STATIONARY SURF WAVES IN RIVERS

BY MARKUS AUFLEGER & VALERIE NEISCH

Inland surfing is in vogue. There are many stationary river waves currently planned in Austria, Germany and other European Countries. However, the generation of stationary waves that are surfable, attractive and safe is a significant technical challenge, particularly because the apparatus, generating the waves has to be adjustable due to the changing hydraulic boundary conditions. The effective design of these structures requires sound scientific investigations.

Surfing is more than just sport – it is a lifestyle! In many coastal regions, waves, created by complex hydraulic processes, are the foundation for tourism and the way of life. The attraction of surfing is in the sport itself, which can be addictive, and in the surroundings in which it takes place. This charm captivates also many people living far away from the coast. They want to surf despite the lack of local waves! Therefore, they have to travel, typically during holidays or weekends. Because of this interest, significant ongoing activities focus on ways to expand surfing in inland regions to make it possible away from the coast to enjoy surfing daily after work. This creates by the way an important new inland surf market.

For inland surfing a distinction must be drawn between big surf pools, where mechanical devices and pumps are used to generate waves similar to those of the ocean, and stationary surf waves. The latter can be created in artificial environments equipped with strong pumps or in rivers by making use of the natural slope. In terms of energy consumption, carbon emissions and investment costs, surfing on river waves has significant advantages.

Until now, the most well-known inland standing wave is formed by the Eisbach in Munich, Germany. Here an artificial river forms a nearly 1m high standing wave, which has become a popular river surfing spot. This wave is the result of a combination of the non-optimal hydraulic design of a conventional stilling basin, a unique stationary flow (controlled steady channel flow) and some additional stabilisation measures performed by the local surfing community. The Eisbach Wave is an excellent example of the socio-economic benefits of standing waves. Everyday this spot is busy with many surfers and even more spectators (Figure 1).
It has thus become a magnet for locals, tourists and surfers from all over the world.

Even though this spot was originally not intended to end up as a legendary surfing spot, the ´Eisbach Wave´ can be considered as an archetype for artificial standing waves. It remains important to point out, that the hydraulic boundary conditions at this artificial river differ very much from a natural river system with changing flows.

Figure 1. Surfing at the Eisbach in Munich. Photograph: Valerie Neisch

The hydraulic theory of energy dissipation describes the occurrence of stationary standing waves ([1] [2]). In hydraulic engineering works, stilling basins are built to dissipate the energy of the flow downstream of a barrage, a weir or a dam. The principle aim in the hydraulic design of stilling basins is to achieve adequate energy dissipation through a stable and fully developed hydraulic jump, which must be formed effectively and close to the drop rather than moving downstream. After leaving the stilling basin, the water flows calmly. This is the goal of engineering design.

The area near a hydraulic jump is dangerous. If a person unexpectedly gets into a hydraulic jump, the consequences could be life threatening [3]. The near-surface current is very strong in direction of the upstream side and it can become impossible to escape the roller.

Stationary standing waves are unwelcome nearby weirs and other hydraulic structures. The energy of the flow downstream is much higher in comparison to a regular hydraulic jump and as a result, riverbed erosion can increase. Apart from that, despite the rough visual appearance of the flow, there is relatively very little risk for a person to get stuck in these waves. However, a wild but harmless standing wave can veer rapidly into a deadly roller triggered by a minor change in the hydraulic boundary conditions.

Although it is not always easy to avoid stationary standing waves in traditional water construction projects, creating stable, surfable waves is a challenge. There are numerous examples of unsuccessful attempts to create surfable waves by adding or by moving boulders in the riverbed. Sometimes waves do not develop at all,

Figure 2. Physical model test at the University of Innsbruck, 2018 (Dreamwave – concept). Photograph: Marco Schuster

sometimes they occur for a very limited range of discharges, and sometimes they disappear as soon as there is a very little change in the hydraulic system (e.g. a little rise of the tail water level due to local sedimentation processes).

Together with a private company, the University of Innsbruck carried out a number of physical model tests (Figure 2) and numerical simulations in order to develop a commercially viable technology to develop reliable standing waves in rivers.

The basis of this patented technology is a device, which controls the upstream water level whilst ensuring an appropriate geometry for the generation of waves if needed. By implementing an adjustable wave structure, it becomes possible to generate waves of different sizes, shapes and surf levels, which are surfable for beginners and advanced.

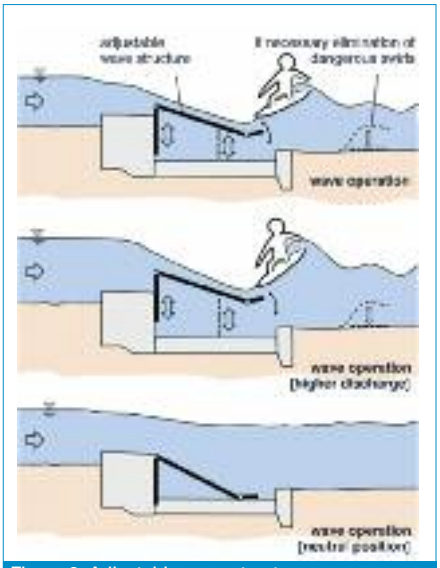

Figure 3. Adjustable wave structure (Dreamwave – concept)

This device makes the creation of river waves under changing natural hydraulic conditions possible. The bigger the specific flow, the higher the difference between the upstream and downstream water level has to be in order to get a stable stationary standing surf wave. Apart from that, in any position during wave operation the basic geometry corresponds to a flat ramp, which ends in an abrupt drop (Figure 3). Downstream of this drop a ´natural´ wave, without any structure below, develops. An additional ´kicker´ fixed at the end of the ramp ensures the appearance of a standing wave. The adjustable wave structure can also be lowered outside the wave operating hours in order to ensure free flow conditions. River wave structures can be implemented directly in the river course or – for more advantageous in terms of operation – in a river diversion (Figure 4).

These structures have to operate in a safe and reliable way and the requirements for design, construction and reliability of these devices correspond to those of traditional hydromechanical steel structures. Recent technological enhancements include two or more adjustable wave structures side by side (module ramp).

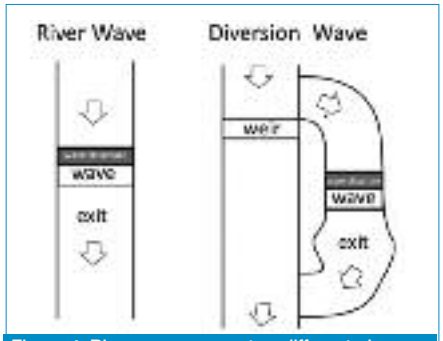

Figure 4. River wave concepts – different plan view situations

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This arrangement increases the range of usable flows for wave generation due to the possibility to block parts of the cross section during low water conditions. Additionally it becomes possible to create spatial effects in the stationary standing wave by steering the modules individually. This capability turned out to be extremely attractive for the target groups, surfers and kayakers. For the successful development of these structures the collaboration between hydraulic engineers and professional surfers was of the utmost importance.

Despite the high number of ongoing projects and the remarkable engagement of the surfing community, the number of river wave projects that have been completed so far is very limited. The restraining factors are generally the investment costs, water permits, ecological issues and the liability risk. In spite of these challenges, a very colourful community consisting of surfers, kayakers, tourist experts, local politicians and last but not least hydraulic engineers are developing a number of exiting, artificial surf spots in rivers. ■

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