WEIGHT ANALYSIS FOR STABILITY OF ROCK RIPRAPS

ZHANG WEI[1] and YU JIN[2]

[1] Professor, Doctor, IAHR Member, College of Ocean, Hohai University,
1 Xikang Road, Nanjing, 210098, China
(Tel: +86-25-8378-7706, Fax: +86-25-8370-1905, e-mail: zhangweihhu@mail.edu.cn)
[2] Doctoral Student, College of Ocean, Hohai University,
1 Xikang Road, Nanjing, 210098, China
(Tel: +86-25-8378-7991, Fax: +86-25-8370-1905, e-mail: yujinsjy@tom.com)

In river engineering such as river revetment, sluice scouring and polder, river bottom protections are often used to prevent the riverbed from erosion. While designing the riprap apron, special attention should be taken to the rock weight of ripraps. This is very important for the safety of project. Compared with plain rivers, the flow velocity of mountainous rivers is so faster that may result in an outstanding problem related to the stability of rock block. Therefore, it is not appropriate to improve the rock stability of ripraps by simply increasing the block weight (Zhang, 2003).

Actually, the problem about rock stability of ripraps is one of incipient motion. As the forces acting on rock block are very complicated, formulas for the calculation of incipient velocity are different from each other. Even though, incipient velocity can be usually expressed to be proportional to the square or cubic root of rock size or rock diameter. For instance, the most used formulas are Isbash's formula (Chen, 2000) and the IIIamob's formula (Wang, 2001). Based on the analysis of the relationship between the stable weight of rock block and flow velocity, a discussion is made on the stability of ripraps in plain rivers and mountainous rivers. Research shows that stable rock weight is proportional to the high power of velocity. For example, it is proportional to the sixth power of velocity in Isbash's formula and ninth power of velocity in IIIamob's formula. Obviously, stable rock weight is very sensitive to the change of flow velocity. A little change of flow velocity will lead to a great variation of stable rock weight. Fig.1 shows the relationship between incipient velocity V_c and rock weight W obtained from the Isbash's formula and the IIIamob's formula (in which the water depth is set to be $H = 1.0$ m), respectively. As we all know, the flow velocity in plain rivers is low, and the requirement for the weight of ripraps is usually less than 70kg, so there is little problem for the stability of ripraps. While for the mountainous rivers, the flow velocity is high, and the requirement for the weight of ripraps may reach several tons. So, the difficulty in the mining and the construction of ripraps with such a weight may result in an outstanding problem related to the stability.

For obtaining the margin of safety, engineers usually multiply safety coefficient by the rock weight computed by the above mentioned formulas. This procedure seems to be very reasonable, but if we analyze it more in details, it may be seen that the rock weight determined by this method has not possess the margin of safety what we had hoped. Actually, uncertainty of safety is mainly caused by dynamic factors. For computing stable rock weight, the main dynamic factor is incipient velocity, which can not be estimated accurately. This may be why many riprap constructions have been damaged. To explain it more in details, we have to discuss whether the safety coefficient should be put on stable rock weight or on incipient velocity further. Result shows that if putting the safety

coefficient on stable rock weight, a great increase of stable rock weight only leads to a restricted improvement of safety margin of incipient velocity; if putting the safety coefficient on incipient velocity, a little increase of designing velocity would result in a great variation of rock weight.

According to these research results, the flow velocity of rivers should be estimated as accurate as possible and the safety coefficient should be reasonably determined for calculation of the weight of ripraps.

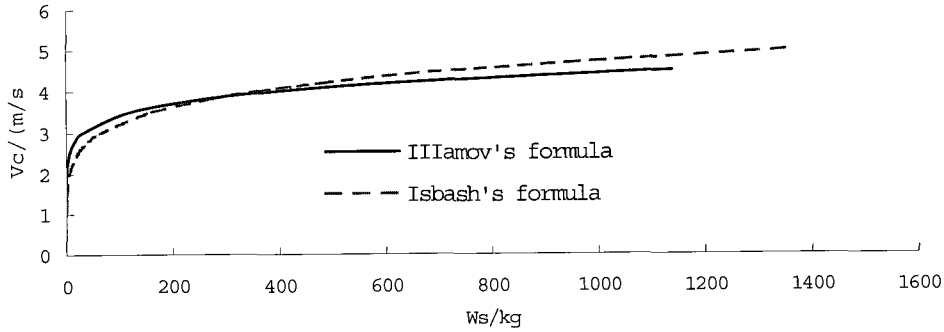

Fig. 1 The variation of incipient velocity with rock weight

REFERENCES

Chen, J.Y. (2000). *Reclamation Projects in China*, Hydraulic Engineering and Hydro Power Press (in Chinese).

Zhang, W., Liu, H.H, Qu, L.F. and Xu, J.H. (2004). Analysis on Stability of Rock-fill Dykes in a Mountain River, *Journal of Hydrodynamics*, Ser.B, Vol. 16(6), pp. 665-668.

Wang, C.J. (2000). *River Dynamics*, People's Traffic Press (in Chinese).