

# World Heritage Site Pingyao Historical and Cultural City Flood Disaster Damage Research and Reflection

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With the global warming, a large number of thermal energy formation typhoons caused by heavy rainfall frequently, located in the Asian region of Japan and China and other countries due to their geographical location and climatic factors, is a frequent area of heavy rain and flood disasters. In October 2021, the torrential rain in Shanxi Province broke through the record, and the ancient city of Pingyao became one of the most severely damaged areas in the flood disaster. Taking this as an example, this paper analyzes and studies the disaster mechanism of the ancient city through literature collection and other means, and examines the existing rescue and protection measures of the ancient city, and finally discusses and makes suggestions for the problems existing in the protection of the ancient city of Pingyao. It aims to provide reference for disaster prevention and mitigation methods for cultural heritage of historical and cultural cities under the influence of flood disasters.

**Keywords:** *World cultural heritage, Historical and cultural city, flood disaster, damage overview, disaster prevention measures*

## 1. Research background

### (1) Introduction to Pingyao Ancient City

Shanxi Province is located in north China (Fig 1), the terrain is undulating, the river valley is longitudinal, belongs to the temperate continental monsoon climate, perennial precipitation mainly occurs in June to September every year (Fig 2). Since ancient times, it has been a major province of cultural relics in China, and the number of cultural relics ranks third in the country. Pingyao Ancient City is located in Pingyao County, Jinzhong City, in the central part of Shanxi Province, with a history of about 2800 years, the total circumference of the Pingyao City Wall is 6163 meters, the height of the wall is about 12 meters, and the county seat covers a total area of 2.25 square kilometers. The streets, paving and city towers within the city wall retain the Ming and Qing dynasties, which is one of the larger, older and more completely preserved ancient city walls in China, and is also the core component of the World Heritage Pingyao Ancient City.

On December 3 1997, the 21st Session of the World Heritage Committee of UNESCO in Naples, Italy, inscribed the ancient city of Pingyao on the World Heritage List as a whole, which is a physical specimen for

the study of China's political, economic, cultural, artistic and religious development. Therefore, maintaining the authenticity and integrity of the ancient city of Pingyao and protecting its outstanding value are of great significance to the exploration of the protection mode of world cultural heritage in various countries.

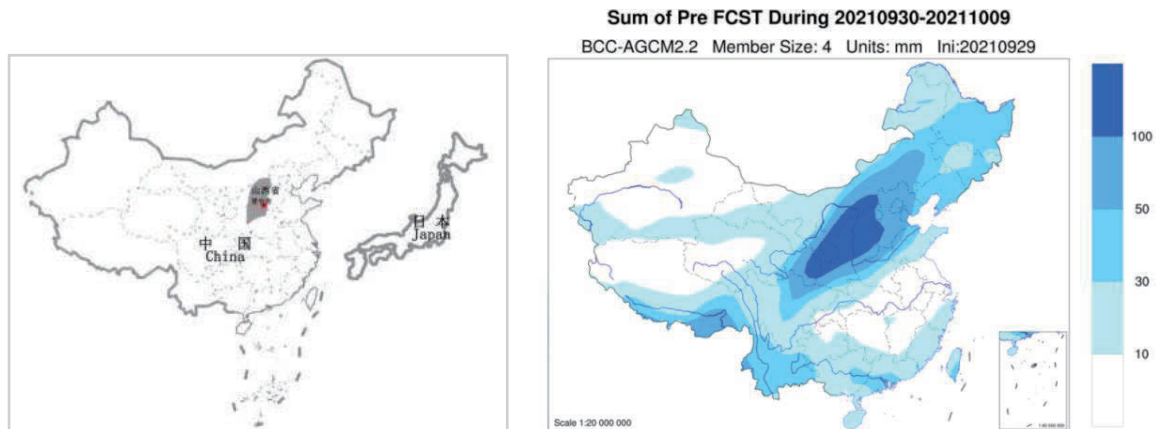


Fig. 1 Bit map of Jinzhong urban area (self-drawn)

Fig. 2 National cumulative precipitation forecast from September 30 to October 9, 2021<sup>1)</sup>

## 2. Overview of damage and protection of the ancient city of Pingyao under the flood disaster

### (1) Analysis of the damage characteristics and causes of flood disasters in ancient cities

#### a) Overview of damage to historic buildings

According to the "Pingyao Ancient City Protection Plan" promulgated by the Pingyao County Government, the ancient city is divided into absolute protected areas and first-class protected areas, but in addition to the key protection areas, there are still more protection planning ash spaces in the ancient city, of which few people patronize the streets and houses, and there are many places with different degrees of collapse and water seepage in this rainstorm. At the same time, due to the heavy rainfall for many days, the road in the ancient city of Neima Road was dangerous, and there were historical buildings on various streets that were threatened by the disaster, resulting in the collapse of the building wall (Fig 3) .

#### b) Overview of the damage to the infrastructure of the ancient city

Pingyao Ancient City is a very long history of historical and cultural city, as early as thousands of years ago the city has been arranged a perfect infrastructure system, but due to the ancient city for maximum protection, resulting in the city's water supply and drainage facilities are old and lack of renewal. During this heavy rainfall, the drainage in the city was blocked, resulting in floods, and a large amount of water in the city was concentrated at the north gate of the ancient city, flooding many roads in the city. Villages in Pingyao County were also severely damaged by the flood.



Fig. 3 Damage to buildings and streets in the ancient city<sup>2)</sup>

### c) Overview of the damage to the walls of the ancient city

As of October 5, the internal wall of No. 84 in Pingyao Ancient City had collapsed about 25 meters, and the remaining part of the wall collapsed and slipped in a total of 51 wall sections, and 15 of the rammed earth of the inner wall collapsed. Wall 84 is a long-standing rammed earth interior wall that was damaged by the collapse, and the outer surface of the wall appeared to be relatively intact. During the torrential rains, the walls were exposed to yellow walls, and the protective brick walls were damaged. The damage near the top of the city wall is more serious (Fig 4, Fig 5). In the past two decades, problems such as holes in the interior of the wall, partial collapse of the inner wall, large cracks in some walls, the disintegration of bricks in the outer city wall, poor drainage system at the top, and poor anti-seepage function have been plaguing the pingyao ancient city wall.



Fig. 4 Before the destruction of the city wall<sup>3)</sup>



Fig. 5 After the destruction of the city wall<sup>4)</sup>

## (2) Analysis of the effectiveness of protection measures under flood disasters in ancient cities

### a) Ancient city monitoring platform construction

The cultural relics department of Pingyao County has been concerned about the safety of the ancient city wall. Since 2016, all levels of finance have invested a total of more than 35.5 million yuan, repaired about 10 sections of Pingyao internal walls, and the Platform of the Monitoring and Early Warning System of the World Cultural Heritage of Pingyao Ancient City has been initially built before the flood disaster (Fig 6). However, at present, only four front-end monitoring equipment has been installed at four heritage element points to monitor cracks and slopes, including the city wall, the city tower, the Temple of Literature, and the former site of the Collaborative Celebration Ticket Number.



Fig. 6 Monitoring platform built by the ancient city<sup>5)</sup>

### b) Transformation of municipal infrastructure in ancient cities

In this flood disaster, although there was a problem of drainage blockage in the ancient city of Pingyao, before the flood, the protection of the ancient city had formulated a flood prevention emergency plan in combination with the situation of each drainage outlet, and completed the upgrading and transformation of



rainwater, sewage, water supply and other pipelines and road restoration programs for about 130 streets and alleys in the ancient city, in order to solve the problems of "poor drainage, bad ditches, and insufficient capacity of pipe networks" in the ancient city ( Fig 7 ) . At the same time, Pingyao County has carried out special research on key technologies for the low-impact upgrading and transformation of the political infrastructure of historical and cultural cities, key technologies and demonstrations for urban waterlogging risk prevention and control and system governance, and upgrading technologies for the upgrading of existing urban residential pipe networks.

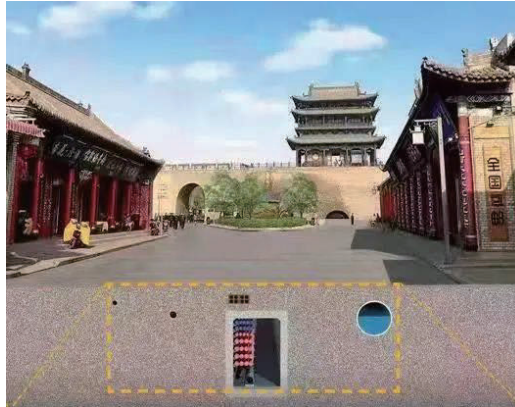


Fig. 7 Ancient city infrastructure renovation plan<sup>6)</sup>

### c) Formulate a plan for the repair of the city wall

After the disaster, the repair experts carried out phased repair according to the priority steps and according to the degree of damage, that is, the ancient city of Pingyao adopted the form of construction and reporting plan for the more serious damage, while the less damaged area was first formulated and then repaired, so as to reduce the damage caused by the heavy rain to the ancient city. Pingyao County also cooperates with universities and other research institutions to carry out experiments on rammed earth reinforcement of the city wall, changing its properties by debugging the formula of the soil, such as blending different proportions of ash in the rammed soil, or adding glutinous rice juice and aggregate to form a triad. The restoration method mainly uses the traditional method, using traditional materials, and repairing according to the prototype system using the rafter process to repair the old as old.

## 3. Flood disaster risk prevention problems and suggestions in historical and cultural cities

### (1) Disaster monitoring and early warning level

Disasters in the development of cultural relics protection has the characteristics of suddenness, so many residential buildings in the ancient city of Pingyao, due to the division of the protection system in the scenic spot, tourists often visit the places have been better policy protection and resource tilt, and some of the resource ash space residential buildings, in this rainstorm suffered from rain soaking after collapsing. Therefore, for world cultural heritage such as Pingyao Ancient City, disaster risk assessment and preventive protection are particularly important. Comprehensively cover the cultural heritage of Pingyao Ancient City for flood disaster risk assessment, make risk level judgments on different cultural relics, form a thematic database of cultural relics disasters, combine the existing Pingyao Ancient City World Cultural Heritage Disaster Early Warning Platform, and make full use of Internet big data and other technical means to build a complete set of Cultural Relics Disaster Monitoring and Preventive Protection System for Pingyao Ancient City, and open an expert online diagnosis of cultural relics and diseases, focusing on cultural heritage and



risk prevention<sup>7)</sup>.

## **(2) Planning plan level**

The occurrence of flood disasters is often due to the characteristics of watersheds in the geographical and geological environment, so the mapping and assessment of the geological and climatic environment is very critical for the protection of cultural heritage<sup>8)</sup>. The walls of pingyao ancient city have collapsed a total of four times due to rainfall, and this time Shanxi Province has caused great losses due to sudden heavy rainfall, and the response measures of Pingyao ancient city are particularly insufficient. Therefore, for the protection of cultural heritage in the category of historical and cultural cities, we should first conduct research on flood prevention planning and measures at the macro level of the whole basin, and increase the prevention and understanding of flood disasters in Pingyao County<sup>9)</sup>. In addition, flood prevention and disaster reduction planning should be upgraded to the legal level, the existing disaster protection management regulations, regulations and norms should be improved, and the policy guarantees or preventive measures for cultural heritage response to emergencies or extreme weather should be strengthened. Carry out special flood control planning for ancient city walls and residential buildings at the micro level, and improve the emergency plan system of Pingyao Ancient City.

## **(3) Repair management level**

At the level of protection management, because many houses in the ancient city of Pingyao are still inhabited, and most of them are classified as cultural security units, complex property rights and cost problems make the repair work of the houses in the ancient city have certain particularities, the process of residents declaring repairs is more complicated, and there is often a state of expensive residents ignoring them, residents are the first responsible person for cultural relics in the ancient city<sup>10)</sup>, so it is necessary to consolidate the main responsibility for the safety of cultural relics, clarify property rights, repair costs and policy subsidies at the same time, strengthen residents' awareness of the protection of cultural relics, Promoting the information linkage and rapid response between residents and cultural relics safety management departments and monitoring platforms, and form a perfect disaster protection system for ancient cities with bottom-up response and top-down command.

## **4. Conclusion**

The flood disaster caused by the heavy rains in Shanxi in 2021 is an extremely serious one, and under the influence of the flood, all aspects of the ancient city of Pingyao have suffered different degrees of damage and threats. Although in the previous maintenance, Pingyao Ancient City has taken a variety of flood disaster prevention measures, but the existing flood control capacity is still challenged by heavy rainfall, the future Pingyao Ancient City in the disaster monitoring and prevention, disaster prevention planning plan and post-disaster protection management and other aspects still need to continue to strengthen.

Due to its geographical location and climatic factors, Japan is also a country prone to torrential rains and floods, and its cultural heritage exposed to the climatic environment is constantly threatened by disasters such as floods. This paper hopes that through the analysis of the damage characteristics of world cultural heritage under the influence of floods and the effectiveness of flood prevention measures, it will play a certain reference and reference significance for the prevention and reduction of cultural heritage in Japan and other parts of the world.

**Acknowledgment:** This research is supported by Key R&D Projects of Sichuan Provincial Science and Technology Department (課題番号 : 2021YFS0367), National Key R&D Program(課題番号 : 2019YFC1520800). We would like to thank the various people who provided useful advices and helpful assistance during the whole writing process. Special appreciation goes to the all members of WHRC (World Heritage Research Center in Southwest Jiaotong University 西南交通大学世界遺産研究センター), for their intelligent insights and rigorous analysis. This article is part of the WHRC in SWJTU research results.

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