono and Knight (1991) discussed the variations of the Darcy–Weisbach friction factor, the dimensionless eddy viscosity and the secondary flow factor in smooth compound channels. Research concerning resistance to flow in compound open channel has been studied by many scholars, such as Lotter (1933); Pavolvoskii (1932); Einstein and Banks (1950), Krishnamurthy and Christensen (1972), Myers and Elsawy (1975) developed models for composite friction factor. Habersak et al. studied flow resistance caused by wooden sticks representing vegetation in floodplain with flood flows condition. Knight and Hamed (1984) extended the work of Knight and Demetriou (1983) to rough floodplains. Pang (1998) conducted experiments on compound channel in straight reaches under isolated and interacting conditions. It was found that the distribution of discharge between the main channel and floodplain was in accordance with the flow energy loss, which can be expressed in the form of flow resistance coefficient. Yang et al., (2005) presented the study of Manning‘s and Darcy‘s Weisbach equation and through vast number of collected experimental data indicated that Darcy‘s Weisbach resistance factor is a function of Reynolds number but the functional relationship is different from single channel.

III. OBSERVATION AND DISCUSSION

Study of the literature review reveals that lot of works has been done in the field of open channel which is related to flow resistance, momentum exchange, turbulent flow structures, velocity fields and shear stress. Due to the resistance on the bed the depth of water in the main channel and flood plains have been changed and it effect the flow of water and the velocity in the channel. In momentum exchange it indicates that the lateral momentum transfer occurs between main channel and floodplain are generally slows down the flow in the main channel while acceleration the flow into the flood plain. Analytical and experimental investigation studies have been done to established compound channel bounded with different vegetated flood plains.

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