# Research Analyzes Flow Structure Under Breaking Waves

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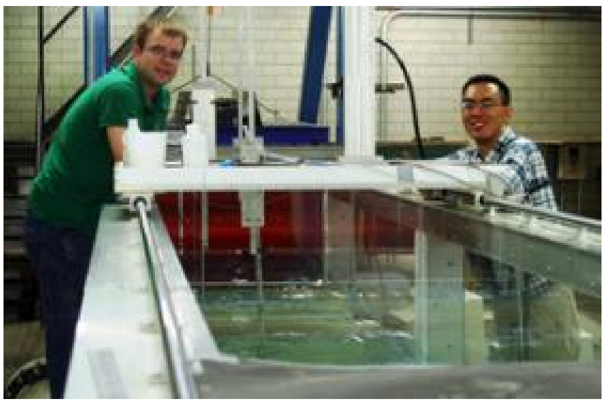

Professor Francis Ting, right, shown here with undergraduate student Chris Olson, uses a 92-foot flume to study the structure of breaking waves inside his South Dakota State University laboratory.

In landlocked South Dakota, hundreds of miles and 1,600 feet of elevation from the nearest ocean, South Dakota State University professor Francis Ting studies the structure of breaking waves like those that pound the world's coastlines.

It's not as odd as it sounds, given the fact that Ting worked previously as a postdoctoral research fellow at the University of Delaware Center for Applied Coastal Research.

"You see this wave breaking at the beach, and you just fall in love with it," Ting said.

South Dakota offers few opportunities to study breaking waves at the beach, so Ting makes his own in the lab. He uses a 92-foot flume in the SDSU College of Engineering Fluid Mechanics Laboratory. The flume is a Plexiglas tank equipped with a computer-controlled wave maker. A measurement system consisting of a laser and two cameras captures the fluid motion produced by the waves as they break on a sloping bottom.

"A plane slope is the first step toward mimicking a beach in nature, although in this case it doesn't have sediment," Ting said. "That makes it easier to study the motion of the fluid without worrying about the sediment-transport aspects of it."

Just as stormy conditions in the atmosphere sometimes produce the energetic local structures known as tornadoes, Ting said, breaking waves, too, have structure.

"The turbulence generated by the breaking waves has structure to it like a tornado in a storm," Ting said. "The objective of the research is to identify the structures, what do they look like, how strong is the velocity, how big are these structures, and how long do they last — their temporal extent. Currently there's very limited information on what is the flow structure produced as the wave breaks."

With the help of a grant of $214,628 from the National Science Foundation, Ting, in SDSU's Department of Civil and Environmental Engineering, has carried out extensive studies to try to answer those questions. The first step was to study a single wave.

"We found that the dominant structure consists of a downburst of turbulence. It's quite logical. The wave impinges on the water surface as it breaks and then the jet of the breaking wave continues to move downward toward the bottom like someone pouring water into a pond."

However, the downburst doesn't just stay in the form of a jet of fluid but bends and rotates and creates vortices. Each downburst consisted of a core of downward flow accompanied by two spiraling flows, or vortices, that rotate in opposite directions to each other.

From measurements Ting and his students were able to identify the spacing of these structures and determine approximately how often they are generated.

From a single wave they moved on to study a periodic wave that consists of many identical waves breaking one after another. Ting said it's important to study a wave train because it produces two effects that don't occur with a single wave — the interaction of structures from successive waves, and the current known as the undertow. That current sometimes forces the flow structures within waves to change positions, Ting said.

Ting's study found there are important differences in how two different types of breaking waves responded to the undertow. In plunging waves, like those with the curled crests that surfers ride, downbursts could overcome the effect of the undertow and carry turbulence onshore.

But in spilling waves — those in which the wave crest becomes unstable and water begins to fall down the front of the wave like a landslide — downbursts were quickly carried offshore by the undertow.

Ting said these findings are consistent with what coastal engineers have observed: that plunging waves tend to build up beaches, while spilling waves tend to tear them down.

"The detailed mechanism still has to be determined. It hasn't been determined yet," Ting said.

Ting said the logical next step would be to carry out similar experiments that include sediment to determine exactly how different types of breaking waves transport sediment. The work could lead to tools — in this case, computer models — that would help civil engineers and coastal managers better understand the different scenarios in which waves breaking on beaches erode or deposit sediments.

Ting needs additional instruments that can measure sediment transport before he can carry out that work. He's pursuing funding to get that equipment and carry out those experiments.

Ironically, Ting is building South Dakota State University's reputation in the meantime as the source of some important research that could find applications such as protecting beachfront property — not exactly the sort of thing for which South Dakota scientists are best known.

Ting's lab was established with funding from the National Science Foundation, the Office of Naval Research, and South Dakota EPSCoR, the Experimental Program to Stimulate Competitive Research.

An oral presentation and computer animations of his laboratory measurements can be viewed at sdces.sdstate.edu/ces_website/ … Ting-BW/Ting-BW.html.

Provided by South Dakota State University