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Review of Characteristics of Flow Behaviour in Vicinity of Spur Dikes

Rahul Kumar Singh[1], Shikhar Sharma[2], Shikhar Singh[3], Shubham Kashyap[4],Dr Mohammad Amir Khan[5]

[1,2,3,4] Research Scholar,Galgotia College of Engineering & Technology. Greater Noida
[5]Assistant Professor, Department of Civil Engineering, Galgotia college, India

ABSTRACT

The spur dike is an important structure of river training because it changes the flow field, bed topography and sediment transportation in river quickly. The flow mechanism and sediment transport process and operation in a channel are quite complex, especially when a spur dike is built in the bend. Scouring is considered as a natural process that occurs in rivers and is triggered by activated water's erosive activity. Spur dikes are built across the river to prevent river erosion and to allow the river to shift away from the bank. The scouring in stream bed and erosion weakens the spur dike, which is frequently cited as the primary spur dike failure reasons. As a result of this failure, researchers are trying to figure out what causes the scouring occurrence and how they can predict the deepest depth and temporal size of space around spur dike.

1 INTRODUCTION

Rivers and streams are the most important sources of water. To use water, human created canals and channel to transfer and utilize water far away from sources that can be Rivers, streams etc.

Hence, it is required to protect rivers and streams against sediment erosion due to flow of water. For protection of rivers and channels as well as other water bodies we have to do river training works.

River training works includes all methods and techniques used to control and regulate river flow and its configuration. The basic function of river training works is to stabilize the river channels with a certain cross sections and alignments, in stabilization it includes control of flow path of normal and medium flood flow. It's also provided safe passage of discharge without water overflowing from banks of channels and rivers. Protection of land, farming and water bodies can also be done. Using river training works river can be drive away from the bank on which it can attack. There are two types of river training works one is high water training and other is low water training. In high water training protection from damage due to high elevation water is the main objective but in case low water training it is main objective is to provide sufficient depth of Water for inland water navigation, this training is generally done in summers and can be done by contracting the width of channel in low water. In river training works some structures are also constructed such as bridges, dams, weirs, aqueduct, guide banks etc. But one of the most important structure that is used for river training works and optimum usage of water resources is spur dike.

Spur dikes are man-made hydraulic structures that are constructed transverse to the flow of river and these structures are used for disaster reduction and river restoration. These are erodible wall also used for flow diversion, flood control and to create an appropriate path for directing the flow. Spur dikes decreases sediment erosion force and amount of sediment transportation effectively. In the river engineering practices, Spur dykes are hydraulic structures that are being used widely now a days. They are located and constructed along the shoreline and stretch to the river banks, at right angles or at an angle that is current-driven.

According to the permeability of structure, spur dykes can be divided in two types: impermeable and permeable type of dikes. The permeable spur dykes often constructed of one or many rows of timber piles, reinforced concrete piles or steel piles. The impermeable spur dykes is made of the locally available soils, gravels, stones or rocks with toe protection and suitable slope. So far there are lot of researches has been done about it. Some are regarding the turbulence around the flow and some about erosion at the top of spur dike. Flow turbulence plays an important role here. Due to flow turbulence starting velocity, erosion of bed sediment and kinetic energy distribution also taken place different for every spur dike. So, it is necessary to study the flow turbulence in the area of the spur dike.

2 LITERATURE REVIEW

Spur dikes are frequently employed in river engineering for bank protection and navigation, for instance limiting the flow along a bridge, and in coastal engineering for shore protection. The flow patterns around a single spur dike with free-surface flow were replicated in this work by means of a computational model termed as fluent. To anticipate dominant flow in vicinity of structure, the model computed a fully three-dimensional, Reynolds-averaged Navier–Stokes's equation'

"Ikeda (1975) studied lateral bed slope variation in a bend. Zimmerman and Kennedy (1978), Odgard (1981 and 1984), Komura (1986) and Blanckaert (2002) among others. Spur dikes, which are built transverse to the flow and extend from the bank into the river, are commonly used for raising water depth, bank protection, and flood plan rehabitation." [5] Scour is frequently linked with the outside banks of river bends and because of that channel lateral relocation may occur.

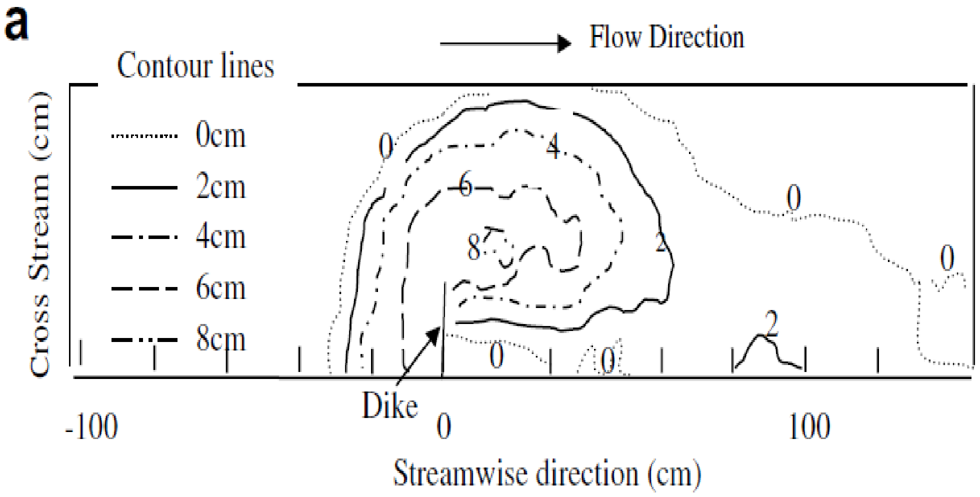
Molls et al. (1995) created 1D as well as 2D models in order to mimic the flow and the features of a spur dike. Mayerle et al. (1995) used this method in which Static pressure was used to recreate the flow around the spur dike. Stream velocities and the side-wall boundary condition using a three-dimensional model. They used a hydrostatic-pressure distribution as a starting point and proposed that it could be a reason for the discrepancies in the characteristics of flow near area surrounding the dike. To describe the phenomenon that there is a velocity field.

Zhou (2001) created a (LES) also known as large eddy simulation model, around a spur dike. Muste and Ettema (2004) scale was determined via a series of flume experiments and flow in vicinity of a singular dike in small-scale models placed in a channel having fixed as well as flat bed.

J. Yazdi a, H. Sarkardeh b, H. Md. Azamathulla c & Aminuddin Ab. Ghani d (2010) selected three experimental cases with fixed beds The spur dike was buried in the water and put at a 60 degree angle to the upstream in this test. The Navier– Stokes's equations are utilised in the flow domain upstream and also downstream of a dike which was modelled using experimental flume data gathered by another investigators. When the 3D model was compared to the flume findings, it was discovered that the model accurately produced flow around a spur dike.These experiments revealed that "the length and width of the recirculation zone (reattachment length) are nearly consistent for varied angles of the spur dike. Changing the discharge has little impact on the reattachment length, while changing the length of the spur dike has a significant impact on the recirculation zone dimensions." [4]

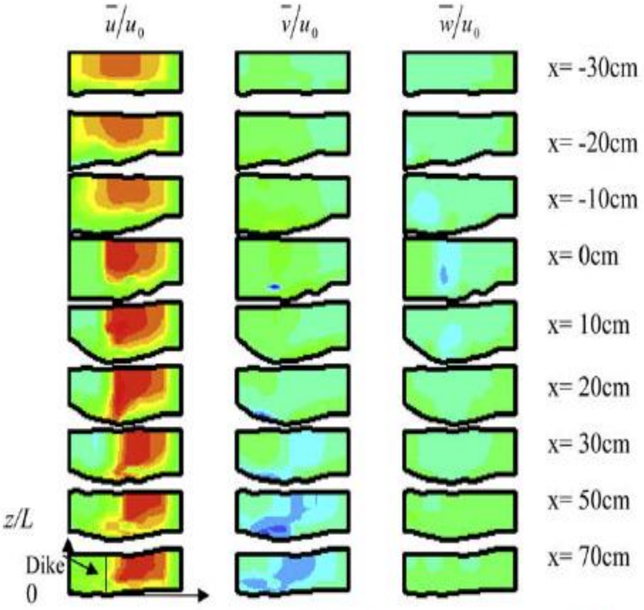
R. Mayerle, F. M. Toro (2014) For the velocities in the horizontal plane, the surface elevation, and the vertical velocity, the three-dimensional arithmetical prototype is based on the result of the time dependent nonlinear Navier Stokes equations, the kinematic state of the unrestricted surface, and continuity equations.The "Efficient Element Technique," a numerical methodology that incorporates the benefits of both finite element as well as finite difference approach is used. A working piece is established for each node in the domain by the nodes that are around the node in question.In conjunction with the working element, a node collocation strategy is used to solve the partial differential equations. Now this study concludes that the eddy viscosity field has a clear dependence on the reattachment dimensions behind the spur dike, as well as the rates and slopes for the free surface. None of the eddy viscosity techniques evaluated were able to represent the flow patterns accurately in the area of the dike.

The velocities' dependency on the side wall boundary conditions was also confirmed. The one based on mixing length and also the supposition of the equilibrium for the choppy kinetic energy yielded wake length in very exceptional arrangement with the observations and realistic flow characteristics among the eddy viscosity techniques investigated. It does not require any calibration, which relieves the user from the burden of turbulence modelling. The mixing length, on the other hand, should not be applied arbitrarily because it is analysed the basis of measurements in conventional rectangular channels.

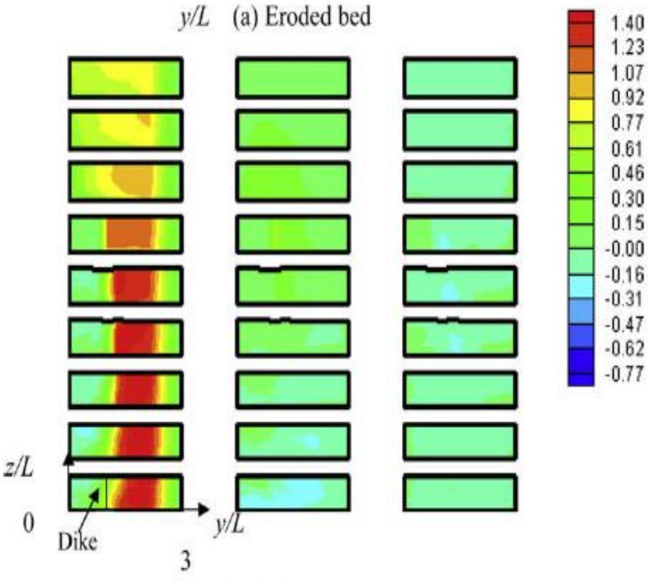


Jennifer G. Duan a,*, Li Hea,b, Xudong Fu b, Quangqian Wang b performed a study in which the flow and turbulence around an experimental spur dike in a flat and scoured bed were measured using an acoustic Doppler velocimeter. Between these two flow fields, differences in mean velocity, turbulence intensity, and Reynolds stresses were investigated. The turbulence frequencies (u0 and v0) are significantly higher, and the vertical component (w0) is significantly lower than in the flat bed. The qu0w0 and qv0w0 components of three Reynolds stresses are substantially smaller than the qu0v0. The shear stress of the bed material near the dike can be 6 to 8 times that of the oncoming flow, resulting in a local scour near the dike without the approaching flow shear stress reaching the critical shear stress of the bed material. The local scour began upstream of the dike and progressed downstream from the dike's tip.

”The origin of the Cartesian coordinate system in the data analysis is on the upstream side of the dike on the right wall of the initial bed surface elevation, so the x-axis is downstream, the y axis is pointing to the left bank in the transverse direction, and the z axis is vertically towards the water surface. In the flat bed run, the z = 0 plane was the flume bottom, whereas in the erodible bed run, it was the initial bed surface. The velocity components are indicated by the letters uj, vj, and wj. The oncoming flow has a mean velocity of 59.43 cm/s. Dimensionless turbulence parameters (e.g. turbulence intensity, TKE, shear stress) were employed by Dey and Barbhuiya [11], Dey and Raikar [12], Duan et al. [13], and many others to generalise their distributions in completely developed turbulent flows. Because the flows in both trials are totally hydraulic rough with Reynolds numbers greater than 38,000, this model hypothesizes that the distributions of turbulence characteristics and bed shear stresses are typical for flows over a spur dike with a flat and degraded bed surface.” [1] The experiment lasted for 48 hours to let the local scour to achieve an asymptotic condition and totally armour the bed surface. Figure 1 shows the contour outlines of the weathered depth, with thezerocontour line representing the initial condition of bed as well as scouring hole's edge. The total volume of scour was 0.0081 m3. At x 1/4 15:4 cm, y 1/4 25 cm, the maximum scour is 8.87 cm.



(a) Eroded bed



(b) Flat bed

Figures 2 a and b illustrate “the contour lines of dimensionless time-averaged velocity components u, v, and w at different cross sections of the flat and scoured bed, respectively.” [1] The downstream component of mean velocity has a alike distribution, while the vertical along with lateral components have substantially distinct distributions. The highest downstream mean velocity was somewhat under the unrestricted surface in both cases. The modest flow aspect ratio in the current tests makes this dip phenomena obvious. The presence of a free surface and a narrow channel aspect ratio create secondary flow, which reduces vertical velocity variations.

The asymptotic length of flow separation is around 3.5 times the dike length, which is significantly less than that of a bed which is non erodible. Towards the end of the scour hole, flow was instantly reconnected. The separated shear layer has a practically 0 mean downstream velocity and correlates with the thalweg of the surface of bed, particularly for 0:5 x=L 3:5 sections. The greatest scour formed through the route of the separated shear layer, which is also when the strength of turbulence is maximum. The mean velocity factor, u, at the section of contraction of the scoured bed is around 1.2 times than the incoming flow, whereas mean velocity component, u, at the contraction section of the flat bed is around 1.3 times than the incoming flow. As Thompson noted, the streamwise factor of mean velocity is lowered once the scour pit is produced. Meanwhile, in the downstream factor of mean velocity “The primary flow zone was raised towards the bed and the secondary flow zone was lowered. negative velocities (in the

recirculation zone Fig. 2a shows the blue1 colour). In the scoured bed, the mean downstream velocity, u, reaches its maximum near the dike portion. In the scoured zone, the streamwise velocity has been considerably reduced. The distribution of mean flow velocity in the zone above the starting bed, where z=L > 0:0, is comparable to that in the plane bed. Flow decreased at the dike portion, resulting in a considerable skewness in the u component, as shown by the contour lines of u. As the flow approaches the dike in both circumstances, the transverse component of mean velocity increases. The mean vertical velocity is highest at the centre of the flow depth and decreases as you get closer to the surface and the bed. Figure 3a depicts a strong upward flow where hydraulic suction may occur, dislodging bed silt downstream of the dike at x=L 1/4 5:0. W progressively decreases as one moves downstream. Because of the increased cross sections in the scoured bed, the mean downstream velocity was lowered. The mean flow and turbulence fields surrounding a spur dike in both a flat and scoured bed surface were investigated. The flow separation zone in the lee of the dike was shortened in the scoured bed. Although the mean streamwise velocity has decreased, the lateral and vertical mean velocities have increased. The scour is initiated at the dike upstream side and advances in the zone of high shear stress generated by horseshoe vorticies, according to differences in shear stress and Reynolds stresses distributions. The scour depth was greatest where the bed shear tension was greatest." [1]
The utmost bed shear stress is almost about 6-8 times that of the incoming flow for both types of bed that is erodible as well as non-erodible. As a result, even if the oncoming flow shear stress is lower compared to critical shear stress of the bed material, local scour would be created in vicinity of a dike.

3 RESEARCH GAP

In this study, we investigated the flow behaviour in vicinity of spur dike.
Therefore, the goals of this study are-

- The study the bed evolution and flow structure caused due to spur dikes.
- To investigate bursting event near the spur dike.
- To create numerical models that can simulate spur dike related problems.

Despite the relevance of the spur dike in bend or curved channels, little recognition has been dedicated to studying the scouring process in scenario, according to a review of the literature.

"Ahmed (1953), Mesbahi (1992), Przedwojski et al. are the only research on scour near spur dike in bend or curved channel that has been known of.
It is important to note that none of the current approaches can forecast the scour dimensions in a curved channel around the spur dike. Furthermore, the effect of the position of the spur dike in a bend or curved channel has not yet been examined. It states clear that there is a dearth of understanding of the scouring process and flow pattern around the spur dike in a bend or curved channel".[5]
The adequate reproduction of the flow pattern in the downstream on the water surface downstream of an object in a flow by a moving object. This phenomenon caused by density differences of the fluids or secondary flow formed downstream. This is one of the crucial challenges in numerically simulation process of flows in the spur dikes.

"**R. Mayerle, S. S. Y. Wang and F. M. Toro**, even while algebraic models are effectively utilised for anticipate some forms of near parallel flows and diverse geometric configurations, each particular type of flow usually requires a new model to be developed and tuned, i.e. this indicates that these cannot be utilized or have potential universal model. Numerical noise which are short-wave oscillations which deteriorates the numerical possible solution and this leads to instabilities are needed to be damped out. For this, a much higher values of eddy viscosity are used in respect to small geometries. As a result, despite the fact that the solution seems to stable, the physical consideration was not adequately characterised".[2]

"**J. Yazdi, H. Sarkardeh, H. Md. Azamathulla and Aminuddin Ab. GhaniIt** was vital for validation the accuracy of the numerical models before using it for examine the flow pattern around the spur dike.
Directions which had minor depths, had the most errors (in terms of depth). The two equation turbulence models cannot accurately forecast turbulence at such small depths because of presence of a thrust or shear layer between the downstream direction of flow and zones of recirculation".[4]

4 SCOPE FOR FUTURE WORK

Even over the past few years, significant progress has been made in defining scouring around the spur dike and still there are many questions for future research**.** Sedimentation and erosion of heterogeneous sediments, which provides a significant impact on the scouring process, is closely related to the ecosystem of the river. However, development of a reliable system is moving at a snail's pace. Because of the scarcity of prediction technologies, scientific understanding of bed sorting processes and data from a high-quality experiment. Since in actual rivers, silt or sediment particles usually cover a large area. This is an area of research that needs to be investigated as soon as possible.
" The effect of the ground water and pore water pressure in the scouring process, it is worthy of particular attention. During the drawdown of a flood or tsunami, the pore pressure gradient may produce a large depletion in the effectual shear stress in the substrate, resulting in increased silt and scour. A transient scour could form quickly behind spur dikes when there is an immediate variation in the ground water table. This occurrence could lead to the spur dyke collapsing and the pool ecosystem around the spur dyke deteriorating. Hence, incorporating ground water table in the morphological model gives a new challenge with a lot of potential to explore.
Sediment transport has previously been associated to near bed shear stress and mean flow. Although, it has been discovered that this concept is not sufficient for accurate and quantitatively precise forecasting of scour (CHRISOHOLDES et al. 2003). Importance of turbulent coherent structure on sediment threshold and transportation has been highlighted by GYR and HOYER (2006) are two researchers who have looked into this. The complete knowledge of the scouring process requires a lot of understanding".[3] This understanding must likely to link the knowledge of small scales such as the micromechanics of flow and sediment transport on a large scale, like vortex systems, but also deformed from banks and riverbeds in laboratory water and river conditions, in real time.

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