Underdrainage System in Paddy Field

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Purpose of underdrainage in paddy field

The underdrainage system has been constructed in paddy fields in Japan to promote downward permeation of water and improve conditions for the growth of rice plants.

It was recognized that by constructing an underdrainage system, it lowered the water table for planting of upland crops and moreover ground workability increased owing to the enhanced strength of soils. It is very rare that the underdrainage system was used for these purposes because it has primarily been employed to increase rice production.

Underdrainage not only augments rice output but also one of the fundamental purposes is hiking the bearing capacity of paddy fields to enable mechanized cultivation of rice, improving the underground water table conditions and moisture content to facilitate the planting of upland crops.

The change made in the purpose of underdrainage resulted in a demand for higher underdrainage functions such as a more complete and speedier drainage system.

On the other hand, the construction of underdrainage methods has made rapid progress and instead of the conventional system of burying earthen pipes by manual labor, diversified construction methods and materials have been adopted.

Mechanized installation has been adopted using either a large or small type of machinery, and vinyl polychloride and polyethylene pipes are being used. Although the introduction of huge agricultural machinery presses down the soil decreasing its permeability, it has made conditions favorable for improving paddy-field drainage: subsoil/breaking and the mole drainage system can easily be executed whenever necessary with mechanization.

Permeability of paddy-field soils and underdrainage in paddy field

Although the direct sowing method on well drained fields which is more suitable to a bigger mechanized cultivation system has been started the transplantation method on ponding field is still prevailing.

In the latter method, a comparatively low permeability is favorable in the first half of the rice cultivation period, and good drainage and highly dry condition are required toward the end of the period to make the field suitable for mechanized work.

These conditions can be achieved by a high permeability of soil and improving the hydraulic conditions so that the underground water table can easily be controlled.

The factors to lower permeability are predominant in the transplantation method on ponding field and it is very important to maintain good drainage and promote drying of the soil toward the end of the rice cultivation period.

Drainage and drying of soil in the paddy

field during this period are strongly influenced by meteorological conditions. If there is very little precipitation at this time and also not much inflow of underground water, the paddy field would become extremely dry to permit travelling of machines with evapotranspiration in 10 to 20 days after the water is drained off from the paddy-field surface. Therefore, it is essential for the paddy field to have good surface drainage that can eliminate ponded water in such a case, and permeability of the soil does not present any problem.

However, when rainfall exceeds the amount of evapotranspiration, it would be necessary that the soil has a high permeability to eliminate water and soil and that the field is equipped with such hydraulic facilities to expedite underground drainage.

Permeability of ground is generally high in the case of larger grain size. However, in the case of soils 30 to 40 per cent of which consist of grains smaller than silt, its permeability is influenced by the condition of soil structure rather than grain-size distribution.

Soil structures with a high permeability can be developed and maintained by adequate water distribution and soil management but the soils of ponding paddy fields under the transplantation method is in an over-moist condition and generally speaking, their lower layers very rarely attain pF 1.5–2.0 or more which is effective for structural development.

Surface soil undergoes a certain soil structural development under drying conditions toward the end of the rice cultivation period and thereafter, but in a ponding condition, the soil is disturbed and structural destruction is repeated. Through this process, paddy-field soils maintain permeability far lower than upland soils with an identical grain-size distribution.

Underdrains are hydraulic facilities for promoting drainage of paddy fields but not a direct means to change soil permeability. Therefore, as a principle, the interval and structure of underdrainage are to be decided by soil permeability.

However, although only partially, the execution of underdrainage alters soil conditions and the effect of underdrainage changes the soil itself by altering the moisture condition of the soil. Especially when the soil contains too much water and its permeability is low in the initial stage, the change that occurs in the soil owing to the construction of the underdrainage is rapid and great so that it is important to plan the construction in order to make better use of these changes.

Various methods of underdrainge execution in paddy fields

The underdrain construction method most frequently adopted at present is to dig up ditches by using either a small or medium-size trencher, place pipes and refill the soil by manual labor. Sometimes a large trencher is used by which digging, placing and refilling can be carried out successively. In this case, the speed of installation is from 300 to 600 m an hour.

The underdrainage pipes (water absorption pipes) presently used are, besides the traditional earthen and porcelain, pipes, hard vinyl polychloride pipes, polyethylene pipes, 4 to 9 cm in diameter and 3 to 4 m in length, having round perforations or slits. The superficial area of the perforations or slits is 20 to 30 cm^2 per meter. Sometimes the pipes are wrapped in chemical fiber to prevent inflow of silt through perforations or slits but in some types of soil, floating soil particles adhere to the chemical fiber or substances dissolved in the permeating water settle on it and by clogging, the absorption capacity of the pipes is sometimes extremely lowered.

Since these chemical products have a high plasticity and flexibility with a high possibility of choice, pipes of high flexibility as long as 100 m or over can be made, thus saving the trouble of connecting shorter pipes. A remarkable case is that pipes are drawn by a mole drain placing machine into the soil layer. Using a 40-hp level tractor, underdrains as long as 600 to 1,000 m pipes can be installed

by this method.

However, when underdrains are installed under such a condition that the earth around the pipes is puddled, water is not drained so well at the initial stage taking some time before their effectiveness becomes noticeable while conventional manual placing of underdrainage pipes used to take some time until all the pipes could be buried, ditches being dug up not at one time but on several occasions after an interval of a few days so that the ditch walls and the soil for refilling get thoroughly dried, effectively draining the water from the paddy field since water flowed through the refilled soil at the initial stage after the underdrains were installed.

A large quantity of brushwood and straw were also used for the purpose of securing the joints of earthen pipes, creating many chinks in the ground, which helped the capacity of the drain to collect and let through the water in the ground. These merits in the conventional method are now being re-evaluated, pipes are buried as long as possible after the ditches are dug up and such materials as straw or rice-husks are also being used.

Underdrains which are directly laid down are suitable for peaty soils or the soils with highly developed soil structure, having a comparatively high permeability. Since this method is simple in execution, it is favored also in construction of initial shallow drains when it is necessary to increase the burying depth by stages when the ground is soft with a low permeability.

Although the mole drains are short-lived, they have the merit of not requiring any pipe material and they can be constructed whenever necessary if a tractor with over 20-Hp capacity is available. Another advantage of mole drains is that they are effective in bringing about changes in the physical properties of the soil so that their short life is regarded as the other side of their advantages.

Mole drains easily get crushed and they do not necessarily remain continuous so that they cannot be expected to remain functioning for a long period of time and for a long distance but if they are connected with drain pipes, which are more durable, they would serve as the waterway collecting water for drains.

Some methods are being tried to increase durability of mole drains by covering with rice husks or other porous materials making sure to provide a lot of chinks in the drain hole. The drains filled with rice husks can maintain their hole communication and are durable but are still inadequate to function as drainage pipes for a long distance.

Therefore, they should be connected with more durable drain pipes as in the case of ordinary mole drains. The space above the deep and durable underdrains to be connected with the mole drains is filled with rice husks, etc. up to the depth of 35 to 40 cm below the ground surface; thus, they can easily be connected to the mole drains which cross with them and the connection is made more secure.

Maintenance of underdrains in paddy field

Underdrains become useless in the following two cases: one of them is that the drainage of paddy field becomes possible without depending upon the drains. After that permeability is improved by the execution of underdrainage. Underdrains do not actually become entirely unnecessary; in many cases only one-half to one-third of the density of the initial underdrain distribution would suffice for drainage.

The other case refers to the underdrains losing their function when the drain pipe is mechanically destroyed due to clogging when perforations or slits get clogged so that it is unable to let the water through and when an uneveness occurs in the ground where the pipe is laid hindering the flow of water.

Considering the short life of the underdrains, they must be maintained so that their function can be prolonged as much as possible and at the same time permeability of the soil must be quickly improved to permit the soil to exercise its own drainage function.

The operation of underdrains depends upon

the condition of water management. It is better to keep them open unless it becomes vital to raise the level of the underground water table to improve permeability of soil and to prolong the life of rains.

It is an effective method to allow the upper tip of the drain pipe come up to the ground surface and pour water into the pipe to clean it periodically in order to prevent silting inside the pipe.

References

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