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学 位 論 文 要 旨

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題目： **STUDIES ON HYDRAULIC ANALYSIS FOR DESIGN AND MANAGEMENT IRRIGATION SYSTEM**

灌漑システムの水理設計およびその管理に関する研究

Actually, thanks to many advantages compared with other irrigation methods, the pipeline irrigation method is largely used in agriculture. As topographical conditions and irrigation requirements of crop varieties in each zone are different, irrigation systems are differently designed under complex forms with pipelines of different diameter, length and slope. Depending on each irrigation measure, different kind of sprinkler is installed on laterals. It is why to attach much importance to rapidly and accurately identify several parameters of the irrigation system such as working discharge and pressure head on each pipeline and sprinkler, or total discharge on main pipeline in order to adjust and manage the water source in time.

Therefore, the main duties of our thesis are:

1. Putting forth a new method of hydraulic analysis and design of pipeline irrigation systems in order to rapidly and accurately calculate working discharge and pressure head in each pipeline of the systems.

2. Bringing out a new method to accurately calculate discharge and pressure head at each sprinkler of a sprinkler or drip irrigation system with given water source.

3. Providing calculating procedure and design method of bypass flow meters installed on main pipes in order to accurately define flow discharge in the main pipe through the bypass flow meter.

In chapter 2, our study on hydraulic analysis is based on the special phenomenon of hydraulics that is unsteady flow. Unsteady flow is used synonymously with water hammer to indicate flow conditions changing with the time. Rapidly closing or opening a valve causes pressure transients in pipelines, known as water hammer. Valve closure can result in pressures well over the steady state values, while valve opening can cause seriously low pressures, possibly so low that the flowing liquid vaporizes inside the pipe. In steady flow there is no change in conditions at a point with time. In unsteady flow conditions at a point may change velocity at any cross section at any given instant. This phenomenon was analyzed by solving the following equation of motion and the equation of continuity (Streeter and Wylie, 1967).

In calculations of water hammer, the accurate determination of value a is requested. Steady flow is a special case of unsteady flow, in which the unsteady flow equations must satisfy. In steady state analysis, the role of wave speed is not an important issue, because there is no actual wave speed in the pipeline when the terminal state is achieved.

By using this method, we can calculate quickly and accurately the velocities and friction factors at each location on the single pipelines system, series of pipeline system, branched pipeline system as well as complex system combined different types of pipeline. The accuracy of unsteady flow method is checked by comparing the results obtained by a step- by - step method. They are almost in full agreement

for every pipe element.

However, when using unsteady flow method for multiple outlets and larger complex sprinkler systems with many laterals and sprinklers on each lateral, it usually requires a very much time to make program, and it is not favorable for a large use in agriculture.

As known, the discharge at each sprinkler is a function of its operating pressure. Based on this relationship and applying step-by-step method for each lateral of sprinkler systems, the relationship between total lateral discharge and working pressure head is determined and represented by lateral pressure head equation.

Applying the lateral pressure head equation calculated for the valve on the flowchart in chapter 2, velocity and pressure head at each lateral will be identified. Discharge and pressure head at each sprinkler on each lateral will be then identifies by forward method. Procedures of analysis and calculation are presented in chapter 3.

Combining unsteady flow method with the lateral pressure head equation, calculation procedure for sprinkler or drip irrigation systems will be considerably shortened with high accuracy.

Moreover, in order to facilitate the water source management, it is also very necessary to accurately identify total discharge in each lateral or in main pipeline. In general, flow meters are used, directly installed on the pipeline. However, they often have high energy loss coefficient, so the working pressure of the system through the flow meters will be significantly reduced. Actually, there are lots of flow meter types with different principle such as sensor flow meter or laser flow meter, but this flow meter has several advantages, such as high accuracy and low energy loss coefficient, but its price is too high and it isn't suitable for large use in agriculture.

With these goals in mind, the possibility of using a 90^o pipe bend with taps placed at the midpoint of the bend as a measuring device on a pipeline were investigated. By connecting two midpoints of an inside and outside pipe bend with a section called a "bypass route," Replogle (1971) introduced a new method to define the total main pipe flow rate. Based on the difference of centrifugal forces between inside and outside of the bend pipe, the coefficient expressing relationship of bypass flow and main flow will be defined.

The above studies have shown that it is possible to use bypass flow meters to accurately and economically determine the total main pipe flow discharge in cases where the pipe flow often changes.

There are irrigation systems in which 90^o bend pipes can be economically installed, but this is not always convenient. The installation may be difficult and may change the flow direction and system construction.

Therefore, chapter 4 presents an investigation of a new method of using bypass flow meters and 45^o bend pipes that can be easily installed in any straight section of an irrigation system without changing the flow direction or system construction.

Orifices of different diameters can be used for the bypass route on the basis of the relationships of the orifice diameter and hydraulic resistance coefficient of the bypass route to allow convenient and general applications in irrigation systems with different discharges without requiring the change of the bypass flow meter.

The 45^o bend pipe can be very simply and conveniently mounted on irrigation systems at any section without changing the flow direction or the system construction.