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CHALLENGES OF UNDULAR JUMP MODELLING

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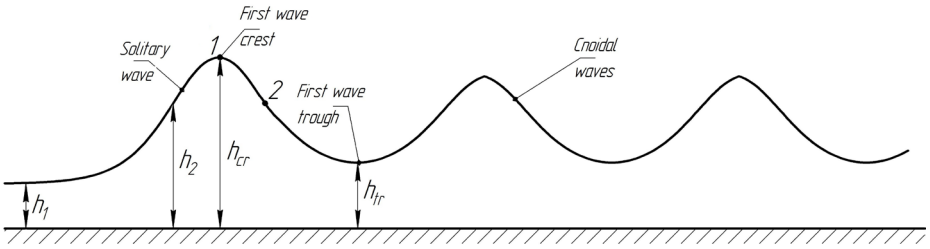
Abstract – The study of open channel flow hydraulics extends beyond supercritical and subcritical flow states to include a distinct state known as near-critical flows. This category encompasses various hydraulic phenomena, with some of the most notable being solitary waves, cnoidal waves, and undular jumps. This paper specifically addresses the phenomenon of undular jumps, providing a brief overview of its characteristics and discussing instances of undular jump formation in natural rivers settings and during the operation of various hydraulic structures. When there is a sudden change in flow depth from a lower level to a higher one, it typically leads to a sudden increase in the water surface, known as a hydraulic jump. However, if the jump is relatively small, meaning the depth change is minor, the water does not rise noticeably and abruptly. Instead, it will traverse from the lower to the higher stage through a sequence of gradually diminishing undulations that extend over a considerable distance. Such phenomenon is called an undular jump (see figure)



Scheme of undular jump.

The occurrence of undular hydraulic jumps can be observed in various open channels such as irrigation and water supply channels, beneath vertical sluice gates, within estuaries during specific tide periods, and in narrow or shallow passages affected by strong currents. Additionally, this phenomenon often manifests downstream of low drop structures or in transitional zones from steep to gently sloping channels. In channels where undular jumps occur, waves with significant amplitudes develop and travel downstream of the jump. Accounting for the propagation of these downstream free-surface waves is essential for canal design and natural channel maintenance. The wave height serves as a crucial design parameter that dictates the necessary sidewall height of the canal. In natural channels, the embankment height must exceed the crest of the free-surface undulations to prevent overtopping and subsequent erosion, which could ultimately lead to bank destruction. Moreover, the propagation of free-surface waves may subject downstream canal structures, such as gates, locks, and weirs, to additional impact loads, perturbations, and vibrations.

In recent years, different scientists have made various attempts to investigate and describe this phenomenon using physical, mathematical and computer modelling. However, this phenomenon has a number of peculiarities that are not always taken into account. An objective of this article is to present the particularities of different type of undular jump modelling and to compare the obtained results.

Keywords – Environmental impact; hydraulic regime; modelling; undular jump