

Fire Loads in Heritage Buildings

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Abstract

The results of a fire load survey carried out on Daria Daulath Bagh and Mahadwara Gopuram Ranganatha Swamy temple at Srirangapatna Taluk, Mandya District, Karnataka (India) are presented. Two heritage buildings with a floor area of 1068.64 m² were surveyed. The inventory method was used in the present survey. Analysis has been made to determine the influence of room use and floor level on fire loads. It is found that room use and room floor area are major parameters affecting the fire loads in a room. An attempt is made to calculate the composition of fire load in the buildings surveyed. In these buildings wood contributes to a substantial portion of the total fire load and the immovable contents contributes to about 90% of the total fire loads.

Key Words & Phrases: *Heritage buildings, protection of structures & moveable items / contents*

1.0 Introduction

"Conservation of Cultural Heritage" is a stated goal of the ISO Technical Committee on Fire Safety Engineering. Heritage buildings are exposed to the same fire threats as other buildings. Unlike most other buildings, heritage buildings are of significant architectural and historical importance, and often contain irreplaceable contents. Implementation of the modern prescriptive codes can even have an unfavorable effect on the architectural value of the building. As a consequence, the fire safety engineer needs to use different approaches to guarantee the fire safety level.

The Heritage structures are divided in three categories from the point of view of materials used in their construction viz wood, stone and bricks. Concerning wooden building, the most cause of damage is due to twisting, joints are crushed, and partially rotted these

damages may occur in limited area of the structures but the major cause of destruction is due to fire accidents.

The fire protection of heritage buildings is necessary because a large proportion of the buildings are made of wood. They are historic wooden structures that are densely packed and where the threat from fire is high. Some buildings are located in rural areas which correspond to a high risk.

2.0 - Literature Review

2.1 - Case Studies

The Roza d' Antananarivo, Madagascar. This historic hill top complex of nine buildings (Royal palaces, tombs and temples) was built primarily in wood during 17th to 19th centuries. The cultural and religious heart of the country, it had been proposed for inclusion on the world heritage list.

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The Rova d' Antananarivo, Madagascar. Fanned by high winds, a fire devastated the complex on 6th November 1995. Five of the buildings were razed to the ground ; of the remainder, only basements and perilous masonry elements survived. It was observed that, out of 6175 inventoried objects, 1183 were saved.

Katarina church built between 1656-1695. The architect was Jean de la vallee. The church was damaged and re built again in 1723, but it was not an exact copy of the church. The magnificent tower was new and was finished in 1739. The architect was Goran Adelcrantz. The church is on a hill in the south of Stockholm, sodermalm, and you can see it from a long way away. It is a very important part of the Stockholm skyline. The organ façade, which is from 1763, was by Jean Erik Rehn. The altar paice from 1732 and the pulpit from 1753 were by Goran Adelcrantz'son Carl Fredrik Adelcrantz. The altar painting from 1735 was by Lorenz Gottman.

The church was destroyed by the fire in May 1990. This was one of the most notorious fires on the cultural heritage building in Sweden. Only the outer walls made of stone (or bricks) survived. The cause of the fire was most probably an electric fault in the cable of the great hoist chandelier. The church had no smoke detectors. Had there been detectors, the fire would have been discovered at an early stage and probably been put out. The fire brigade was located next door to the church. But when the fire brigade came to the church there was already a big fire and they had no possibility to save the church. The church had an old sprinkler system in the tower but it could not be used because there was not enough water in the Municipal water pipes.

It is important to check old electrical installation regularly and to consider the effect of heating previously not heated spaces. In addition, it is important to have fire detectors in all the spaces, particularly in the attic. Fire brigades should have information concerning the historic buildings in order to act correctly. Remaining structures should be documented as this might have revealed something interesting about the wood joints or other details in the roof constructions. A Fire can be provided a researcher with an opportunity to find some thing that is normally invisible and unobtainable.

2.2 - Objective and Scope of Work

The objective of the present study is

- i) Calculation of fire loads of different heritage buildings.
- ii) Comparison of fire loads of different heritage buildings.
- iii) Recommendation of the suitable solution for protection of the heritage structures against the fire accidents.

2.3 - Scope of The Present Work

Scope of the present work is limited to finding the fire loads in the following buildings.

- i) **One heritage building** – Daria Daulath Bagh at Srirangapatna a national protected monument at Srirangapatna Taluk, Mandya district.
- ii) **One heritage structure** – Mahadwara gopuram consisting of seven tiers, where wood has been used as reinforcing materials at Ranganatha Swamy temple at Srirangapatna Taluk, Mandya district.

The following are the heritage monuments, which have been considered for the fire load calculation and an brief description of the monuments are given below.

Daria Daulat Bagh (D.D. Bagh)

The D.D. Bagh, "the wealth of the sea" was built in the year 1784 on the bank of the River kaveri and their building served as Tippu sultan's summer palace. The building was built in Indo-Islamic style of Architecture. Rectangular platform with arched entrance. The main structure is a double storey building comprising of wide corridor, several pillars, canopied balconies, an audience hall and private chambers. It is surrounded on all sides by a garden designed in the Islamic char bagh, the water fountains and pathway with Cypresses on either sides were with area on which the garden was divided into four geometric solutions. The structure made by teak wood, bricks and lime mortar was used in the construction. The Northern and southern as well as the inner walls are adored with fine floral patterns and geometric motifs and there are several niches on the outside walls to hold lamps or flower vases. This heritage is an important tourist attraction in Srirangapatna.

Mahadwara Gopuram of Sri Ranganatha Swamy Temple at Srirangapatna Taluk, Mandya District

The Sri Ranganatha Swamy temple is one of the largest in the state and of great importance. An inscription dated 894 AD reveals the Thirumalaiah, the ganga Chieftain, built the temple of Sriranganatha to commemorate the tradition. There came up a temple dedicated to the god in Sheshashayi form. On the cornices of the plinth on the southern side is an inscription of 1200 AD belonging to the period of Viraballala II, The hoysala king, stating about certain grants made to the priests and temples of the tituva-Ranga-Narayana –Chaturvedi Mangalam. This probably indicates the period of the foundation of the temple and the place as an Agrahara, a centre of traditional learning. Later the vijayanagara Kings, the Mysore wodeyars and Haider Ali enlarged and improved it. The structure is one of the important national protected monuments and the temple is in religious use. Further the significance cause of fire may be due to lighting caused by atmospheric action and by the rituals performed during Vishnu deep utsava The Lofty Mahadwara and imposing the gopura is constructed in vijayanagara period and consist of five tiers (five floors) with total of 131.14 Sqm of wooden floor area and 29470.66 cum of wooden members made of wood.

2.4 - Fire Load

The term fire load is defined as the heat energy that could be released per square meter of a floor area of a compartment of storey by the complete combustion of the contents of the building and any combustible parts of the building itself.

$$q_c = \frac{\sum m_v \times H_v}{A_f}$$

Where,

q_c = Fire load (MJ/m²)

m_v = Total mass of the combustible material (kg)

H_v = Calorific value of combustible material (MJ/kg)

A_f = Floor are (m²)

2.5 - Movable Contents

Movable content includes the combustible wooden antique furniture, barricades, Showcases made of

ply wood, murals, clothes, and pencil sketches made on paper, Bamboo mats, plastic chairs, and signage's made both of wood and plastics.

2.6 - Immovable Contents

The immovable contents consist of the combustible materials viz wooden members used as supporting frame beams, columns, ceiling, canopied balconies an audience hall.

3.0 Calculations

A sample calculation of [Model Room (1)] shown below.

Model Room - 1

Floor area (A_f) = 27.00 m²

Weight of immovable combustible material (m_v) = 2499.50 kg

Weight of movable Combustible material (m_v) = 741.00 kg

Total 3240.50 kg

$$\begin{aligned} \text{Fire Load } q_c &= \frac{\sum m_v \times H_v}{A_f} \quad (\text{MJ/m}^2) \\ &= \frac{3240.50 \times 18.60}{27.00} \\ &= 2232.34 \text{ MJ/m}^2 \end{aligned}$$

Calorific value for wooden items (H_v) = 18.60 MJ/kg

Similar calculations have been adopted for the entire Structures. Tables in the next few pages gives the computation of weights and the corresponding fire load for the entire structures floor wise.

Daria Daulat Bagh at Srirangapatna

Total floor area = 937.50 Sqm

The following materials have been considered as Movable and Immovable contents inside the heritage structure.

Movable Items

Wooden antique furniture, barricades, Showcases made of ply wood, murals, and clothes, pencil sketches made on paper, Bamboo mats, plastic chairs, and signage's made both of wood and plastics.

Immovable Items

The immovable contents consist of the combustible materials viz wooden members used as supporting frame beams, columns, ceiling , canopied balconies an audience hall.

Mahadwara gopuram of Sri Ranganatha Swamy temple at Srirangapatna Taluk, Mandya District

Total floor area = 131.14 Sqm

The following materials have been considered as Immovable contents inside the heritage structure.

Immovable Items

The immovable contents consist of the combustible materials viz wooden members used as supporting frame beams, columns, floors.

Table 1: Fire Load for Daria Daulat Bagh

Sl. No.	Particulars	Floor area	Immovable content			Movable content			Total fire load (MJ/m ²)
			Wt of combustible material, mv (kg)	Calorific value Hv(MJ/kg)	Fire load qc (MJ/m ²)	Wt of combustible material mv (kg)	Calorific value Hv (MJ/kg)	Fire load qc (MJ/m ²)	
1	Front Varandha	115.50	74870.63	18.60	12057.09	109.00	18.60	17.55	12074.64
2	Left Side Varandha	115.50	63733.63	18.60	10263.60	104.00	18.60	16.75	10280.35
3	Rear Side Varandha	115.50	75783.30	18.60	12204.06	128.00	18.60	20.61	12224.68
4	Right Side Varandha	115.50	62275.39	18.60	10028.76	100.00	18.60	16.10	10044.87
5	Models Room-- 1	27.00	2499.50	18.60	1721.88	741.00	18.60	510.47	2232.35
6	Models Room-- 2	24.75	3956.23	18.60	2973.17	397.00	18.60	298.35	3271.52
7	Models Room-- 3	24.75	3956.23	18.60	2973.17	869.00	18.60	653.07	3626.23
8	Models Room-- 4	27.00	2499.50	18.60	1721.88	746.00	18.60	513.91	2235.79
9	Models Room-- 5	60.00	1910.72	18.60	592.32	464.00	18.60	143.84	736.16
10	Models Room-- 6	24.75	3956.232	18.60	2973.17	417.00	18.60	313.38	3286.55
11	Models Room-- 7	24.75	3956.232	18.60	2973.17	397.00	18.60	298.35	3271.52
12	Models Room-- 8	27.00	2499.504	18.60	1721.88	-	-	-	1721.88
13	Models Room-- 9	24.75	3956.232	18.60	2973.17	-	-	-	2973.17
14	Models Room-- 10	24.75	3956.232	18.60	2973.17	-	-	-	2973.17
15	Models Room-- 11	27.00	2499.504	18.60	1721.88	-	-	-	1721.88
16	Models Room-- 12	60.00	1910.72	18.60	592.32	-	-	-	592.32
17	Models Room-- 13	24.75	3956.232	18.60	2973.17	-	-	-	2973.17
18	Models Room-- 14	24.75	3956.23	18.60	2973.17	-	-	-	2973.17
19	Open Space--1	71.50	63567	18.60	16536.31	60767.00	18.60	15807.92	32344.23
20	Open Space--2	71.50	63567	18.60	16536.31	60577.00	18.60	15758.49	32294.80
									143852.45

Table 2: Fire Load for Sri Ranganatha Swamy Temple Main Entrance

GROUND FLOOR									
Sl. No.	FLOORS	Floor area	Immovable content			Movable content			Total fire load (MJ/m ²)
			Wt of combustible material, mv (kg)	Calo-rific value Hv(MJ/kg)	Fire load qc (MJ/m ²)	Wt of combustible material mv (kg)	Calo-rific value Hv(MJ/kg)	Fire load qc (MJ/m ²)	
1	First Floor	52.80	6651.79	18.60	2343.24	-	18.60	-	2343.24
2	Second Floor	42.75	5856.45	18.60	2548.07	-	18.60	-	2548.07
3	Third Floor	33.88	5011.08	18.60	2751.07	-	18.60	-	2751.07
4	Fourth Floor	28.05	4392.19	18.60	2912.47	-	18.60	-	2912.47
5	Fifth Floor	17.76	3714.20	18.60	3889.87	-	18.60	-	3889.87
6	Sixth Floor	13.20	2287.43	18.60	3223.20	-	18.60	-	3223.20
7	Seventh Floor	6.60	1928.05	18.60	5433.60	-	18.60	-	5433.60
Total		195.04	29841.19	-	23101.51	-	-	-	23101.51

4.0 Conclusions

The following conclusions have been drawn based on the limited scope of the project work,

Daria Daulat Bagh

It has been found that the intensity of fire load is maximum in the open space 2 and minimum in the model room 12. In case of accidental fires, precautions have to be taken in open space 2.

Sri Ranganatha Swamy Temple at Srirangapatna

It has been found that the intensity of fire load is maximum in the first tier and minimum in the fourth tier. In case of accidental fires precautions have to be taken in fourth floor.

An efficient fire safety management is essential because these heritage buildings are visited by an average three thousand tourist per day hence the fire alarm, smoke detectors and suitable necessary equipments are to be installed for preventing the major fire disasters.

The most effective method to eliminate the risks of fire is to conduct a fire risk assessment regularly with close monitoring and reviewing; i.e. 'prevention is better than cure'.

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