

Research on Optimization Design of Ecological Toilet in Rural Revitalization*

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Abstract—In response to General Secretary Xi Jinping's call of "Toilet Revolution", the development status and existing problems of ecological toilets in China are discussed; this paper first organizes the development context in the context of rural revitalization, then explores the impact of its functionality and its aging trend, and finally proposes countermeasures in line with the new rural construction environment from the perspectives of architecture and ecological technology, aiming to improve to a more ecological toilet environment and extend rural customs.

Keywords—ecological toilet; ecological building; ecological technology

I. INTRODUCTION

A. Social Background

In recent years, although the construction of rural living environment in China has made great progress, problems such as difficulty in traffic, difficulty in toileting, and dirty environment still exist, affecting the living quality of the farmers. The small toilet concerns people's livelihood, and the promotion of "toilet revolution" in villages is an important content for promoting the renovation of rural living environment, an important measure to enhance the farmers' sense of well-being and belonging, and also an inherent requirement for building a well-off society in an all-round way.

B. Political Background

General Secretary Xi Jinping pointed out at the 19th National Congress that toilet is an important task to improve

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rural sanitation conditions and improve the living quality of the people, which is symbolic in the new rural construction. The "toilet revolution" is a revolution that concerns the transformation of concept, consciousness and behavior of toilet. The "difficulty" of toilet lies in the transformation of the concept and optimization of the ecological technology, which are also the problems that need to be solved in the toilet revolution. In the process of toilet optimization, there is a lack of considerations for the research on building materials, the beautification of modeling design, and ecological technology; in resource allocation, there is also a problem of waste of resources.

II. THE STATUS QUO AND DESIGN DIRECTION OF ECOLOGICAL TOILETS IN RURAL REVITALIZATION

A. Fecal Treatment Is the Main Problem

In the past, rural toilets were mainly latrine pits, which were basically outdoor public toilets by "digging a pit, building a wall, and setting up a shed" on the flat. Since Han Dynasty, Chinese ancestors had recorded the "faeces makes good fertilizer", and the idea of "not letting one's own fertile water flow into others' field" brought about by such small-scale agricultural production has continued to the middle of the 20th century. However, nowadays, due to changes in national policies, the users of farmland have changed, and the form of fertilization with faeces has disappeared; with the development of chemical industry, chemical fertilizers are used in large scale, and a more efficient form of fertilization appears, so the natural bandage between the rural land and humans is gradually disintegrating, and there is no reason for the latrine pits to exist. From the perspective of physiological health,

traditional latrine pits can easily cause some physical diseases and hinder the improvement of rural civilization. Therefore, the problem of toilets in the new countryside mainly lies in how to improve the construction form of toilets and fecal treatment according to the economic situation of the countryside.

B. Improving the Integration of Public Toilets and Environment

The concept of small-scale peasant economy has run through China's agricultural development. "Pursuing the use" and "demand first" seems to be synonymous with rural areas. However, with the process of urban-rural integration, rural areas also need beautiful construction, and the aesthetic taste and cultural complex of the Chinese people are also gradually improving with the progress of the times. However, the traditional public toilets that people know have single shapes and lack innovation, and are piled up simply with red bricks and cement, and are universally reproduced; especially in rural areas as tourist attractions, public toilets can not act as a landmark.

At the same time, the materials used in the facade of public toilets are not reasonable: traditional materials are mostly high-energy materials such as red brick, cement and lime, which not only consumes a lot of energy, but also fails to make good use of local waste materials. The use of these traditional materials stabilizes the buildings, but fails to play a role in the decontamination of public toilets, fecal treatment and odor removal of public toilets. Local materials are taken from nature, which are renewable and can be naturally blended with the rural environment both in ecology and culture. Traditional public toilets are mostly isolated from the surrounding greening facilities. Public toilets have not taken into account the integration of the ecological cycle of interior space with the landscape landscape of external environment. Greening and buildings have always been in such an unreasonable parasitic relationship.

C. Transforming the Corresponding Ecological Technology

The existing public toilet infrastructure in rural areas in China is still not perfect, and there are widespread problems such as lack of supporting facilities, low disinfection effect, insufficient fertilization of faeces, and lack of maintenance. In the public toilets that have been reconstructed, there are also problems, for example, the components of the toilet are not matched and are used unreasonably.

To improve the toilet problems in the new rural construction, it is necessary to find environmentally friendly materials suitable for rural economic support to build toilets; use low-tech high-energy cutting-edge technologies to improve fecal treatment in toilets; use ecological toilets for harmlessness and recycling and return to farmland, which is conducive to reducing pollution of agricultural chemicals and improving rural living environment. It is imperative to implement the ecological transformation of rural toilets. For the main method, it can choose more low technologies that are conducive to farmland recycling or energy conversion, such

as: solar energy ecological treatment, odorless biological toilets, environmentally friendly toilets, etc.

III. FUNCTION OF ECOLOGICAL TOILETS IN RURAL REVITALIZATION

A. The Status Quo of Public Toilets

Taking a village in Hubei as an example, there are 267 households in the village, the current population is 936, and the proportion of males and females in the village is about 3:2. During the investigation in the village, it is found that there are 3 public toilets in the village. There are 12 pits and 6 urinals in male toilet and 16 pits in female toilet.

During the investigation of the public toilets in the village, it is found that the size, quantity and materials used for the pits cannot meet the needs of the villagers. With the acceleration of urbanization, there is a serious phenomenon of left-behind elderly and children in village. The public toilets in the village are constructed only in accordance with normal standards, and there is no emphasis on the needs of the elderly and children in design.

According to the support provided by national policies, if the village develops tourism, the village economy will develop rapidly. The rapid economic development has brought about an increase in the floating population, so that the rural public toilets cannot meet the needs of the people during the peak season of rapid population growth. The small toilets cannot accommodate too many people, which will lead to the short supply of pits.

B. The Status Quo of Aging

With the improvement of production level, the development of production relations and the continuous improvement of urbanization level, the urban public service facilities are being improved, and rural population outflows. With the improvement of social living standards and the increased average life span year by year, the problem of aging in cities is also becoming prominent. Therefore, in the process of building ecological toilets, it is necessary to take into account the real problem of faster aging in rural areas.

The construction of ecological toilets needs to consider the individualized design of public toilets. It is necessary to divide into female toilet, male toilet and barrier-free toilet, and consider the phenomenon of aging in rural areas and the elderly disabled in action. In response to this phenomenon, a certain proportion of toilet bowls should be set for the elderly and disabled in design. Flushing devices with automatic induction or foot pedal should be used for the flushing system for urine and stool. The hand washing faucet of the toilets should be non-contact type; in terms of lighting, the lighting factor should be increased or artificial lighting should be added; safety grab bars for body balance and movement should be set around the toilet bowls, squatting pans, urinals and wash basins in male and female toilets; the entrance ramp of toilets should be designed to facilitate access for the elderly and the disabled, and the slope should not be greater than 1/12.

In design, it is necessary to follow the people-oriented design principles. In the new rural construction, toilet is an important part, which needs to be considered for the local residents.

C. Functional Requirements for Toilet

1) *Internal needs:* The physiological needs of the village population and the need to use the product transformed from the implementation of ecological toilet installation.

Compared with urban public toilets, the demand of public toilets in the development of new rural areas is not only the demand for toileting, but also needs to consider lingering of outsiders and their rest space. When waiting in line for toileting, people accompanying can wait or have a short rest.

To exert the practical functions of ecological toilets, the hand washing water and the collected sewage from the toilet can be used as toilet water after being treated by ecological devices to achieve green water use and reduce excessive waste of water resources.

The recycling of excreta is one of the functions of building ecological toilets. It converts manure into energy, improves energy reuse, and meets the daily energy use of the toilet. The reuse of excreta enables waste to be recycled and returned to farmland, which also reduces agricultural production costs. Solar-powered ecological toilets can quickly dehydrate the faeces into a harmless soil fertility regulator, which is another way for faeces to return to farmland, increasing soil fertility and improving the soil environment.

2) *Foreign tourists' needs:* Solving physiological needs is one of the basic functions of public toilets. With the development of new rural areas, the population of rural areas is increasing, the proportion of external population is increasing, making higher requirements for public toilets, as well as the cubicle in public toilets. In order to enable a large number of people to solve physiological needs in a short time, there should be enough cubicles in toilets. In order to make the public toilets meet the needs of most people, the cubicle form of the toilets needs to be diversified and the function shall be more humanized.

According to the characteristics of mobility of external tourists during the peak season, the toilets will meet the needs of the peak season, but will be vacant in off season; seasonal time-based storage space is used for the conversion and storage of ecological toilet products.

IV. SUGGESTIONS FOR OPTIMIZING ECOLOGICAL TOILETS FROM THE PERSPECTIVE OF CONSTRUCTION

A. Architectural Modeling

Due to productivity, society, people's awareness and other factors, traditional rural public toilets are mostly simple huts, or made of red bricks, even without cement and lime finishing. Aesthetics and landmarks are not considered, and even the health and safety are not considered, as long as they can be used.

The renovation of the new rural public toilets pays more attention to the aesthetics of modeling and hygiene, and the modeling of toilets is more integrated with the local culture, making the public toilets a cultural heritage. Daming Mountain in Nanning has evolved from a rural area to a scenic area; as its popularity increases, the flow of people has also increased. The surrounding villages have also been built, and the setting of public toilets is more reasonable. The public toilets around Daming Mountain combine the characteristics of local buildings with the local terrain. Depending on the terrain, the tourist toilets are mainly divided into attached, suspended, and rail types. Similarly, the warm tone of the building's exterior can make the public toilets harmonious with the surrounding environment.

Similarly, the urine-fecal separated ecological public toilet ("Fig. 1") in Haotang Village, Xinyang City, Henan Province, is made of steel members and scaffold. It crosses the lake in the form of shelter bridge, and lightly spans the creek, which is ingeniously combined with local topographical features, and the entire shape is stable and novel.



Fig. 1. The urine-fecal separated ecological public toilet in Haotang Village.

It can be known from the above, public toilets are also a window to show the new rural civilization. The modeling renovation of public toilets can be changed according to the facade, combined with local culture in new construction techniques, and used as landmarks to create a lively place for people to rest. As public buildings, the new rural public toilets should respect the original appearance of local buildings and the surrounding environment, and match the geometrical composition, pattern splicing and traditional gray bricks to change the visual effect of the facade. For example, metaphor can be used to make the wooden structure hollowing part into

the leaking window of traditional garden in South China style, and the silhouette of branches can be extracted to create a transparent and multiplexed visual effect of facade. Each region has its own characteristics, and most of them should be combined with local characteristic cultures to extend rural culture connotation while ensuring the combination of modeling transformation and practical functions; it also promotes sustainable development policies.

B. Building Materials

The buildings of ecological toilets can be made of local materials during the design process. In the construction of new rural areas, local materials have the application advantages of low cost, strong adaptability and obvious cultural attributes. They are taken from a certain range, and have the advantages of convenience, wide range and low price in the construction process.

1) *The use of bamboo materials among building materials:* In the technical processing of bamboo materials, relatively simple construction process is selected. The bamboo is more durable after antiseptic and anti-insect treatment. By using other materials as auxiliary, and regularly replacing the flimsy and aging materials, it can increase the service life of bamboo buildings to more than 30 years. In the consideration of the performance, structure, skills and other aspects of bamboo materials, the application of new non-polluting materials in architectural design can be promoted through the integrative development of modern aesthetics, new ecological awareness and new technological means. Taking Baguazhou in Liuhe District, Nanjing as an example, the bamboo structure design coexists with the environment through design. Therefore, in the south, public toilets in the new rural areas are constructed through the bamboo structure and skin, so that the toilet building materials and the local materials are integrated ("Fig. 2").



Fig. 2. Ecological toilet in Taolin Village, Chun'an, West Zhejiang.

2) *The use of raw soil material among building materials:* In the construction process of buildings, the construction process of the raw soil material is simpler and more convenient, for it can be obtained nearby, and the price is lower than other materials. In traditional culture, it conforms to the concept of integration and harmonious symbiosis

harmony between the settlement and nature. Through the use of raw soil materials, the local characteristics can be inherited and developed. The northern part of Henan Province is rich in loess, and there is a unique architectural form in the local area - the soil-cultivating dwellings. Therefore, the local raw soil material is for the construction of public toilets in the local area, which conforms to the local characteristics, and can increase the temperature in public toilets and reduce economic costs.

3) *The use of straw material among building materials:* The straw material is sturdy and durable, and has the advantages of convenient raw material collection and good sound insulation and moisture resistance. Taking Tangyuan County as an example, straw burning brings great environmental pollution, and the local area uses straw to make local residents experience the advantages of building a house with straw bricks, which is at a low price, warm in winter and cool in summer ("Fig. 3"). Therefore, in the construction process of ecological toilets, buildings can have the advantages of heat preservation and low economic cost.



Fig. 3. Straw house.

4) *The use of brick material in building materials:* Bricks exhibit unique characters in architectural design due to their different colors, textures and qualities. There are a wide variety of brick materials ("Fig. 4"), creating a variety of styles of brick buildings. In the new rural construction, brick materials are convenient for construction and low in cost. Therefore, in the construction of public toilets, the use of brick materials can reduce economic costs and integrate with local environmental characteristics.



Fig. 4. Tianhan Cultural Park.

C. Peripheral Supporting Greening

While constructing public toilets in new rural areas, the peripheral landscape and vegetation facilities should not be underestimated. In addition to considering the ecological cycle of the internal space, the integration with the external environment landscape style is also particularly important in the design of ecological toilets.

In addition to the use functions, public toilets also have the function of landscaping in new rural construction. Some symbolic elements different from urban construction can be made use of in the new rural areas, to create featured landscapes and highlights for visitors who take a rest. When setting up the peripheral landscapes, it is necessary to respect the historical original appearance of the local rural development, integrate historical information and native culture into it in a modest manner, and extract or express some elements, so that public toilets become the highlight of display as a historical object, and become a new existence that is completely different from the toilets copied from cities.

At the same time, when setting plants around the public toilets, there are: planting roofs, vine on the facades of the outer walls, separation of the outer walls from the roof, placement along the entrance and around. Planting some plants attached to the wall, for example, the vine mainly plays a role in heat preservation and insulation for buildings, improvement of the microclimate around buildings, sound insulation and aesthetic decoration; opening at the top of outer walls and the separation of the outer wall from the roof are mainly to increase the ventilation of buildings, adjust the indoor temperature and reduce energy consumption; finally, at the entrance and exit, some small flower pots with local representativeness or aroma-flavored broad-leaved plants that are easy for replacement and maintenance all year round can be placed to guide and decorate; vertical greening can also be carried out for the decoration materials for building facades to lower stiffness. The landscape vegetation around the entire public toilet is mainly for the purpose of echoing the building and extending the rural customs, which shall be natural and properly. (See "Fig. 5")



Fig. 5. Plant vine on facades of outer walls.

D. Ecological Technology for Fecal Treatment

Nowadays, technological development provides a variety of ways for ecological fecal treatment; however, considering the status quo of economic development in China and the ability level of new rural construction, the main methods selected are mostly low technology that is conducive to farmland recycling or energy conversion.

1) *Ecological treatment of solar energy:* Solar eco-san toilet can be one of the priority technologies, for solar energy has a wide range of energy utilization and is highly usable. The fecal treatment of solar eco-san toilets is carried out through dehydration and degradation, or a combination of the two methods; water treatment is carried out through separation of urine, separation of water and combined treatment. Under the current economic level, the conditions for manufacturing solar eco-san toilets are no longer difficult; solar eco-san toilets are conducive to the development of a series of environmental protection industries, which protect the rural ecological environment, ensure water quality, reduce water stress in toilet flushing, and save the cost of building public toilets. The harmless faeces treated by solar eco-san toilets can be used as a soil fertility regulator, with effect as good as that of commercial fertilizers. The faeces is returned to the farmland for use after treatment. Solar toilets can most effectively alleviate toilet demand in the shortest time, and improve the sanitation of toilets and the environmental quality of new rural areas.

2) *Odorless biological toilet in Japan:* Japan's development and research level of eco-san toilet is leading in Asia; the waterless and odorless biological toilet researched by Japan has no residual odor and does not pollute the water source; it does not need to flush with water after use. In research and development, advanced biotechnology is used, based on the principle of microbial decomposition of excrement, a treatment layer with sawdust is placed under the toilet stool, and the excrement can be directly drained into the sawdust, and then rotated by the internal screw device; a thermal device is used to fully evaporate the water of excrement, and the final excreta is controlled within 1/10 of the original. Generally speaking, the sawdust used can be

replaced once every 2 to 3 years, and the labor force is reduced. In addition, during the heating process of the device, the temperature is maintained at about 55 °C, which is beneficial for killing some harmful bacteria such as coliform, thereby converting it into an inorganic substance containing nitrogen, phosphorus, potassium or the like as a fertilizer.

3) *China's environmental toilets*: In response to the national guidelines and policies, the "one pool three reforms" technology is implemented in rural areas, which is implemented with peasant household as a unit; this technology is to combine the construction of biogas digester with the reconstruction of kitchen, toilets and pigsty, combine with the recycling of the "three wastes" (stalks, faeces, organic household wastes), hardening of roads in villages, and safe treatment of drinking water for humans and animals, and eventually achieve the goals of "warm and clean homes, efficient garden economy, harmless agricultural production". Among the sanitary toilets, water flushing type account for 30.05%, two-grid septic tank type account for 30.01%, double-hopper funnel type account for 25.03%, triple gas digester type account for 7.04% and double-tank water seal type account for 5.87%. The toilets of double-hopper funnel type and triple gas digester type are recommended by the National Patriotic Health Office.

V. CONCLUSION

Since General Secretary Xi Jinping proposed the "rural toilet revolution", it has been carried out nationwide. The transformation of rural public toilets has greatly improved the infrastructure health in rural areas, and the fecal discharge is more reasonable, which has led to sanitary rural environment and brought great health benefits to people. The improvement of the defecation structure of public toilets provides a reasonable destination of faeces, which is no longer discharged randomly, bringing ecological benefits to the rural environment. The renovation of public toilets has improved rural health problems, and has also promoted the development of tourism and increased tourism volume; conversely, the increasing tourism volume has brought economic benefits to rural areas, and ecological technology has also saved labor and resources, which also brings deep social benefits. From now on, the rural areas will no longer be dirty, messy and stinking, but will be a sign of comfort and ease.

Similarly, the construction of public toilets is a publicity window for rural areas, and a channel to show their own regional culture. Therefore, in the process of optimization, it is necessary to pay more attention to the public toilet culture; at the same time, the building materials should be more ecological, the architectural modeling should conform to the local cultural characteristics, and the surrounding greening shall be supported; ecological technology is combined with sustainable development strategy, and "comfortable" toilets are built with the concept of ecological environment; in the national conditions that meet the development of the times, comfortable ecological public toilets that make the new rural areas better are built.

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