Structural Design of New Permeable Ecological Side Edge

Qing Bai¹, Jiahui Sun², Dong Han¹, Tianli Zheng², * and Wei Huang²

¹ Qinghai Transportation Construction Management Co., Ltd., Xining, Qinghai, 810021, China
² Key Laboratory of Environmental Protection Technology on Water Transport, Ministry of Transport, Tianjin Research Institute for Water Transport Engineering, M.O.T., Tianjin, 300456, China

*Corresponding author e-mail: czgk3@starpipe.com.cn

Abstract. The side ditch is a longitudinal ditch set up on both sides of the road cutting to collect and remove precipitation from the road surface, road shoulder and side slope. It is the most common drainage facility in highway construction. However, the existing side ditches are generally wide, large, and deep, with a single structure, and poor coordination with the environment along the line. For this reason, this paper proposes a new type of permeable ecological side ditch structure design. Under the premise of ensuring the basic functions of the side ditch, this design effectively solves the problem that the edge of the side ditch is susceptible to erosion due to accumulated rainwater or frost heave in the alpine areas with high groundwater level. At the same time, to maximize the strength of the side ditch and enhance its ecological function.

1. Introduction

The side ditch is a longitudinal ditch set up on both sides of the road cutting to collect and remove precipitation from the road surface, road shoulder and side slope [1]. It is the most common drainage facility in highway construction. Because of its single structure and simple design, it is widely used in the early stage of highway construction [2]. However, with the advancement of ecological civilization construction, the disadvantages of this traditional side ditch have gradually emerged, such as causing vegetation damage, soil erosion, and even severely affecting the balance of the ecosystem in the road area [2]. Therefore, it is particularly important to build an ecological and economical side ditch. The research and application of ecological drainage system in foreign countries started earlier, and a relatively complete system has been formed. Denmark incorporates ecological improvement goals into the design of urban drainage systems, which can improve the value of urban grassland ecosystems while effectively draining water [3]. Australia has transformed the traditional drainage system into an urban rainwater circulation system to solve the problems of urban flooding and ecological degradation [4]. Relevant research in my country started relatively late, and the research results are relatively scarce. The concept of ecological side ditch is only proposed in the road construction of some cities [5], for example, Guangqingbei Expressway and Zhujiang Expressway in Guangdong, and Shaoshan Expressway in Hunan. All these indicate that the ecological function of the side ditch plays an important role in reducing pollution, and while obtaining better ecological benefits, it also improves economic and social benefits [5-6]. The purpose of this paper is to propose a new type of permeable ecological side ditch structural design based on the existing problems in the construction of the side ditch. Under the premise of ensuring
the basic functions of the side ditch, this design effectively solves the problem that the edge of the side
ditch is susceptible to erosion due to accumulated rainwater or frost heave in the alpine areas with high
groundwater level. At the same time, to maximize the strength of the side ditch and enhance its
ecological function.

2. Main structure design of the new permeable ecological side ditch
The new permeable ecological side ditch consists of two parts, the ditch body and the rainwater retention
filtration system inside. The structural section of the new permeable ecological side ditch is shown in
Figure 1. The ditch body is the carrier of the entire ecological side ditch and the connection point with
other parts. On the side of the ditch close to the side slope of the road, an overflow pipe and two different
sizes of sewage interception filters are arranged, wherein the sewage interception filters are respectively
located above and below the overflow pipe. On one side of the ditch body close to the road, the same
sewage interception filter as that above the overflow pipe on the other side is installed. The rainwater
retention filtration system located inside the ditch body is composed of gravel layer, sand layer, planting
soil layer, covering layer, planting layer and perforated pipe.

2.1. Design of the ditch body
The ditch body of the ecological side ditch is a "U"-shaped structure, which is a prefabricated part poured
by permeable concrete according to a certain length. Generally speaking, the "U"-shaped side ditch is a
defization of the prefabricated side ditch. The structure of this side ditch is reasonable in force, can
improve the overall compressive strength, and can better resist the earth pressure. It should be noted that
the prefabricated design of the ecological side ditch is based on the standards of secondary roads, in
which the bottom width and depth are 400mm, the thickness is 100mm, and the edge of the ditch body
is 150mm higher than the soil layer. During the design and construction of specific road side ditches,
the bottom width, depth, etc. of the side ditch can be adjusted according to the different road grades
and the design standards of the side ditches.

2.2. Design of the overflow pipe
In this structure, the overflow pipe is arranged on the side of the ditch body close to the road slope, near
the bottom of the road slope. The overflow pipe can drain the rainwater into the side ditch when the
rainwater accumulates on the slope is serious, to prevent the edge of the side ditch from being soaked in

Figure 1. Schematic diagram of the structural section of the new permeable ecological side ditch
1. Ditch body 2. Overflow pipe 31. Sewage interception filter ① 32. Sewage interception filter ②
4. Gravel layer 5. Sand layer 6. Planting soil layer 7. Covering layer 8. Planting layer 9. Perforated pipe
rainwater for a long time and reduce its service life. It should be noted that the overflow pipe can be an existing product on the market. For example, use Mingshi brand DE200/1 type overflow pipe. As long as the function of draining accumulated rainwater can be realized, there is no need to be limited to the specific structure and model. During the design and construction of the road side ditch, the position of the overflow pipe can be adjusted according to the actual situation at the bottom of the side slope, and there is no specific fixed position.

2.3. Design of the sewage interception filter
In this structure, the sewage interception filter ② and the sewage interception filter ① are respectively located above and below the overflow pipe. The device can not only filter leaves, sand, etc., but also reduce the impact of slope water and overflow pipe water on the planting layer inside the ditch. It should be noted that the sewage interception filter ① and the sewage interception filter ② only differ in size, and the structure and function are exactly the same. Among them, the structure of the filter device is shown in Figure 2.

![Figure 2. Schematic diagram of sewage interception filter](image)

2.4. Design of the rainwater retention filtration system
The rainwater retention filtration system is designed with reference to the general form of rainwater gardens. It is a miniature rainwater garden. It consists of gravel layer, sand layer, planting soil layer, covering layer, planting layer and perforated pipes, etc., which can retain and filter rainwater. It can reduce the infiltration of rainwater and reduce the pressure of soil on rainwater absorption in areas with high groundwater levels.

2.4.1. Gravel layer. The gravel layer is composed of gravel with a diameter of \( \leq 50 \text{mm} \), and the thickness is controlled at about 150mm.

2.4.2. Sand layer. The sand layer is made of medium sand with a uniform texture in the range of 0.5mm-0.25mm, and it is mainly responsible for purifying rainwater.

2.4.3. Planting soil layer. The planting soil layer can provide a good growth environment for plants, and at the same time has better filtration and adsorption. It should be noted that the thickness of the planting soil layer generally varies with plant species. In this structural design, the thickness of the planting soil layer is set to 200mm.

2.4.4. Covering layer. The covering layer is made of tree bark, which can maintain soil moisture and avoid soil compaction. The interface between the covering layer and the planting soil layer creates a microbial environment, which is conducive to the growth of microorganisms and the degradation of organic matter, while also helping to resist erosion by runoff and rainwater. It should be noted that the maximum depth of the covering layer generally does not exceed 75mm. In this structural design, the
depth of the bark covering layer is set to 50mm. During the design and construction of specific road side trenches, the depth can be appropriately adjusted within the allowable range based on actual conditions.

2.4.5. **Planting layer.** The planting layer should try to choose native plants with complete root systems, drought-tolerant and short-term water and wet environment.

2.4.6. **Perforated pipe.** The inner diameter of the perforated tube is 100mm. Its main function is to collect part of the filtered rainwater and discharge it into the municipal pipe network. It should be noted that the perforated tube can be an existing product on the market. For example, use Jintai brand 110mm*2.7mm perforated pipe. As long as it can collect and filter rainwater and discharge it into the municipal pipe network, it does not need to be limited to the specific structure and model.

3. **Conclusion**

Based on the existing problems in the construction of the side ditch, this paper proposes a new type of permeable ecological side ditch structure design. Under the premise of ensuring the basic functions of the side ditch, this design effectively solves the problem that the edge of the side ditch is susceptible to erosion due to accumulated rainwater or frost heave in the alpine areas with high groundwater level. At the same time, the ecological side ditch embodies the new concept of the harmonious development of man and nature. It not only reduces construction time and has quick results, but also improves the road environment, integrates the road and nature, and maximizes the satisfaction of ecological and beautification demand.

**Acknowledgments**

The authors gratefully acknowledge financial support by the Fundamental Research Funds for the Central Public Welfare Research Institutes (TKS190409).

**References**

[1] Xin, G.S., Cui, H.B., Xing, X.D. (2010) Reconstruction of Highway's Wide, Large and Deep Side Ditch. In: Maintenance and Management Branch of China Highway Society. Kunming. pp. 64-67.

[2] Yang, B. (2016) Discussion on the Research Progress of Ecological Drainage Technology of Expressway Ditch in my country. J. Construction Materials & Decoration, 36: 219-220.

[3] Monberg, R.J., Howe, A.G., Kepfer-Rojas, S., et al. (2019) Vegetation development in a stormwater management system designed to enhance ecological qualities. J. Urban Forestry & Urban Greening, 46: 1-14.

[4] Coombes, P.J. (2018) Status of transforming stormwater drainage to a systems approach to urban water cycle management-moving beyond green pilots. J. Australian Journal of Water Resources, 01: 1-14.

[5] Zhang, F.Q., Cao H., Cheng, C. (2011) Research on Ecological Grassed swale in Highway. J. Communications Standardization, 11: 54-57.

[6] Liu, L.H., Wang, W.P., et al. (2016) Ecological Technology for Decreasing Agricultural Non-point Source Pollution from Drainage Ditch. In: 2016 6th International Conference on Information Engineering for Mechanics and Materials (ICIMM 2016). Hohhot. pp. 525-530.