A STUDY ON THE ANALYSIS OF DIGITAL SURVEY ACTIVITIES OF TRADITIONAL JAPANESE WOODEN ARCHITECTURE

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Abstract. The importance of creating architectural drawings based on digital surveying is growing increasingly significant for the preservation of historic structures. Over the three-year period from 2023 to 2026, 68 buildings were surveyed using digital technology, of which 19 were traditional wooden structures (temples and shrines). Disaster preparedness was the primary reason for commissioning these surveys. A consistent correlation was observed between height and the number of man-days required. It should be noted that even among buildings with a small floor area, some require a large number of man-days due to factors such as height and the complexity of their internal structures. Furthermore, for tall buildings, drone-based surveying can reduce the number of man-days required. The data obtained from this survey and analysis serves as a useful reference for building surveys using digital technology in other regions.

Keywords: Digital Survey, Reasons for commissioning, Relationship between volume, height and man-days

Research Objectives & Research Method

The survey, conducted by a team of Master Carpenters beginning in 2023, covered a total of 68 structures, including traditional wooden architecture, through March 2026. From this

sample, the study focuses on 19 traditional wooden structures (primarily shrines and temples) to analyze their actual conditions. The objectives are to analyze post three years of survey results and to utilize further survey activities.

Focusing on the buildings surveyed by the Master Carpenter Team, this study organizes data on the year of construction, cultural property designation status and building scale (width, depth, height, building area and volume). It also analyzes the reasons for commissioning the surveys and the number of man-days spent on each survey.

1. Survey Subjects

A total of 19 traditional wooden structures (shrines and temples) were surveyed, 8 in 2023, 5 in 2024, and 6 in 2025.

The construction years of the surveyed buildings are as follows, 5 from the 1900s, 7 from the 1800s, 3 from the 1700s, 2 from the 1600s, and 2 from the 1200s.

Regarding cultural property designations, there are 2 National Treasures (The Main Hall and The Three-Storied Pagoda of Myōtsū-ji Temple), 15 Important Cultural Properties, and 2 with no designation. The National Treasure buildings were constructed in the 1200s.

In terms of floor area, the largest is the Main Hall at Eiheiji Temple at 750.3 m^2, while the smallest are N Shrine at 9.76 m^2, the Worship Space at Ōtaki Shrine at 14.7 m^2, the Main Hall at Ōtaki Shrine at 15.4 m^2, the Three-Storied Pagoda at Myōtsū-ji Temple at 17.4 m^2, and the Gate for Imperial Messenger at Eiheiji Temple at 19.4 m^2. The average of 19 cases is 260.7 m^2.

In terms of volume, the largest is Gōshō-ji Temple at 21,811.7 m^3, the smallest is N Shrine at 73.8 m^3, followed by the Main Hall of Ōtaki Shrine at 160.3 m^3 and the Worship Space of Ōtaki Shrine at 106.9 m^3. The average of 19 cases is 4,954.8 m^3.

In terms of height, the tallest is Gōshō-ji Temple at 24.0 m lowed by the Three-Storied Pagoda at Myōtsū-ji Temple at 22.1 m, the shortest is the Worship Space at Ōtaki Shrine at 7.2 m, and the average of 19 cases is 15.9 m. (Table 1. Summary of Survey Subjects)

2. Reasons for Commissioning

Of the 19 cases surveyed, 14 were for “disaster preparedness” (earthquakes, fires, lightning strikes, etc.), 7 were “in preparation for repairs,” 5 were for “drawing preparation,” and 2 were due to “deterioration.”

By era, there were 5 cases from the 1900s, 7 from the 1800s, 3 from the 1700s, 2 from the 1600s, and 2 from the 1200s. Both buildings from the 1200s are National Treasures and had previously undergone thorough surveys. The largest numbers were buildings from the 1800s (7 cases) and the 1900s (5 cases). (Table2. Year of construction and reasons for commissioning of surveyed buildings.)

3. Man-Days and Labor Input for On-Site Surveys

3-1 Analysis of the Relationship Between Volume and Man-Days

Relationship between volume and man-days is analyzed. The distribution is shown in Fig. 1, and the relationship can be expressed by the linear regression equation

$y = 0.00036x + 11.17.$

No clear similarities can be identified. Looking at buildings with small floor area values, N Shrine has a floor area of 73.8 m^3 and required 5 man-days for the on-site survey, the Main Hall of Ōtaki Shrine has a floor area of 160.9 m^3 and the worship Space has 106.3 m^3, each requiring 8 man-days, and the Three-Storied Pagoda at Myōtsū-ji has a floor area of 384.7 m^3 and required 12 man-days.

Table 1. Summary of Survey Subjects

Research Year		Temple Shrine Name	Location	Year Of Construction	Cultural Property Designation Status	Building Scale					Reasons For Commissioning The Surveys				Man-Days		
						Width m	Depth m	Height m	Area m²	Volume m³	1 Disaster Preparedness	2 Drawing Preparation	3 Measures for Deterioration	4 In Preparation For Repairs	1 Measurement on site	2 Editing	3 Making Drawings
2023	1	Eiheiji Temple Buddha Hall	Fukui	1902	2	18.4	17.2	18	316.5	5,696.6	●				13	7	N/A
	2	Eiheiji Temple Main Hall	Fukui	1842	2	32.2	23.3	20.6	750.3	15,455.4	●				15	7	N/A
	3	Eiheiji Temple Main Gate	Fukui	1747	2	16.6	9.1	19.6	151.1	2,960.8	●	●	●	●	18	15	N/A
	4	Eiheiji Temple Monastery	Fukui	1901	2	26.6	21.1	14.1	561.3	7,913.8	●				12	8	N/A
	5	Eiheiji Temple kichen ・Temple Office	Fukui	1929	2	41.6	13.4	19.1	557.4	10,647.1	●	●	●	●	18	14	N/A
	6	Eiheiji Temple Meeting Room	Fukui	1929	2	23.6	19	15.8	448.4	7,084.7	●				13	6	N/A
	7	Eiheiji Temple Mausoleum Of Zen Master Dogen	Fukui	1891	2	12	11.6	12	139.2	1,670.4	●				13	7	N/A
	8	Eiheiji Gate for Imperial Messenger	Fukui	1844	2	5.1	3.8	9.6	19.4	1,860.1	●				8	4	Total 100
2024	9	Gōshō-ji Temple Bell Tower	Fukui	1811	2	5.5	5.5	15	30.25	453.8	●				8	4	N/A
	10	Myōtsū-ji Temple 3 Storied Pagoda	Fukui	1270	1	4.2	4.2	22.1	17.4	384.7	●				12	8	N/A
	11	N Shrine Main Hall	Ibaraki	1695	3	1.8	5.6	7.6	9.8	73.8				●	5	3	N/A
	12	Myōtsū-ji Temple Main Hall	Fukui	1258	1	14.7	14.7	13.3	216.8	2,886.0	●				12	8	N/A
	13	Zōjō-ji Temple Gate	Tokyo	1611	2	21.1	9.7	21.3	204.6	4,357.2				●	25	20	20
2025	14	Gōshō-ji Temple Main Hall	Hukui	1884	3	29.7	30.6	24.0	908.8	21,811.7	●				16	12	N/A
	15	Saitokuji Temple Main Hall	Tokyo	1930	2	16.5	18	18.2	297.0	5,405.4		●		●	15	9	40
	16	Zenko-ji Temple Main Gate	Nagano	1750	2	20.4	8	20.5	163.2	3,345.6	●				15	12	4
	17	Zenko-ji Temple Sutora Strage	Nagano	1759	2	11.5	11.5	14.2	131.9	1,866.5	●				12	8	3
	18	Ōtaki Shrine Main Hall	Fukui	1840	2	3.6	4.2	10.5	15.4	160.9		●		●	8	N/A	total 125
	19	Ōtaki Shrine Worship Space	Fukui	1840	2	3.8	3.8	7.2	14.7	106.3		●		●	8	N/A	
					Ave rage	16.3	12.3	15.9	260.7	4,954.8	14	5	2	7			

※1 National Treasure, 2 Important Cultural Treasure, 3 None

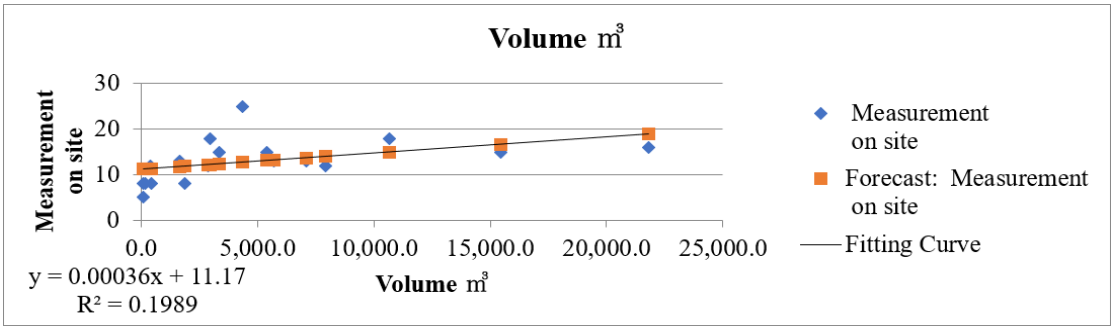


Fig.1 – Relationship between Volume and Man-Days

Table 2. Year of Construction and Reasons for Commissioning of Surveyed Buildings

Research Year	Number of Cases	Reasons			
		1	2	3	4
1900～	5	4	2	1	2
1800～	7	5	2	0	2
1700～	3	3	1	1	1
1600～	2	0	0	0	2
1200～	2	2	0	0	0
Total	19	14	5	2	7

Legend
Reason 1 Disaster Preparedness
Reason 2 Drawing Preparation
Reason 3 Measures for Deterioration
Reason 4 In Preparation For Repairs

Among buildings with large volumes, Gōshō-ji Temple has a volume of 21,811.7 m³ and a labor input of 16 man-days based on the on-site survey. The Main Hall at Eiheiji has a volume of 15,455.4 m³ and a labor input of 15 man-days based on the on-site survey.(Fig. 2)

Even among buildings with smaller volumes, some require a larger number of man-days compared to other buildings with larger volumes. This is thought to be influenced by factors such as the building's height, the complexity of its internal structure, and the extent of its ornamentation.

Myōtsū-ji Temple's Three-Storied Pagoda has a small volume but stands 22.1 m tall. At Ōtaki Shrine, both the Main Hall and the worship Space feature complex roof shapes, and intricate carvings cover the entire surface of the building walls.(Fig. 3)



Fig. 2 – Eiheiji Temple, Main Hall, Source : Eiheiji Temple



Fig. 3 – Ōtaki Shrine, Main Hall
Source : Echizenshi Travel And Tourism Association (https://www.echizen-tourism.jp/travel_echizen/visit_detail/36)

3-2 Analysis of the Relationship Between Height and Man-Days

Relationship between height and man-days analyzed, as shown in the distribution in Fig. 4, this relationship can be expressed by the linear regression equation y = 0.71x + 1.71.

Examples of low-height buildings include the worship Space at Ōtaki Shrine (7.2 m), which required 8 man-days according to the field survey, the Gate for Imperial Messenger of Eiheiji Temple (9.6 m), which required 8 man-days, and the Main Hall at Ōtaki Shrine (10.5 m), which required 8 man-days.

Taller buildings include the Main Hall at Eiheiji Temple (20.6 m, 15 man-days), Gōshō-ji Temple (24 m, 16 man-days), The Three-Storied Pagoda at Myōtsū-ji Temple (22.1 m, 12 man-days), the Main Gate at Zōjō-ji Temple (21.3 m, 25 man-days), and the Main Gate at Zenko-ji Temple (20.5 m, 15 man-days).

In the past, surveying tall buildings required erecting scaffolding and involved a large number of man-days however, since surveys can now be conducted using drones, this saves time and reduces the number of man-days required.

Even for lower structures, such as the Main Hall and Worship Space at Ōtaki Shrine, the number of man-days required is high because the roof shape is complex or the ornamentation is intricate. Although the Myōtsū-ji Temple Three-Storied Pagoda is tall at 22.1 m, its structure consists of repeated identical stories, resulting in fewer man-days compared to other tall structures.

(Fig. 5)

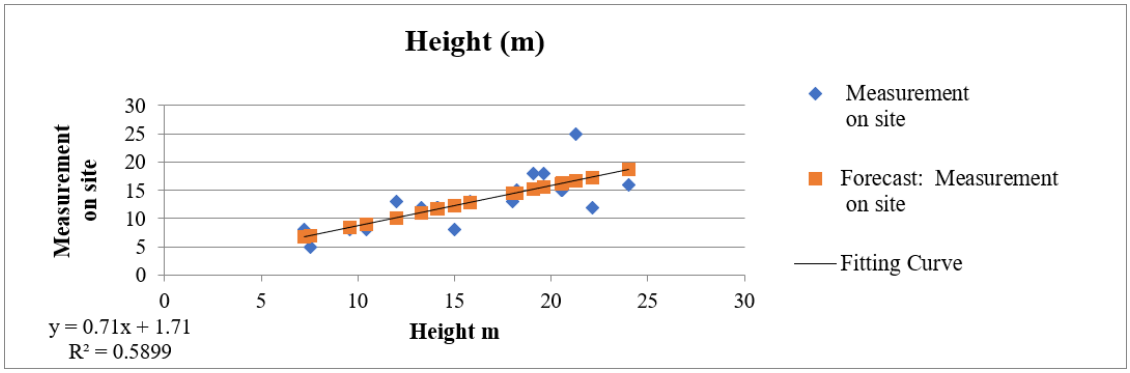


Fig. 4 – Relationship Between Height and Number of Man-Days



Fig. 5 – Myōtsū-ji Temple the Three-Storied Pagoda & Survey Progress, Source :T&I Co.Ltd.

4. Conclusion

Over the past three years, architectural surveying using DX has been conducted. The results of analysis of 19 traditional wooden structures (temples and shrines) selected from this group are as follows.

Most of the structures surveyed were built in the 1800s and 1900s. In terms of cultural property designations, there are 2 National Treasures (both from the 1200s) and 15 Important Cultural Properties. The average of 19 cases of area is 232.6 m², the average of 19 cases of volume is 4,954.8 m³, and the average of 19 cases of height is 15.9 m.

The reasons for commissioning the surveys were disaster preparedness (earthquakes, fires, lightning strikes, etc.) in 14 cases, preparation for repairs in 7 cases, creation of architectural drawings in 5 cases, and deterioration in 2 cases.

The relationship between volume and man-days is represented by the linear regression equation $y = 0.00036x + 11.17$.

However, even for buildings with small volumes, factors such as height and the complexity of the internal structure can result in some projects requiring a high number of man-days.

The relationship between height and man-days is represented by the linear regression equation $y = 0.71x + 1.71$.

As height increases, the number of man-days increases. On the other hand, although the Three-Storied Pagoda of Myōtsū-ji Temple is tall at 22.1 m, its structure consists of repeated layers, and since it can be surveyed using drones, the number of man-days can be reduced, consequently, it requires fewer man-days compared to other tall buildings.

The data presented above will serve as a useful reference for future building surveys conducted via digital transformation in other regions.

REFERENCES

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