

Research on the Damage of Cultural Relics Buildings and Disaster Prevention Countermeasures in Heavy Rain in Henan, China

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In July 2021, China's Henan Province suffered from extreme rainstorms, and cultural relics were damaged to varying degrees in the torrential rain disaster. A total of 563 cultural relics were affected. Among all the disaster-affected cultural relics, the cultural relics buildings were damaged in the largest number, with a total of 470. The report examines the damage mechanism and causes of the rainstorm disaster and cultural relics buildings through literature collection and field research, and examines the damage of typical cultural relics buildings. Suggestions on disaster prevention and mitigation methods for buildings.

Keywords: *rainstorm disaster, heritage building, Disaster prevention measures*

1. Research Background

(1) Geographical location

Henan Province is located in central China, with a land area of 167,000 square kilometers, of which about 26% is mountainous, about 18% is hilly, and about 56% is plain (Fig. 1). Most of Henan is located in the warm temperate zone, and the southern part spans the subtropical zone. It has a continental monsoon climate with complex and diverse climates and frequent climatic disasters¹⁾. As the province with the most capitals in Chinese history, Henan ranks second in China for above-ground cultural relics and first in China for underground cultural relics. It has 358 key cultural relics protection units in China and 113 national intangible cultural heritages.



Fig. 1 Location map of Henan Province (self-drawn)

(2) Overview of rainstorm disasters

Since July 11, 2021, affected by the continuous heavy rainfall in southeastern Shanxi and northwestern Henan, the water level of rivers in Henan has risen, causing natural disasters such as mountain torrents. Mainly concentrated in the west, north and central²⁾. From 08:00 on July 20 to 06:00 on July 21, 2021, there were heavy rainstorms (250-350 mm) in Zhengzhou, Xinxiang, Kaifeng, Zhoukou, Jiaozuo and other places, and some areas in Zhengzhou reached 500-657 mm, Zhengzhou, Xinxiang, Henan, Kaifeng, Zhoukou, Luoyang and other places a total of 10 national-level meteorological observation stations daily rainfall exceeded the historical extreme value since the meteorological record³⁾.

As of September 24, after investigation, there were a total of 563 cultural relics affected by the disaster in Henan Province, including 90 national cultural relics protection units, 109 provincial cultural relics protection units, 215 city and county cultural relics protection units, and 131 unrated immovable cultural relics. 19 museums and some archaeological excavation sites (Table 1).

Table 1 Statistical table of cultural relics affected by heavy rain in Henan Province (self-drawn)

Heritage type	National cultural relics protection unit	Provincial cultural relics protection unit	City and county-level cultural relics protection units	Unrated immovable cultural relics	Museum
Number	90	109	215	131	19
Percentage	16%	19%	38%	23%	4%

2. Overview of Damage to Cultural Relics

(1) Statistics on the number of damaged cultural relics

Among the 563 cultural relics affected by this disaster, they are mainly divided into four types: cultural

relics buildings, Grotto temples and stone carvings, ancient tombs and museums. Among them, cultural relics and buildings suffered the most, with a total of 470, accounting for 83%. 14 cave temples and stone carvings, accounting for 2%; 60 Ancient tombs, accounting for 11%; 19 museums, accounting for 3% (Table 2).

Among the 470 cultural relics buildings affected by the disaster, there are 45 cultural relics protection units at the national level, accounting for 9%; 93 cultural relics protection units at the provincial level, accounting for 20%; and 202 cultural relics protection units at the municipal level, accounting for 43%. , there are 130 ungraded cultural relics building units, accounting for 28% (Table 3).

Table 2 Proportion of types of disaster-stricken cultural relics in Henan (self-drawn)

Heritage type	Cultural relics buildings	Grotto temples and stone carvings	Ancient tombs	Museum
Number	470	14	60	19
Percentage	83%	2%	11%	3%

Table 3 Proportion of damage to cultural relics in Henan (self-drawn)

Heritage type	National cultural relics protection unit	Provincial cultural relics protection unit	City and county-level cultural relics protection units	Unrated immovable cultural relics
Number	45	93	202	130
Percentage	9%	20%	43%	28%

(2) Statistics on the damage degree of cultural relics

In order to summarize the damage of cultural relics buildings, according to the actual investigation of cultural relics buildings, the damage grades of cultural relics buildings are divided into three levels: general, heavy and serious.

Severely damaged: 1. The cultural relics are completely or partially washed out or collapse in a large area, the damaged area of a single building accounts for more than 20%, and the roof of the building collapses or collapses more than 50%. 2. Although the building has not collapsed, the structure is in an extremely dangerous state. For example, the beam frame is seriously unbalanced and may collapse at any time, and the wall is seriously inclined and deformed.

Moderately damaged: 1. The damaged area of a single building accounts for less than 20%, and the roof of the building collapses or collapses less than 50%. 2. Although the roof of the cultural relic building has collapsed, and the beam frame and wall have local cracking or deformation, the overall structure is stable.

Mildly damaged: The overall preservation of the building is good, and only minor damages, such as local leakage, small-scale damage to the roof or partial cracking of the wall, do not affect the stability of the overall structure.

Among the 470 cultural relics buildings assessed this time, there are 138 cultural protection units with severe damage, accounting for 29%; 164 cultural protection units with moderate damage, accounting for 35%; There are 168 cultural protection units with mild damage, accounting for 36% (Table 4). It can be seen from the figure that the reported disaster-stricken cultural relics are relatively average, but the proportion of severely-stricken cultural relics is lower than that of the heavier and average, less than one-third of the overall reported

disaster-stricken cultural relics.

Among the cultural relics buildings, there are 158 ancient buildings in the key cultural relics protection units of China in Henan Province, and 35 important historical sites and representative buildings in modern times. Among the cultural relics buildings reported by Henan Province this time, there are 45 national key protection units, of which 8 are severely damaged national security units, accounting for 4% of the total, and 18 are severely damaged national cultural relics protection units, accounting for 9%, 19 state-level protection units were moderately damaged, accounting for 10%, and 148 state-level cultural relics protection units were not reported to be affected, accounting for 77% (Table 5).

Among the cultural relics buildings, there are 428 ancient buildings in key cultural relics protection units in Henan Province, and 169 important historical sites and representative buildings in modern times. There are 93 cultural relics protection units at the provincial level among the damaged cultural relics buildings reported by Henan Province this time, of which 27 are severely damaged provincial cultural relics protection units, accounting for 5% of the total, and moderately damaged provincial cultural relics protection units There are 29 units, accounting for 5%, 37 provincial-level cultural relics protection units with minor damage, accounting for 6%, and 504 provincial-level cultural relics protection units that have not reported disasters, accounting for 84% (Table 6) . It can be seen from the figure that nearly 90% of the cultural relics buildings in the provincial cultural relics protection units in Henan were not damaged, and the proportions of severe, moderate and mild damage were relatively average. From this, it can be concluded that the proportion of severely damaged national cultural relics protection units in the cultural relics building category in Henan Province is lower than that of moderate damage and mild damage, more than half of the national cultural relics protection units have not been affected, and the overall Better protection.

Table 4 Damage to cultural relics buildings (self-drawn)

Damage grades	Severely damaged	Moderately damaged	Mildly damaged
Number	138	164	168
Percentage	29%	35%	36%

Table 5 Disaster situation of national cultural relics protection units of cultural relics buildings (self-painting)

Damage grades	Severely damaged	Moderately damaged	Mildly damaged	Not damaged
Number	8	18	19	148
Percentage	4%	9%	10%	77%

Table 6 Disaster situation of provincial cultural relics protection units of cultural relics buildings (self-painting)

Damage grades	Severely damaged	Moderately damaged	Mildly damaged	Not damaged
Number	27	29	37	504
Percentage	5%	5%	6%	84%

(3) Summary of Damaged Forms of Cultural Heritage Buildings

a) Roof leaks

The lap joint structure of traditional Chinese sloping roof and tile is complex, which requires extremely high level of craftsmanship and construction quality. The structure below the tile, in the higher-grade buildings, has generally good quality; but in general residential buildings, the materials used are frugal, the strength itself is not enough, once it is affected by heavy rain erosion, its joints easily damaged. In the rainstorm disaster in Henan, China, there were many cases of roof leakage in damaged cultural relics buildings.

b) Structural instability

The precipitation of this torrential rain is strong and lasts for a long time, and it has a great impact on buildings, especially some buildings that lack daily maintenance, which are most likely to be damaged in this rainstorm. The damage to the building wall and wooden frame will lead to the instability of the overall structure of the building, resulting in potential safety hazards.

c) Peeling paint

Affected by the uplift of the surrounding ground and the lack of drainage capacity of the cultural relics buildings, the cultural relics buildings such as the Jigong Temple in this heavy rain disaster were soaked in the accumulated water for a long time. Under the scouring of the rainstorm, the roof leaked, and the rainwater penetrated into the room through the cracks in the components. The indoor beams and columns were eroded by the rainwater, and the surface paint fell off.

(4) Causes of damage to heritage buildings

a) Torrential rain

Long-term rainstorm erosion can easily lead to damage to the connection of building components, which not only damages the cultural relics building components, but also affects the interior decoration of the cultural relics building due to the rainwater immersed in the room. In this rainstorm disaster in Henan, the scouring of the rainstorm caused the roofs of cultural relics such as the Shan-Shaan-Gan Guild Hall to leak.

b) Stagnant water immersion

The impact of standing water immersion on buildings is small. From the observation of the damage to the cultural relics buildings that have been investigated, the standing water immersion for several days does not have a significant impact on the building foundation and wall stability. It didn't affect it too much.

c) Rainwater reflux

The rise of surrounding ground leads to rainwater recharge, which not only aggravates the property loss within the scope of cultural relics, but also poses great difficulties for drainage. At the same time, the ground uplift makes the column root and wall foundation in soil immersion for a long time, affecting the stability of the building structure.

3. Damage of Representative Cultural Relics Buildings

(1) Shan-Shaan-Gan Guild Hall

Located in Kaifeng City, Henan Province, China, the Shan-Shaan-Gan Guild Hall has a history of more than 200 years. The hall is a quadrangle layout, mainly with wooden structure, accounting for 3866.67 m², the building area of 1882.51 m².

Under the influence of continuous heavy rainfall, the guild hall was washed by rainstorm and soaked in accumulated water (Fig. 2). Although the overall preservation of the building is good, the structure is stable, but there are roof leakage, doors and windows columns paint off (Fig. 3). The building of the hall is a brick-

wood structure, and the rainstorm mainly causes serious roof damage of the east and west compartments, and many roof leakages. Leakage occurs in the gullies of the hall, the north house of the west span courtyard and the north house of the east span courtyard.



Fig. 2 Water in the Hall



Fig. 3 Paint peeling off

(2) Jigong Temple

Jigong Temple is located in Zhengzhou City, Henan Province, China. The temple was built in the Tang Dynasty, and now the temple is rebuilt after the Tang Dynasty. Under the influence of this rainstorm disaster, Jigong Temple was soaked in accumulated water⁴⁾. And the roof wall was scoured by rainstorm (Fig. 4). Continuous heavy rainfall results in unsmooth drainage and serious surface water accumulation, resulting in erosion of foundation and peeling off of wall paint (Fig. 5). The surrounding environment of Jigong Temple was damaged by large area of rainwater immersion, sludge sand accumulation, vegetation greening and other cultural relics.



Fig.4 Jigong Temple accumulated water⁵⁾



Fig.5 paint peeling off⁵⁾

4. Reflection

(1) Imperfect linkage mechanism for early warning and response

In this disaster, the meteorological department of Henan Province closely monitored the weather changes and released the monitoring and forecasting warning information on a rolling basis, but the relevant cultural relics protection units did not take early warning response action in time to delay the timing of cultural relics protection.

(2) Lack of unified command

In the face of this disaster, due to the lack of specific unified arrangements for the protection of cultural relics, there is no leadership in the command center at a critical moment to sit in town to command and control the overall situation, due to poor communication, poor information and lack of understanding of the overall

disaster situation of cultural relics, the relevant leadership has lost the initiative to deal with this global disaster⁵).

(3) Lack of daily maintenance

Although there are regulations related to the maintenance and maintenance of cultural relics buildings in China, there are some difficulties in the daily maintenance of cultural relics buildings in reality. The main reasons are as follows : 1.The staff of grass-roots departments is insufficient. 2.The special maintenance funds cannot be implemented in time. 3.The cultural relics buildings cannot be repaired in time in remote areas⁶). In this rainstorm disaster in Henan, cultural relics buildings were damaged due to inadequate maintenance.

5. Protection Suggestion

(1) Improving the linkage mechanism of early warning response

To establish a monitoring and early warning system for rainstorm disasters and emergency plan for disaster prevention and mitigation, strengthen the integrated management of early warning and response, ensure that the relevant departments can respond to early warning in the first time when disasters occur, and make corresponding protective measures according to emergency plans.

(2) Improving the Responsibility System of Cultural Relics Protection

Vigorously improve the risk awareness and emergency response capacity of leading cadres, enhance leadership and overall awareness, and clarify the specific division of labor between leaders. Leading cadres can rush to the scene at the first time when disasters occur, clarify their responsibilities and tasks, and give full play to the leading role in the protection of cultural relics and buildings.

(3) Enhance daily maintenance and maintenance

Governments at all levels should implement their own responsibilities and give support to relevant experts, policies and funds. This paper investigates the damage of cultural relics buildings and compares them with those before the disaster, establishes relevant databases, analyzes the damage degree and causes, puts forward scientific basis for daily maintenance, and explores new ways and methods for the protection of cultural relics buildings. Establishment of traditional materials base for brick, tile, stone and other ancient buildings to ensure the authenticity and quality of maintenance materials for ancient buildings⁷).

6. Conclusion

In the July 2021 rainstorm in Henan Province, cultural relics in Henan Province were affected to varying degrees, and the number of damaged cultural buildings was the largest. The disaster reflects that there are many problems in the protection system of cultural relics buildings in China. The disaster early warning system, disaster emergency response plan and daily maintenance of cultural relics buildings need to be improved.

Japan has many cultural heritages, and meteorological disasters occur frequently. Cultural heritages are vulnerable to natural disasters such as earthquakes and floods. This paper summarizes the disaster situation of cultural relics buildings in Henan Province in July 2021, analyzes the problems existing in the emergency protection of cultural relics buildings, and puts forward corresponding protection suggestions. It is hoped that

the research report will have certain reference value for disaster prevention and mitigation of cultural relic buildings in Japan and other countries in the world.

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