Steady Flow Streamlines and Streamtubes

SPEAKER Bob Holmes: Okay, it's very important for us in this particular lesson, we have to characterize what the flow is doing, and we have to talk about the concept of streamlines. Now, fluid flow may be either steady or unsteady at a particular location or also in space. Whenever we talk about flow characterization, we're gonna talk about two dimensions, the dimension of time and the dimension of space. We have--when we talk about a particular location and space, we characterize whether it's steady or unsteady by whether any of the flow variables change with time. So if your stage changes with time at a particular location, if your flow rate changes with time at a particular location, if your velocity changes with time with a particular location, then that is an unsteady flow problem. If you have none of those changed at a particular location, then you have a steady flow problem.

Now, you can have a steady flow and have the velocity or the discharge change with space, that's still a steady flow problem, but it's a non-uniform flow problem, okay? So it's steady non-uniform flow as opposed to steady uniform flow, where if all the variables are constant with time and space.

Now, the discussion in most of this course deals with steady flow problems only.

On your screen you'll see a hydrograph. And you'll see that we go through some time there, a couple days, where we have a base flow in a particular stream and all of a sudden we have some sort of event, be it rainfall or snow melt, and you have a rapid rise in the stage and then it comes back down at peaks and flows--comes back down. Now, if you look at that, can you tell me on that particular hydrograph where we have steady flow and where we have unsteady flow, or is it all unsteady or all steady? If you look at the first couple days, particularly in day two, you can see that the stage is fairly constant. We can assume during that period that that's steady flow.

Now, as the hydrograph rises, as the rain falls and runs off the landscape, we have a period of very unsteady flow, highly unsteady. In this case, it goes up several feet in a matter of hours. The hydrograph crests and then starts to fall out as the stream recedes. In this recession period, the flow is also unsteady.

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Now to apply the energy concepts, we often have to make some steady flow assumptions or approximations. For example, we assume steady flow at the peak of that hydrograph in order to use our indirect discharge computation methods. If we're unable to get a direct measurement of discharge, either with our ADCPs or our current meters during the actual flood, especially on smaller streams, we have to go out and use those indirect concepts, which we're gonna introduce later on in this course and many of you will apply in your career. In order to apply those concepts that are based on energy, we have to assume steady flow in order to make those energy concepts work out. And we'll talk more about that in this particular lesson.

Now, let's talk a little bit about streamlines. We have a path line, which is a trace made by a single particle over a period of time. If you could imagine turning the lights off and having a luminescent particle and we are able to put that with a black light or something on it and we would turn on the camera and we watch that particle as it moves through space, the trace of that particle makes is called a path line. Now contrast that with the streamline, which is the curve that is tangent to the directional velocity at every point on the curve. Okay? So tangent means if I have a curve, a tangent to the top of my knuckle, if my knuckle with the curve, the tangent line would be the vector, or if I put my other finger, my forefinger, on top of that, that's what we define to be as tangent to the curve. So you can think of that if you have a streamline then the velocity is tangent at every point on that curve. That would be our definition of a streamline.

In two-dimensional space, we talk about something called a stream tube, which is the area between two streamlines. It resembles a tube or a passageway. For steady flow, a path line and a streamline are identical.

All right, so let's put aside this concept of streamlines a bit. We'll come back to the second when we derive the energy equation, because it's gonna be crucial to making some assumptions of how the energy equation works.

At this point, we wanna insert the flume demonstration, where I actually demonstrate the streamlines. This will be Lesson 4, Section B.