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## Sustainable Design and Recycle of Water Resources in Civil-building

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**Abstract:** Nowadays, India, as well as China, is in its critical period of transforming from resource-consuming society to resource-saving society. To realize a rational utilization of environmental resources, water conservation is the first issue that should be dealt with. Previously, understandings on the water conservation of buildings is usually confined to the water conservation during the use of buildings. In fact, since the design, construction and use of buildings is a huge systematic project, the usage of water during the use of buildings cannot represent all of its consumption. By adopting the concept of building life cycle, this paper regards buildings as products and discusses the realization of water consumption and conservation of civil buildings, ranging from their production to use and recycle, aiming at providing some inspiration to the Indian construction industry for its sustainable utilization of water resources.

**Keywords:** *Water-saving design, sustainable utilization, civil buildings, industrialized buildings*

### 1. Introduction

China is seriously short of water resources. Its per capita water availability is only 1/4 of that of the world average level, ranking one of the 13 countries with highest shortage of water resources in the world. India is very similar to China in this perspective. According to the latest report issued by EA Water, an authoritative Indian consulting company in the field of water resources, India will be faced with water crisis in 2025 because of its dramatic increase in population. The protection of water resources is the foundation of the existence of a country. As countries who lack water resources most in the world, China and India should learn the mature experience and achievements in the protection and recirculation of water resources from each other, especially those on the water

conservation and recycling from the perspective of design, which are effective approaches for the rapid development of a sustainable society.

The construction industry is the pillar industry of China, but its rapid development is based on the cost of massive amounts of water resources. Such consumption is mainly demonstrated at two stages: one is the production and manufacturing stage of buildings, and the other is the using and consuming stage of buildings. This paper will conduct an in-depth discuss on the water conservation and recycling of these two stages.

## **2. Water consumption and conservation at the production and manufacturing stage**

Speaking of the sustainable utilization of water resources in the construction industry, most people have their mind stereotyped at the stage of how to save and recycle water after the completion of buildings. Actually, buildings under production and manufacturing also need a lot of water. As the primary stage of the entire building life cycle, the production and manufacturing of buildings is fundamental to the establishment of a grown-up and complete sustainable system. As to the water consumption and conservation of buildings at this stage, it can be considered from two perspectives. The first one is how to effectively control the water consumption of the construction done by the traditional construction method with high water consumption; the second is vigorously promote industrialized buildings with low water consumption, namely controlling the water consumption of construction from its very beginning.

### **2.1 Effective utilization of water resources in the construction of buildings**

In China, buildings constructed by the traditional construction method consume a lot of water for various aspects like construction, living of their constructors, fire control, etc. need plenty of water. Among them, the water consumption of construction is hard to control because most of traditional Chinese construction sites are managed extensively, with high water consumption and many water points on the spot, as well as without any restriction from the guidepost of construction water, all of which lead to the non-quota restriction and plan of water consumption, giving rise to the phenomenon of serious waste of construction water of buildings. The waste mainly exists in the following points that: 1) instead of being appropriately utilized, large amounts of high-quality underground water is discharged directly in the drainage of foundation pits; 2) the sewage and waste water at the construction spot are not appropriately dealt with and directly discharged into the municipal pipe network or the earth's surface; 3) the construction water for the cleaning of formwork, maintenance of concrete, and cleaning of materials and equipment is arbitrarily used with lax management; 4) phenomena like dripping, leaking, emitting and

running of water from taps and pipes can be seen everywhere in the construction site; 5) there is no effective collecting equipment, thus great amounts of rainwater is wasted. <sup>[1]</sup><sup>141</sup>

To solve the above-mentioned questions, the following measures for the consumption and conservation of water are proposed:

1) Since the construction of most foundation pits, especially deep ones, will involve the abundant underground water, at the stage of the construction of foundation works, drainage devices and assembled water tanks can be adopted in the construction site to collect and test the drained water of foundation pits. According to the Chinese national standard "Environmental Quality Standard for Surface Water" (GB3838-2002), if the water meet the standard of the first, second or third class, it can be used as domestic drinking water after appropriate treatment; if it meet the standard of the fourth or fifth class, it can be used as the water for fire control, landscaping, industry, agriculture, etc; if it is highly polluted, it can be discharged into the municipal sewage pipes directly. <sup>[2]</sup>

2) Since most of the waste water in the construction spot contains plenty of silt, it will block up the municipal pipe network if discharged directly without any filtration. Meanwhile, for some waste water that are highly polluted because of some special reasons and with the content of some elements exceeding the standard, they should be under special treatment before being discharged.

3) Adopt professional cleaning and maintaining systems. For instance, adopt small-sized water torch to wash formwork and devices and use sprayers instead of manual watering to maintain concrete. The statistics show that in China, the water-saving rate of construction sites that adopt professional cleaning and maintaining systems is 50% higher than that of those without such systems, with some efficiently operated ones saved 70% to 80% of water, which is really a significant water-saving effect.

4) Strengthen the management of construction water and perfect the system of water utilization. Install independent water meters for the construction sites with economic capability and regulate the standard of water utilization according to the local situation. The sites that do not exceed the standard are charged according to their actual consumption; those that exceed the standard have to pay some fine; and those that meet the water-saving standard will be rewarded.

5) Adopt rainwater collecting and processing systems and advocate the reuse of reclaimed water. For the areas with low air pollution, equipment like rainwater catchpits and settling ponds can be set up according to the local situation. Filter the rainwater first after it reaches a certain amount, and then recycle it into the water-consuming system as construction water for cleaning, maintaining, etc. For the areas with high air pollution, a

test should be included. It should be according to the actual testing result to decide whether recycle the rainwater or not.

## **2.2 Transforming the production method of buildings to be industrialized**

As mentioned above, buildings constructed by the traditional construction method consume a lot of water resources. From the involvement of underground water in the foundation works to the stirring, maintaining and cleaning of concrete, as well as discharge of sewage and waste water, etc., every process are related to the treatment and utilization of water resources. Even if some advanced construction water management systems are adopted, the rational control is still on the premise of consuming a lot of water resources, thus its water conservation is limited. If measures are taken from the perspective of construction method, the dependence of construction on water will be fundamentally cut off so as to greatly improve the saving efficiency. Speaking of the industrialized production method of buildings, it is the transformation of the traditional construction method, a brand new one that liberates the construction of buildings from the bound of water consumption.

According to the definition in the "Guidelines for Government Policies and Measures for the Gradual Industrialization of Buildings" issued by the United Nations in 1974, construction industrialization is "A process that transforms the construction industry according to the massive industrial production method and gradually turns the industry from the traditional manual production to socialized massive production. Its basic approaches are the standardization of buildings, factorization of the production of components, mechanization of construction and scientification of organization and management. Meanwhile, new achievements of modern science and technology should be gradually adopted to improve labor productivity, accelerate the construction speed, reduce the engineering cost and improve the engineering quality."<sup>[3]</sup> From this definition, it can be easily found that the industrialized buildings shift the carrying out of pouring from the previous construction sites to factories, and turn the construction method from the previous involving much manpower to machinery. Besides, it also has a relatively scientific and systematic method of organization and management, which brings the possibility of the green manufacturing of the construction industry.

Take the large panel buildings and frame panel buildings that are vigorously promoted in the Chinese industrialized building system for examples, due to their adoption of precast concrete (PC) components, the production of concrete that previous should be finished at the construction site can be shifted to the factory. Firstly, production in the factory is easier to manage compared to that in the construction site. Thus the production

of building materials can be achieved with higher utilization of water resources. Secondly, since the construction core of industrialized buildings is factorized production and prefabricated construction, its production site is substantially different from the traditional construction site. Large number of PC components like floor slabs, wallboards, roof panels, stairs, etc. are produced in the factory and assembled by machines in the site. The wet construction it involved in is merely foundation works, joint casting (in anti-seismic areas) and the production of several non-modular components. Its wet construction is no more than 40% of that of the traditional construction method, thus the water consumption in the construction site is greatly reduced. What's more, the construction period can be shortened around 50% by the industrialized production of buildings, because of which, the water consumption of builders is decreased accordingly and the hidden perils of fire safety are reduced as well. According to the latest statistics, compared with the traditional buildings, the industrialized ones have a comprehensive water conservation of more than 30%.<sup>[4]</sup> (Figure 1)



Figure.1 Comparison between the traditional construction site and present-day construction site

Nowadays, India is in its rapid development of the industrialization of buildings. Similar to China, the industrialized degree of buildings in many Indian areas is still in a preliminary level and is far behind the European and United State and other developed countries. If the positive impact of the industrialization of buildings on the protection and utilization of water resources can be realized as soon as possible, and industrialization can be promoted by the Indian government, the realization of rational utilization of water resources can be sped up.

### 3. Water consumption and conservation at the using and recycling stage of buildings

The designed lifetime of most Chinese buildings is 50 to 100 years and human beings will consume a lot of water resources in their habitation buildings. The domestic water consumption of buildings takes over more than half of the total urban water consumption and this percentage is increasing with the development of cities. Thus, it is very crucial to adopt effective water-saving measures during this stage. In addition, many buildings in China are demolished before their designed lifetime, which causes the waste of many building materials and components. If the dismantled and qualified building materials can be recycled, the consumption of water resources used in the production of these building materials can be indirectly reduced so as to achieve the fundamental objective of sustainable water utilization.

### **3.1 Direct water conservation at the using stage of buildings**

In the past, people's understanding on the water conservation of buildings is one-sided and they simply equal it with the application of water-saving equipment for buildings. For this point, Zhao Li, vice president of China Architecture Design Institute, evaluated that "In the past, water conservation is frequently mentioned. At the mention of 'water conservation', the application of water-saving equipment like closet pans, urinals, water-saving faucets, etc. will usually come to our mind. But from the perspective of a building, what is water-saving buildings? How to systematically save water? We still don't have a clear judging standard in China yet."<sup>[5]</sup> Thus it can be seen that the water conservation in China is far more than simply updating all the water equipment. The problems of water using at the using stage of buildings mainly lie in the following points: 1) the universality of the over-pressure overflow of water supply systems, and the imbalance of the supply pressure of cold and hot water; 2) the incomprehensive popularization of water-saving equipment; 3) the large discharge and poor circulating effect of hot water system's cold water; 4) the lack of utilization of rainwater and reclaimed water in many areas. Besides, the sustainable utilization of water resources is also hindered by the pipe leakage caused by the shoddy production of drainage pipes and equipment, insufficient precision of water meters, the phenomenon of stealing water caused by the inappropriate installation of water meters, etc.

On the above questions, this paper systematically put forward the following countermeasures from the perspective of rational utilization of water resources:

1) The top reason of the waste of water resources in building's water supply system is the over-pressure outflow of the water supply system. Thus, the water supply pressure should be controlled. Of course, the controlling of water supply pressure does not mean to decrease the pressure blindly. If the water supply pressure is insufficient and the cleaning

of the water coming out in a unit time cannot be completed, the water time will be prolonged by people, which will on the contrary increase the waste of water resources. Besides, different water terminals need different pressures. Take shower heads for example, the pressure they need is higher than that of faucets in the kitchen. The pressure that taps for mop sinks need is higher than that of taps for wash basins though they are all taps. Hence, since the water supply system is a quite complicated system, static pressure control cannot meet the purpose of water conservation. The right way is to frequently control the water supply according to the scale of buildings, and combine methods like pressure reduction of branch pipes to realize a flexible and rational control of water supply pressure.

2) Even though the water-saving devices have been in Chinese market for a long time, they currently still cannot be popularized in certain areas. Therefore, the water-saving devices should be promoted vigorously by the government. According to the rules of the national industry standard of "Domestic Water-Saving Devices" (CJ/T 164-2014), on the condition of economic capability, faucets, flush toilets and showers all should be water-saving ones. <sup>[6]</sup> The related statistics reveal that the water-saving rate can reach 24% or above with the use of all the water-saving sanitary ware. <sup>[7]</sup> However, as this standard is only recommendatory in the industry rather than compulsory, its implementation effect is quite limited as a result. The government should devote more efforts to the research and development of water-saving devices, strengthen its financial support and control the development direction of these devices from a macro level so that the promotion and sales of water-saving devices will not only be a market behavior. (Figure. 2)



Figure.2 Water economizer and the faucet with water economizer

3) The discharge of the cold water (the cold water in the non-cyclic branch pipes and stand pipes) in a hot-water system should be decreased to promote the use efficiency of the hot water. Most of the regions in China all adopt the non-cyclic hot-water systems, which means large amounts of invalid cold water should be let out before the use of hot water. This is not only a direct waste but a psychological suggestion left on the users' mind, which means the water without use efficiency can be wasted, so doubtlessly this suggestion can be extremely negative to the users. Therefore, as for the regions or places that provide hot water, the newly-built buildings should vigorously promote the recycling of branch pipes and stand pipes (the recycling of the main pipes does not matter too much) and old buildings should be reconstructed as soon as possible. <sup>[8]</sup>

4) The collecting system of reclaimed water and rainwater should be rapidly promoted, and scientific waste water acquisition system should be designed. According to the statistics, the content of the pollutant in the municipal waste water is only 0.1%, much lower than that of 3.5% in seawater. Besides, compared with the treatment of the seawater, its cost of reproduction is relatively low, so the reclaimed water system should be promoted vigorously. <sup>[9]</sup> For instance, the cooling water and water from shower, washing clothes and kitchen drainage can be collected for recycling so that even the reuse of water can be realized inside buildings. (Figure. 3) What's more, rainwater is widespread, low cost, easy to be collected, recycled and reused, so the collection of rainwater should be strongly advocated.





Figure.3 Shenzhen Institute of Building Research with reclaimed water system

### 3.2 Indirect water conservation at the recycling stage of buildings

The above discussions are concentrated on how to directly save water by control of water in the using stage of buildings. The last stage of the entire building life cycle—the stage of recycling is inevitable as well. Actually, the waste resources are seldom involved in the process of tearing down of buildings. The water conservation in this stage is actually indirect. Specifically, the building materials should be picked out when they are demolished. The due materials should be treated as ordinary construction waste while the undue ones, components and parts should be gathered for recycling after processing. In the short run, such dismantling method will surely increase cost but the materials saved can be used by other construction companies. Compared with the completely new building materials, the cost of these saved ones is lower. Additionally, there are less resources and energy involved in the reprocessing of these materials. Therefore, the water resources can be used economically at the terminal of the entire building life cycle.

## 4. Conclusion

China and India are both the countries with large population and limited resources, and the experience of resource conservation and environmental protection that these two countries have had are very similar as well. At present, the time has come that China is

highly vigilant about the environment and resource issues. In recent years, the Chinese government has issued many regulations on water and energy conservation. Undeniably, on the issue of environment, China has made many detours in the past and India can learn from these detours. Nevertheless, compared with the regions with rich experience of the protection and usage of water resources, we can find more space that has never been explored. We believe that in the future China and India can learn the valuable experience from each other and completely realize the sustainable utilization of water resources.

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