Investigation and analysis of Super Typhoon Lekima storm flood in Yuhuan

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Abstract: Typhoon disasters occur frequently in coastal areas of China, and heavy rainfall induced by typhoon often leads to flash floods, landslides, debris flow and other disasters in some areas. Based on the investigation of the disaster situation of Yuhuan city during Super Typhoon Lekima, through a large number of investigations, the causes of major disasters in Yuhuan city caused by Super Typhoon Lekima are found, and the shortcomings of flood control and drainage system in Yuhuan city are analyzed. Some suggestions are put forward to supplement the weak points and strengthen the supervision, which can also be used as a reference for disaster prevention and mitigation in other coastal areas with frequent typhoons.

1. Introduction
Zhejiang is affected by typhoons every year. Since 1949, an average of 3.3 typhoons have affected Zhejiang every year, and one typhoon has landed in Zhejiang every two years[1-3]. Yuhuan City is located on the southeast coast of Zhejiang, in the middle of China’s golden coastline, and the southern wing of the Yangtze River Delta Economic Circle. It borders the East China Sea in the east, Dongtou in the south, Yueqing Bay in the northwest and Yueqing City in the northwest, and Wenling City in the northeast. It is a high-frequency area where typhoons pass. It is one of the areas where typhoon storm surges frequently occur and are severely affected along the coast of Zhejiang.

Typhoons have the characteristics of strong wind, strong rainfall, wide impact, and high storm water increase. The strong rainfall induced by typhoons often causes flash floods in some areas, landslides, mudslides and other disasters. This article is to fully grasp the disaster situation of Yuhuan City and clarify flood prevention. The "shortcomings" of the flood drainage system exposed by this typhoon disaster have carried out a large number of investigations on the disaster situation of Yuhuan City after the "Lekima" typhoon.

2. Overview of Super Typhoon Lekima
At about 1:45 on August 10, 2019, Super Typhoon Lekima landed on the coast of Chengnan Town, Wenling City, Zhejiang Province. When it landed, the maximum wind force near the center was 16 levels (52m/s), making it the first landfall in Zhejiang since 1949. Three strong typhoons. Super Typhoon Lekima caused strong winds of magnitude 13-16 in Yuhuan City. The city's average 24-hour rainfall was as high as 392mm. This caused large-scale water and power outages and communication interruptions in Yuhuan, causing a large number of trees to fall and flooding in many places, causing major economic loss. According to statistics, there were 117 disaster-hit villages in Yuhuan City, with a population of 496,300 and 523 collapsed houses, resulting in a direct economic loss of 3.809 billion.
3. Survey methods and survey targets
The survey method used in this article is field survey\[4\]. The site of the field survey was located in Yuhuan City, Zhejiang Province. The subjects of the investigation included ten river systems in Gangnan and Gangbei of Yuhuan City.

4. Analysis of Causes of "Lekima Typhoon" Disaster
According to field investigation and analysis and comparison with planning data, Yuhuan City was severely affected by the impact of Typhoon Lekima, mainly due to the following problems\[5-6\].

4.1 Impact of excessive rainstorm
According to the "Yuhuan City Flood Control and Drainage Plan" (2018), the analysis of the rainstorm in Gangnan District uses the rainfall at the Yuhuan station instead of the regional rainfall. According to hydrological monitoring data, during the typhoon Lekima, the 24-hour maximum rainfall at Yuhuan Station was 341mm. According to hydrological analysis, the rainfall frequency was 3.80%. Rainfall occurred once in 30 years, exceeding the existing flood control standards.

According to the "Yuhuan City Flood Control and Drainage Plan" (2018), the rainstorm analysis in Gangbei District uses the rainfall at the Chumen station instead of the regional rainfall. According to hydrological monitoring data, during Typhoon Lekima, the maximum 24-hour rainfall at Chumen Station was 468mm. According to hydrological analysis, the rainfall frequency was 0.82%. Rainfall occurred once in 120 years, which was far greater than the existing flood control standards.

4.2 The flood control and drainage works of the river system are inadequate
4.2.1. Some rivers need to be dredged
Although Yuhuan City has dredged the river every year since the construction of the "Wanli Qingshui River" in 2003, it has basically completed two rounds of dredging tasks. However, the rivers in Yuhuan City are all river systems that only flow into the sea. The heavy rainfall in the "typhoon season" every year will cause a large amount of sediment to enter the river, and the back siltation is faster. In addition, in recent years, with the rapid economic and social development, the acceleration of infrastructure construction has also caused a certain degree of soil erosion and aggravated the siltation of river courses. With the siltation of the river course, the river bed is raised, the river surface is narrowed, and the tank storage function is weakened, which seriously affects the normal drainage and water storage functions of the river course. For example, the upper reaches of the Huangnikan River in the Renmintang River System have severely silted up.
4.2.2. Some rivers need to be widened

In some areas, due to the lack of attention to the original flood discharge and drainage functions of the river in the infrastructure construction process, the original water system was separated or the capacity of some bridges and culverts across the river was obviously insufficient, which caused the internal waterlogging of the river system to be blocked and difficult to drain. The situation caused severe damage. For example, the bayonet of the Longxi River Bridge has a net width of 6m, the upstream channel is 12m wide, and the lower reaches of the Chen'ao River is open. Under the influence of Typhoon Lekima, the upper reaches of the Longxi River had a submerged depth of up to 1.5m and the submerged duration was 15 hours.

4.2.3. Some rivers are blocked

According to the field survey, there are two temporary road landfills in the connecting section of Chatoutang River and Fangdoutang River, and the water system is poorly connected. The area between Chatoutang River and Fangdoutang River was submerged under the influence of Typhoon Lekima The depth is up to 1.5m, and the submerged time is 20-22h.
4.2.4. Water drainage capacity needs to be strengthened

In recent years, with the construction and operation of the Xuanmen Phase II and Phase III reclamation projects, most of the upstream river system floodwater can be stored in the Xuanmen Phase II and Phase III reclamation areas, effectively reducing upstream flood disasters, but there is still Tongli, Qinglan, and Jiuyan (part of) river systems are discharged into the sea and are easily affected by tidal support. At the same time, the construction of external discharge gates of some river systems is earlier and the scale can no longer meet the flood discharge requirements. For example, the Niutoushan Drainage Gate is located on the Daotou River, with a current net width of 1.6m. It is the only channel for the entire Daotou River area to drain into the Xuanmen Phase II Reservoir. It constitutes a flood channel bayonet and restricts the regional drainage capacity. The Daotou River Basin was seriously submerged in this typhoon Lekima.

4.3 Urbanization continues to expand, underlying conditions change, and block regulation and storage capacity weakens

In 2018, the urban built-up area of Yuhuan City was 23.23 square kilometers, an increase of 5.23 square kilometers from 2008. In recent years, Yuhuan City has continuously expanded its urban scale and increased its urbanization level, which has also caused great changes in the underlying surface conditions. The hardened road surface has increased, the ground elevation has increased, and the original farmland blocks that can store a certain amount of water has become an impermeable and non-regulated urban hardened land. The urban incremental land is mainly concentrated in the second phase of Xuanmen Bay. The overall regulation and storage capacity of the region has declined, the flood confluence time has become shorter, the flood peaks have become larger, and the flood pressure of the river channel Increase.
4.4 "In the event" and "after the event" management of construction projects in the river still need to be standardized

After Yuhuan was withdrawn from counties and cities, the construction of infrastructure projects continued to increase. More and more construction projects involved water areas or water conservancy engineering facilities, and there were more and more riverside approval and supervision tasks. However, the current supervision of personnel, technical capabilities and methods have not been matched, which has also caused some "lack of management" phenomenon in the supervision of some water projects, especially "in-the-fact" and "after-the-fact" management. For example, part of the water area near Shentang River has been landfilled due to the convenience of expressway construction, while the compensation water area in the nearby area is connected to Shentang River through bridges and culverts, and construction is currently underway. Under the influence of Typhoon Lekima, some areas in the upper reaches of Shentang River accumulated more than 1m of water and the waterlogged was discharged for 10 hours.

5. Conclusions and recommendations

The extreme rainstorms induced by Super Typhoon Lekima caused large-scale water and power outages and communication interruptions in Yuhuan City, a large number of trees fell, and many places flooded the country, causing heavy economic losses. This article investigates the disasters caused to Yuhuan City during Super Typhoon Lekima, and analyzes the causes of the disasters, from the impact of excessive rainstorms, the "short-board" of flood control and drainage projects in the river system, and the "short-term" supervision of river crossing and water conservancy projects. "Board" and other aspects systematically analyzed the causes of the serious disaster in Yuhuan City. The following suggestions are put forward for the construction of the flood control and drainage system in Yuhuan City:

(1) To make up for the "short boards" of the flood control and drainage engineering, through the
internal extension card of the river system to "make up the short boards" project, the water system connection "to make up the short boards" project, the river system gate station expansion "to make up the short boards" project, the river system Tuojun's "repairing shortcomings" project will improve the flood control and drainage standards of Yuhuan City, and enhance disaster prevention and resistance capabilities.

(2) In-depth implementation of the "strong supervision" of river-related and water conservancy projects, it is recommended to strengthen the supervision of inland rivers and lakes in accordance with the "Zhejiang Water Area Protection Measures", and engage in the three aspects before (design), during (construction), and afterwards (acceptance). Strengthen the protection and management of waters in each phase.

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