

# DAMAGE INVESTIGATION AND ANALYSIS OF POLYCHROME PAINTINGS ON TIMBERS OF HISTORIC ARCHITECTURE IN ZHEJIANG, CHINA

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## ABSTRACT

Polychrome painting, as painting on historic wooden members, is one of the most important surface decorations of Chinese traditional architecture, containing tremendous values of history, culture and art. The conservation of polychrome paintings is worrying overall, because of the vulnerable materials used and long-time neglects. Systematic research into polychrome paintings are the prerequisite and foundation of preservation. The previous study of polychrome paintings on timbers focused on the north China area, such as Beijing, Shanxi and Hebei provinces. However, knowledge of polychrome paintings in Zhejiang is almost non-existent, except for a few cases in the northern area, as Zhejiang is considered to be a small part of the South Yangtze-River region in traditional architectural research due to the huge gap between the South Jiangsu area in terms of the quantity and quality of paintings. However, evidence shows that there are better and richer painting resources in the Zhejiang area than expected during the latest survey of immovable historic relics. In this study, 11 architectural sites with probably rich remains were selected and the polychrome paintings on these architectures were investigated. Significant information such as damage types and areas were obtained. It is found that the damage conditions of polychrome paintings in Zhejiang are quite different from those in the north and also different from the South Jiangsu area because of their special structures and characteristics.

*Keywords: polychrome painting, damage type, damage area, Zhejiang area.*

## 1 INTRODUCTION

As one of the most important surface decorations of Chinese traditional architecture, polychrome paintings on timbers contains tremendous values of history, culture and art. In recent decades, these values have been gradually excavated and recognized, and the research and protection of polychrome paintings have become increasingly trendy. Nevertheless, the remains of many paintings are not effectively protected, most of them still continue to face the risk of decline even destruction. Data of polychrome paintings in Zhejiang is almost blank except for a few cases in the northern area, as Zhejiang is usually considered as a small part of South Yangtze-River region in traditional architectural painting researches due to its huge gap between South Jiangsu area above the quantity and quality of paintings. However, evidence from latest immovable historic relics suggests that the Zhejiang area has better and richer resources than previously considered, which are also very different from northern area and South Jiangsu area.

Polychrome painting has three layer structures: timber layer, plaster layer, pigment layer. And crafts used on different layers influence the damage conditions. Polychrome paintings in China are divided into four regions respectively: the northern area of China, South Jiangsu area, Zhejiang area and other areas based on content and purpose of this research.

On the basis of detailed literatures and examples in Forbidden City, polychrome painting researches in the northern area focus on the repairing and repainting. For example, Yong Lei [1] had a study on conservation and application conditions for Smalt, an imported blue pigment, in Forbidden City. Liqin Wang [2] found Paris Green, a synthetic pigment after analyzing 27 pigment samples of green gathered from Beijing, Shanxi and Gansu province. Zhaojun Li [3] listed pigments in Summer Palace during an ultraviolet aging experiment.



Zhou and Wang [4] analyzed materials used in plaster layer in Summer Palace with XRF, XRD and EDS. Mazzeo found plaster layer in drum tower of Xi'an matching the literature records. Bingbing Zhao [5] used polyvinyl acetate emulsion (PVAC) and B72 in the Guangji Temple repairing in Jinzhou. The prominent feature of the northern area is complex and exquisite crafts in plaster layer such as "a hemp with five ashes". Ruitian Ma [6] inferred that complex plaster crafts show the inevitability to deal with pieces of timbers because big woods are short of after late Ming dynasty due to generations of endless deforestation. And detachment, flaking, craquelure and plaster loss are main damage types in the northern area.

Without thorough literatures, polychrome painting researches in South Jiangsu area concentrated on its rich remains. After studying painting's significance, crafts and patterns in South Yangtze-River region, Lifang Ji [7] concluded that polychrome paintings in South Yangtze-River region have clear inheritance relationship with paintings described in *Ying Zao Fa Shi*, a book which records Chinese traditional architectural handcrafts a thousand years ago. Weijun He [8] analyzed timbers and pigments of polychrome paintings in Zhao Yongxian's House in Changshu with XRD, FT-IR, EDS and video microscope. Fei Xu [9] listed pigments and damages of paintings in Confucian temple in Rugao during the repairing project. Decai Gong [10] made progress in repairing paintings in Yan ne's House in Changshu with traditional materials after analyzing samples. With high-quality timbers and stable climate, plaster layer of polychrome painting in South Jiangsu area is usually thin compared with the northern area. And craquelure, color changing, peeling, wormholes and molds are frequent in South Jiangsu area.

Polychrome painting researches in Zhejiang area are confined to the northern, while both literatures and remains are almost unknown. Team from Nanjing Museum [11] analyzed ingredients of timber layer, plaster layer and pigment layer of polychrome paintings in Confucian temple in Hangzhou with EDS, and describes damage conditions. Lifang Ji [12] mentioned locations with polychrome paintings in northern area of Zhejiang such as Lingyin Temple and Fenghuang Temple in Hangzhou, but detailed information isn't provided. As "the lower level of polychrome paintings in South Yangtze-River region", paintings in Zhejiang usually don't have plaster layer. Whether "polychrome paintings in South Yangtze-River region" or "polychrome paintings in Taihu basin" connect Zhejiang area with South Jiangsu area can help us find out characteristic and source of polychrome paintings in Zhejiang area. However, most of evidences come from South Jiangsu area, and a few cases in the northern area of Zhejiang are too hard to reveal the whole picture of Zhejiang, so it's necessary to have in-depth investigations.

Other areas of China also have painting researches. Yong Wang [13] studied polychrome paintings' features in Hubei Province, and infers that the paintings show the influences of official paintings, Chu culture in local and architecture culture in surrounding area. Cheng Huang [14] discussed culture connotation and artistic significance of paintings in Huizhou on the background of politics, economy and culture. Zhirui Wang [15] tried to find the relationships between Mongol paintings and official paintings through studying patterns and crafts of polychrome paintings in Zhao Temple. Hongfeng Yao [16] tried to find effective protection methods after finishing damage investigation and ingredient detection of typical polychrome paintings in Quanzhou. Paintings in other areas have no obvious relation to Zhejiang area, but also have the regional features.

Painting researches in European countries started very early. Gill Nason [17] did environment monitoring for the great painted staircase at Knole by collecting information about temperature and humidity as well as light, tourist damage and salinity. Gerhard Gröll [18] did humidity monitoring for paintings on wood at 5 sites in Europe for two years. Ruth Bubb [19] proceeded protection research for xylographs of the Middle Age in The Penn Doom. Charlotta Bylund Melin [20] took a comparison of church's heating energy and damage types to show relationships between indoor climate and climate-induced damages.

Rowena Hill [21] explored methods for protecting traditional paintings of environment, materials and crafts in Papua New Guinea.

In conclusion, the prominent feature of the northern area is complex and exquisite crafts in plaster layer, while complex plaster crafts may show the inevitability to deal with pieces of timbers as big woods are short of after late Ming dynasty due to generations of endless deforestation. With high-quality timbers and stable climate, plaster layer of polychrome paintings in the southern is usually thin even absent. The difference of plaster crafts may influence damage types, as detachment, flaking, craquelure and plaster loss are main damage types in the northern area, while craquelure, color changing, peeling, wormholes and molds are frequent in the southern area. Polychrome paintings in Zhejiang area as part of South Yangtze-River region paintings has reasonability for similar natural environment and cultural characteristics. Even so, scanty cases in Zhejiang cannot readily show the true relationships, more investigations should be performed to construct a complete research system of polychrome paintings in Zhejiang area.

By means of making detailed field investigations and experimental analysis, this research tries to sum up the characteristics of diseases of polychrome paintings in Zhejiang Province and provide the premise and basis for the follow-up conservation and protection works.

## 2 RESEARCH PROCESS AND METHODS

The investigation involves 11 sites among Yueqing, Ninghai, Jiangshan and Shengzhou counties. Yueqing has a strong tradition of patriarchal clan with numerous ancestral halls. Ninghai is famous as the township of China's ancient stage, where remains plenty of historic stages. Located in the mountainous area of western Zhejiang, Jiangshan has a relatively stable culture inheritance. Shengzhou, as the township of Yueju opera, also has a long history of drama culture. All these factors may have favorable impacts on the conservation of polychrome paintings. Besides, large span of geographic range can make the sample more persuasive as the 4 counties respectively belong to the southeast, east, west and middle of Zhejiang (Fig. 1).

The basic information (age, degree of protection, repairing history, etc.) of historic architectures and polychrome paintings on it can be acquired by referring to archives such as chorography, genealogy and materials from administration of cultural relics. And basic information of 11 sites is listed in Table 1.



Figure 1: Distribution of counties and Zhejiang's location in China.

Table 1: Basic information of 11 investigation sites.

<i>Number</i>	<i>Site</i>	<i>Location</i>	<i>Protection grade of architecture</i>	<i>Age of architecture</i>
1	LinAH	Yueqing	County preservation unit	1768
2	LGT	Yueqing	County preservation unit	1789
3	YAH	Ninghai	National preservation unit	1911
4	HAH	Ninghai	National preservation unit	1809
5	PAH	Ninghai	County preservation unit	1851–1911
6	LiAH	Ninghai	County preservation unit	1851–1911
7	MAH	Jiangshan	County preservation unit	Architecture: 1573–1620 Paintings: 1851–1911
8	WCT	Jiangshan	Province preservation unit	Architecture: 1909–1911 Paintings: 1912–1913
9	WAH	Shengzhou		1736–1795
10	ZAH	Shengzhou		1621–1722
11	XZT	Shengzhou		1851–1911

LinAH: Lin's Ancestral Hall; LGT: Leigong Temple; YAH: Yu's Ancestral Hall; HAH: Hu's Ancestral Hall; PAH: Pan's Ancestral Hall; LiAH: Li's Ancestral Hall; MAH: Mao's Ancestral Hall; WCT: Wenchang Temple; WAH: Wang's Ancestral Hall; ZAH: Zhu's Ancestral Hall; XZT: Xinzen Temple.

Statistics for damage areas and types, samplings for painting materials, as well as photo recordings for both itself and its environment of polychrome painting could be finished in the fieldwork. According to “Diseases and legend of polychrome paintings on historic buildings” (WW/T 0030-2010) issued by state administration of cultural heritage of China, the diseases of polychrome paintings are divided into 19 types including cracks, flaking, detachment, damage by animals, damage by microorganism etc. Furthermore, damage by plant and repainting are considered as new damage types based on field investigations.

Component analysis about timber layer, plaster layer and pigment layer of polychrome paintings could be finished in laboratory with XRD, EDS, immunology method.

### 3 RESULTS AND DISCUSSION

Damage types and areas of polychrome paintings are shown in Table 2.

The proportions of areas of different damage types can be intuitively seen in Fig. 2.

Diseases of polychrome paintings in Zhejiang have features which can be seen from the 11 cases of damage types and areas.

#### 3.1 Historical vandalism

Historical vandalism mainly manifested lime coverings and broom scratches during the Cultural Revolution (Fig. 3), when polychrome paintings were regarded as outdated things that must be eliminated, and expressed as other pollution and paint loss in damage types. It's a very common phenomenon with the biggest damage area, which has a great impact on the appearance of paintings. For example, Li's ancestral Hall in Ninghai is a house for progenies of an emperor (685–762) in Tang dynasty, and polychrome paintings of dragons and phoenixes which spread over doors and stages were scarping off during the Cultural Revolution, the quantity of remain gold leaves on stages still show its high specification (Fig. 4).



Table 2: Statistics of damage areas among 11 investigation sites (m<sup>2</sup>).

<i>Site</i>	1	2	3	4	5	6	7	8	9	10	11	<i>Total</i>
<i>Damage type</i>	<i>LinAH</i>	<i>LGT</i>	<i>YAH</i>	<i>HAH</i>	<i>PAH</i>	<i>LiAH</i>	<i>MAH</i>	<i>WCT</i>	<i>WAH</i>	<i>ZAH</i>	<i>XZT</i>	
Painting area	18.8	1.5	17.9	61.7	58.1	40.4	11.5	180	3.9	15	35	443.8
Damage area	12.4	1.3	17.4	49.8	49.3	27.8	3.7	33.5	6.1	7.3	23	231.6
Cracks			0.2	0.8	0.18	0.5				2	0.5	4.18
Craquelure									2			2
Flaking								2	0.01			2.01
Detachment			0.02									0.02
Plasters loss			0.1				0.3	5	0.2		0.3	5.9
Paint loss	0.5	0.3		2	4	0.1		1	0.05	0.2	0.2	8.35
Gold-leaf loss			0.1			0.5						0.6
Color changing	3.5	0.5	0.1	5	20	5		0.01	3	2	1	40.11
Fouling	0.2					0.1	0.5	1	0.8			2.6
Water stains							2.5	20				22.5
Damage by animals	0.5		0.5	5	4	2				0.5	10	22.5
Damage by microorganism	0.1		0.2	10	0.5	2		4.5				17.3
Other pollution	7.6	0.5	16	25	20	17.6					20	106.7
Artificial damage	0.01		0.19	2	0.6	0.01			0.05	0.4	0.01	3.27
Damage by plant							0.4					0.4
Repainting										2.2		2.2

Note: Five types of damage, including disruption, peeling, powdering, scaling and lampblack, have been removed from the table because none of those appear in the filed investigation.

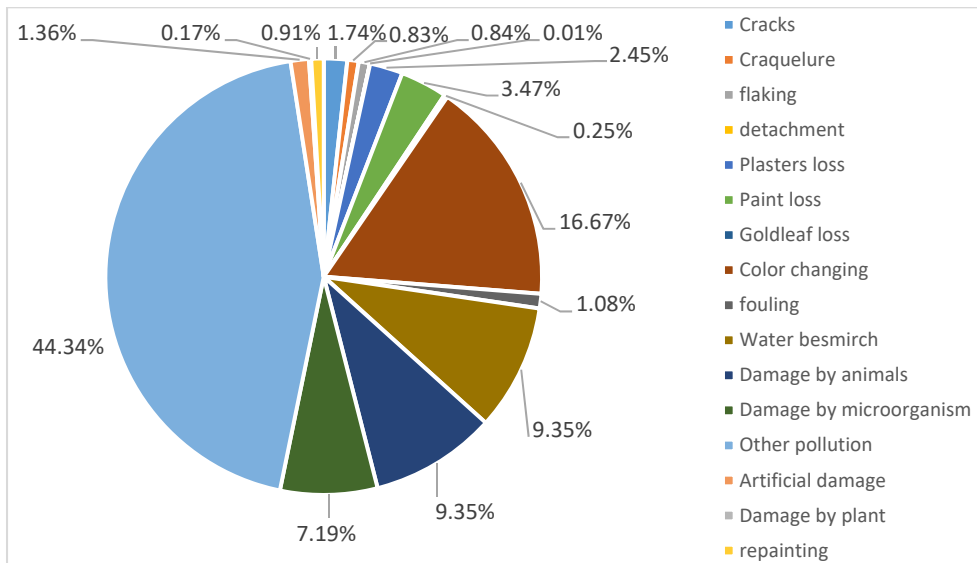


Figure 2: The proportions of areas of different damage types.



Figure 3: Broom scratches in PAH.



Figure 4: Lime covering in LiAH.

### 3.2 Biological damage

Biological damage includes damage by animals and damage by microorganism. Damages by animals include wormhole, bird's nest and honeycomb, among which wormhole is the most widespread and severe damage (mostly termite damage); mold is the main type of damage by microorganism, which is also common in the investigation. There are also a few damages by plant such as moss covering in Mao's Ancestral Hall at Jiangshan. Biological damage is dangerous because it not only has the impact of appearance of paintings, but also multiplies a threat to the timber layer (Figs 5 and 6). For example, Hu's ancestral Hall in Ninghai is a building of 200 years old, and nearly 30% of its polychrome paintings have wormholes and molds, timbers even change positions in some important bucket arch, which largely destroy the stability of building structure.

### 3.3 Leaking rain and water stains

With the subtropical monsoon climate, precipitation in Zhejiang area is large and concentrated, thus leakage of rain is quite common in traditional timber architectures. Accordingly, water stains are quite frequent during the monsoon (Figs 7 and 8). Water plays an important role in making paintings change color and molds grow.



Figure 5: Wormholes and molds in HAH.



Figure 6: Wormholes in YAH.





Figure 7: Leaking rain in LiAH.



Figure 8: Water stains in WCT.

### 3.4 Cracks

Cracks occur frequently on wood structures of the late Qing Dynasty (Fig. 9). On the one hand, it may be because the high-quality wood is scarce after thousands of years of deforestation, so the inferior such as pine was using for building, which is more likely to produce cracks. On the other hand, due to the lack of whole woods, the joints of mall pieces of woods may reduce the integral intensity (Fig. 10).

### 3.5 The type of craft affects the type of damage

Most of polychrome paintings at Zhejiang area don't have complex plaster layer, and damages such as detachment, flaking, disruption are infrequent (Figs 11 and 12). It may infer that pigment can fit timber better than plaster.

And in a small amount of polychrome paintings with plaster layer, paint and plaster loss are normal, but wormholes are almost absent. It may infer that plaster with enough thickness can help to prevent wormhole. As a half-official building, Wenchang Temple in Jiangshan has the most painting remains in Zhejiang. Frequent plaster loss and infrequent wormholes show with crafts of thin plaster layer consists of  $\text{CaCO}_3$  and  $\text{CaSO}_4$  (Fig. 13). And on the wood door at Wang's Ancestral Hall in Shengzhou, pivots are filled with wormholes while planks have none with complex plaster (Fig. 14).



Figure 9: Cracks in XZM.



Figure 10: Connected ways of timbers in ZAH.



Figure 11: Painting of plum blossom in PAH.



Figure 12: Painting of wars in ZAH.



Figure 13: Painting with plaster in MAH.



Figure 14: Wormholes on wood door in WAH.

It should be noted that damage area and damage severity are not completely positive correlation. For example, the area of lime covering is large and has great impact on the appearance of polychrome paintings, but the lime layer can effectively protect paintings from harmful gases and water which may erode paintings from external, paintings with lime layer covering usually have more vivid colors than those without lime through the investigations. By comparison, wormholes and molds usually have small areas but have much severity as they provide huge menace to the timber's stability. Therefore, protection grade of polychrome painting should be suggested to describe conditions of a painting and its environment. Three grades are formulated on the basement of actual situation for Zhejiang area: Grade 1: stable condition and no need for protection; Grade 2: inferior condition and need for positive measures; Grade 3: poor condition and need for rescuing conservation (see Table 3).

#### 4 CONCLUSION

Damage characteristic of polychrome paintings at Zhejiang area has its own reasons, which are different from the North China and South Jiangsu area: lime pollution and pigment stripping by historical vandalism, wormholes and molds under semi-tropics weather, leaking rain and water stains in monsoon climate, cracks caused by kinds and connection ways of timbers, and infrequent detachment, flaking, disruption due to the absence of plaster layer.





Table 3: Protection grades of polychrome paintings for 11 sites.

Number	Site	Grade	Comment
1	LinAH	2	Severe color changing for covering by tung oil
2	LGT	1	Covering by red lacquer
3	YAH	2	Covering by lime, wormhole
4	HAH	3	Severe wormholes and molds, corruption and transposition of timbers
5	PAH	2	Molds
6	LiAH	2	Covering by red lacquer, severe leaking rain
7	MAH	1	Stable pigments
8	WCT	2	Stable pigments, severe leaking rain
9	WAH	1	Stable condition
10	ZAH	1	Stable condition
11	XZT	2	Construction environment

Since damage area doesn't have absolutely positive correlation with damage severity, protection measures applied to different damage types should also be different. From the principle of maintaining a stable/healthy state, insecticide and fungistat should be used to prevent wormholes and molds; fragmentary timbers should be repaired to reduce leaking rain and water stains; cracked woods should be reinforced to slower the growth of cracks; current situation should be stayed for lime covering as there are no appropriate method to wipe off; repainting in Zhejiang area should be very cautious as it's hard to remain authenticity in materials, crafts and patterns.

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