APPROACHES TOWARDS BRIDGE PIER SCOUR PROTECTION

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The presence of hydraulic structures such as bridge piers will cause the change of flow round the piers, which is resulted in local scour around the piers. The local scour at the piers has been a perplexing problem to endanger the stability of the bridge piers. In order to resolve the problem, numerous scour countermeasures have been introduced. They are classified in two groups: armoring countermeasures and flow altering countermeasures. The former is to withstand the increased erosive forces of flow occurred around a bridge pier due to a hydraulic condition by acting as a resistant layer to hydraulic shear stresses providing protection to the more erodible materials underneath. They include ripraps, wire gabions, cable-tied concrete blocks, tetrapods, etc. And the latter is to deflect the approaching flow or to divert downflow for reduced plucking power of flow. Collars and slots shield bed material from the downflow and horseshoe vortices. Meanwhile group piles, vegetation zone, and sacrificial piles protect the pier from scouring by suppressing the approaching bed forms, causing a wake region downstream resulting in weakened entraining forces of the flow, and deflecting the high velocity flow, respectively.

WIRE GABIONS

Wire gabions as new alternative countermeasures to riprap for scour protection around a bridge pier in clear-water conditions have been proved that at given flow conditions smaller wire gabions than ripraps provide an equivalent protection implying cost effective. Or wire gabions with the same size to ripraps provide better protection meaning improved performance. The dominant failure mode is a shear failure and the controlling factors for the shear stress are flow depth relative to pier diameter, length to thickness ratio, coverage, alignment, and placement depth of wire gabions. For circular and square cross section gabions the shape of cross sections has negligible effects on their failure mechanisms.

An equation was proposed to predict the wire gabion size in terms of Froude number and factors reflecting both the effects and limits of significant parameters for a range of flow conditions.

$$d_v/b=2.77K_{LT}K_cK_YF^{2.79}$$

The thickness of wire gabions comply with the rule of thumb that the thickness of gabions is about 1/2 the thickness of ripraps.

INTEGRATED BRIDGE SCOUR COUNTERMEASURES

In live-bed streams, a bridge pier may not be able to be protected by the local armoring countermeasures alone since bridge collapse may be caused by undermining due to the passage of bed-forms. Especially, if the degradation of riprap stones due to the passage of bed forms in live-bed conditions is deeper than the maximum scour depth estimated in clear-water conditions, riprap layers may not provide full protection against scour at bridge piers since a destabilization failure is likely to occur. In this cases additional devices are needed to suppress or to weaken the approaching bed forms before arriving at the pier in some way. Such situations can be alleviated by incorporated armoring devices with the flow altering devices such as group piles or vegetation zone upstream from the bridge pier. The combined system can be termed as an integrated bridge scour countermeasures.

Vegetation zone: The vegetation zone placed upstream the pier acts as a sort of porous bluff body and thereby the flow in the downstream region becomes a complex recirculating flow incorporated with wake behind the vegetation zone. Flow velocity in the vegetation layer, which is the flow region up to the vegetation canopy, is decreased significantly as low as 10% of the average velocity.

The wake and recirculating flow in the downstream region due to the presence of the upstream vegetation zone weaken the downflow along the upstream face of the pier, which in turn reduces the horseshoe vorticies at the bed around the pier significantly in size and strength. Another reason for substantial decrease in the downflow is that in the immediate downstream region the velocity near the bed is reduced as low as one tenth of the surface velocity and this weakens the downflow tremendously. These overall effects contribute to reducing scour depth around the pier.

The scour depth around the bridge pier is affected by both geometric characteristics of vegetation (height, diameter and density) and vegetation zone(width, length and distance between the vegetation zone and the pier). The presence of a vegetation zone is recapitulated as a very effective means for reducing scour at a bridge pier and there exist an optimum dimensions to both vegetation and the vegetation zone.

Pile group: The deformation of dunes by passing a group of piles in an open channel was found experimentally to be substantial and it depends upon characteristics of the pile group such as their diameter and density. The dimensions of dunes are an increasing function of Froude number in a subcritical flow region. At a lower density of piles such as ρ_p=1.47/1000, the effect of pile height is negligible but it needs further study at higher density of piles if the significant effect of vegetation is considered. With increase of pile diameter, reduction in the heights and lengths of dunes amounts to 24% and 40%, respectively at D/y_o=0.1. The dimensions of dunes are reduced significantly with the density of piles but there exists an upper limit of ρ_p=3.45/1000 above which the dunes cease to decrease further. The reduced dunes in their size in the downstream region of the pile zone resume their original magnitude gradually as they move downstream and at X/L$\cong$ 0.6 they reach 90% of the original size. Equations were derived to be able to predict the heights and lengths of dunes in terms of parameters of flow and piles at a given properties of bed material.