European Journal of Science and Theology, February 2015, Vol.11, No.1, 263-272

PROTECTION OF SACRAL AND HISTORICAL MONUMENTS AGAINST FIRES IN THE TOWN BARDEJOV

Ivan Chromek[1], Pavol Hlaváč[2] and Milan Kodrík[2,*]

[1] *Technical University in Zvolen, Faculty of Wood Sciences and Technology, T.G. Masaryka 24, 960 53 Zvolen, Slovak Republic*
[2] *Technical University in Zvolen, Faculty of Forestry, T.G. Masaryka 24, 960 53 Zvolen, Slovak Republic*

(Received 8 November 2014, revised 2 December 014)

Abstract

The protection of sacral buildings and historical monuments against fire is in Slovakia, mainly after the fire of the castle in Krásna Hôrka in 2012, one of the most important roles in order to preserve sacred and cultural values for the generations to come. The study deals with the reassessment of the possible fire-fighting action in the historical centre of the town Bardejov as well as with the reassessment of the decorative vegetation in relation with the risk of fire spread in the town, which is included in the world heritage list UNESCO thanks to its sacral and historical monuments.

Keywords: Sacral monuments, Bardejov, risk of fire, vegetation, protection

1. Introduction

In 2000 at the meeting of the UNESCO World Cultural Heritage Committee the historical centre of the town Bardejov became the fourth location enlisted in the UNESCO world heritage list. The dominating building of the historical centre is Saint Egidius's Basilica – a Gothic sacral building located in the northern part of the Council Square (Radničné námestie) (Figure 1). It is a three-aisle building of the basilica type with aisles built in the east-west direction with the main entrance from the south. Besides important architectural values the Basilica in Bardejov is noticeable mainly due to its interior furnishing [1]. A unique set of eleven Gothic winged altars dated from 1440–1520 comprising a unique collection of altars preserved at one location almost in the original distribution are the dominant of the Basilica. The pope John Paul II with his apostolic breve from 23rd November, 2000 promoted the temple to Basilica minor.

[*]Corresponding author, e-mail: kodrik@tuzvo.sk

Figure 1. Saint Egidius's Basilica on the Coucil Square (Radničné námestie) in Bardejov (Foto: Hlaváč, 2014).

Figure 2. The roofs of the individual buildings on the square are interconnected (Foto: Hlaváč, 2014).

The temple and the town suffered, in the course of centuries, from several major fires in years 1550, 1577, 1640, 1774, 1878 and in 1944 after aerial bombing. In front of Saint Egidius's Basilica minor there is the statue of Saint Florian the patron of all fire-fighters. The stone statue from the late Baroque was

built as a memory of a fire that destroyed town houses and partially also the Basilica on 27th May 1774.

The symbolic location of the fire-fighters' patron in front of the Basilica encourages the citizens to a great vigilance also nowadays [2]; vigilance of a fire that can, in a second, destroy not only historical but also spiritual values [3] that were built by our ancestors in the past [4].

2. Aim of the study

The aim of the study is to design the forces and means for a model action of fire-fighting units in the case of fire on the Council Square in Bardejov as well as the reassessment of the decorative vegetation from the point of view of fire spread.

Listed calculations are identical for all objects located on the Council Square. For the calculation the house no. 4, located in the vicinity of the Rome Catholic Church Offices and Saint Egidius's Basilica minor, was selected as a model example. Regarding the possible spread of fire across adjacent buildings, which interfere with each other by the roof constructions, there is a theoretical presumption [5] that the fire could spread across the whole square and it will endanger also the Basilica.

The risk of fire lies also in the fact that after the reconstruction of the square it remained 'live', since the reconstructed objects serve not only as businesses [6] but also as tenement flats. That means that they pose an all-day long fire risk. Moreover, the roofs of the individual buildings are interconnected [7] what increases the fire risk even more (Figure 2).

3. Methodology

3.1. Methodology for calculating the forces and means

The basis for the calculation of the forces and means needed was the most complex variant of the fire that, if spread, would endanger historical monuments as well as the Rome Catholic Church Offices and Saint Egidius's Basilica minor. This was the reason for selection of the Council house no. 4.

Regarding the renewal of the flats in the reconstructed houses a fire in the attic maisonette of the main building was modelled.

The fire occurred due to the radiant heat from the fire-place affecting clothes hanging nearby to dry. Fire was subsequently spread to the sofa and through the wooden floor to the surrounding furnishing.

For the calculation the calculation methodology in terms of the internal regulation of the Fire and Rescue Corps of the Slovak Republic was used [*Pokyn prezidenta Hasičského a záchranného zboru* (39/2003) z 23. mája 2003 o obsahu a o postupe pri spracúvaní dokumentácie o zdolávaní požiarov]. When calculating the forces and means the following procedure was used:

a) the time for the collection of all fire-fighting units according to the selected degree of fire alarm of the respective fire alarm plan and the values of the arrival of the fire-fighting units to the location were determined;
b) the radius *r* of the fire was calculated;
c) the surface S_p of the fire was calculated;
d) the main direction of the fire attack, workload of fire-fighting units, use of the forces and means and thus also so called direction of fire-fighting and the depth of the fire suppression were determined;
e) the surface of fire-fighting S_h was calculated.

Following these details the forces and means were calculated as follows. Determining the required supply of the extinguishing agent for fire-fighting and protection:

$$Q_p^h = S_h \times I_p \quad \text{or} \quad Q_p^h = O_h \times I_p \tag{1}$$

where:
Q_p^h required supply of the extinguishing agent for fire-fighting [l·min^{-1}],
S_h surface of fire-fighting [m^2],
O_h circumference of the fire being extinguished [m],
I_p required intensity of the extinguishing agent supply per surface [l·m^{-2}·min^{-1}] or per circumference [l·m^{-1}·min^{-1}].

The intensity of the extinguishing agent supply for the protection of the objects endangered by the fire is mostly 2-3 times higher than the intensity of the extinguishing agent supply for fire-fighting.

Water supply for cooling the structures or furnishing is determined according to the equation:

$$Q_p^o = Q_p \times I_p^o \tag{2}$$

Where:
Q_p^o supply required for cooling [l·min^{-1}],
Q_p one meter of cooled surface [m],
I_p^o required intensity of water supply for cooling [l·m^{-1}·min^{-1}].

The overall water supply is determined according to the equation:

$$Q_w = Q_p^h + Q_p^o \ \text{[l·min}^{-1}\text{]} \tag{3}$$

3.2. Determining the number of streams needed for fighting the fire

$$N_{pr}^h = \frac{Q_p^h}{q_{pr}} \tag{4}$$

where:
N_{pr}^h the number of streams for fire-fighting [pcs],
Q_p^h extinguishing agent supply needed for fire-fighting [l·min^{-1}],
q_{pr} flow rate of the nozzles [l·min^{-1}]

or:

$$N_{pr}^{h} = \frac{S_p}{S_{pr}} \text{[pcs]} \tag{5}$$

where:

S_p surface of the fire or fire-fighting [m^2],

S_{pr} surface that can be extinguished by one nozzle [m^2].

The number of streams needed for the protection (cooling) is determined according to the equation:

$$N_{pr}^{o} = \frac{Q_p^o}{q_{pr}} \text{[pcs]} \tag{6}$$

Overall number of streams:

$$N_{pr} = N_{pr}^{h} + N_{pr}^{o} \text{[pcs]} \tag{7}$$

3.3. Determining the required amount of forces and fire trucks

$$N_A = \frac{Q_p}{q_A} \tag{8}$$

where:

N_A number of fire trucks [pcs],

Q_p extinguishing agent supply needed for fire-fighting and protection [$l \cdot min^{-1}$],

q_A extinguishing agent supply that can be provided by one crew and one fire truck [$l \cdot min^{-1}$].

Based on the practice one crew with water tender CAS 25 can create 3 C streams or 1 B stream and 1 C stream (q_A = 600 $l \cdot min^{-1}$) or two foam creating streams. The crew of water tender CAS 30 (CAS 32) – generally 1+1 (1+2) members can create maximum 1 C stream (q_A = 200 $l \cdot min^{-1}$) or one foam creating stream providing that the fire-fighting activities are carried out without self-contained breathing apparatus. When using the self-contained breathing apparatus in conditions with thick smoke one CAS 25 crew can create 2 C streams or 1 B stream. For fire-fighting (extinguishing agent supply) the fire-fighter do not generally use all fire-fighting equipment determined by the calculation but only such amount that provides a sufficient supply of the extinguishing agent for fire-fighting and protection of the surrounding structures.

3.4. Determining the required number of fire-fighters

$$N_p = (2 \text{ x } n_p^{c} + 3 \text{ x } n_p^{b}) \text{ x } 1.25 \tag{9}$$

where:

n_p^{c} the number of ‘C 52 mm’ streams,

n_p^{b} the number of ‘B 75 mm’ streams

1.25 coefficient of the back-up (25%) for the needs of rotation of fire-fighters in the action or work with self-contained breathing apparatus.

3.5. Methodology for recalculation of the risk of fire spread in the decorative vegetation

The methodology is based on the fire of the castle Krásna Hôrka in March 2012. The basis for evaluating the fire were the type and the size of tree-tops of the decorative vegetation (projection in the horizontal plane) and the distance from the endangered object from the nearer edge of the projection to the object (Figure 3). Regarding the type of vegetation the basic relation was determined

$$l_{bezp} \geq d_{zel} \quad (10)$$

where:

l_{bezp} safe distance

d_{zel} diameter of the tree-top horizontal projection of detached decorative vegetation (tree, bush).

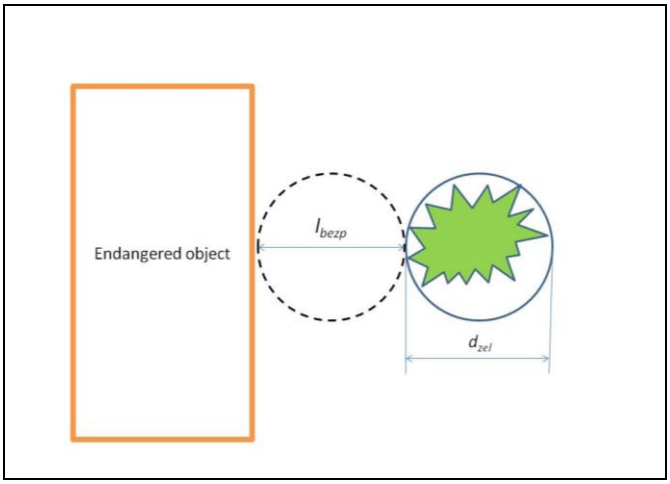

Figure 3. The size of tree-tops of the decorative vegetation and the distance from the endangered object from the nearer edge of the projection to the object.

4. Results and discussion

4.1. Calculation of the forces and means

4.1.1. Preventive measures

All objects on the Council Square are equipped with electronic fire signalisation, portable fire extinguishers and internal fire water supply – net of hydrants according to the valid legislation in the Slovak Republic.

Overall need for water for fire-fighting for the given structure is $Q = 10.01\ l \cdot s^{-1}$. This need is provided through the water service pipe DN 50 mm from the town public water network located within the road on the Council Square.

4.1.2. Intervention using the mobile fire-fighting equipment

The complexity of the intervention caused all structures on the Council Square, including house no. 4, to be included in the 2nd degree of the fire alarm plan (Table 1). For the needs of the intervention the equipment is available.

Table 1. Printout of the fire alarm plan.

Structure	Degree of alarm	Fire station of Fire and Rescue Corps	Type of the equipment	Time of drive [min]	Number of crew members	Volume of extinguishing agent water/foaming agent [litre]
Council house no. 4	II.	Regional Directorate of the Fire and Rescue Coprs Bardejov	AHZS 1B MB Atego 1529	8	1 + 3	3000/250
			Water tender CAS 30 - IVECO TRAKKER		1 + 1	9000/800

4.1.2.1. Arrival and access

Arrival of the fire-fighting equipment is provided for by the access ways and driveways from the Council Square (stone pavement) and from Stöcklova Street (asphalt road). On the Square and near the city walls they provide a quick and safe access for the mobile fire-fighting equipment into the direct vicinity of the structure in question from two sides. The access road is 3.5 m wide and meets all requirements for the intervention in case of a fire.

4.1.3. Calculation of the forces and means

The model fire occurred on the 3rd floor in the two-floor maisonette flat located in the main building in the evening. The fire was noticed at $t_{sp} = 6\ min$, since it occurred, by a person on the 2nd floor of the flat in question. Subsequently the fire was announced to the operating centre in $t_{oh} = 2\ min$. The arrival of the fire-fighting unit (1.5 km away) at the place in question was at time $t_{do}^{Pr} = 3\ min$ since the fire occurred. The time until the unit was ready to fight the fire was $t_{br}^{P} = 4\ min \Rightarrow \boldsymbol{t}_{vr} = 15\ min$.

The fire occurred in the living part of the flat 3.03; it spread from the fire-place located under the staircase. In the middle of the hall it was spreading with the linear velocity $v = 0.7\ m \cdot min^{-1}$ at a certain angle. The radius of the fire since it was noticed until the announcement ($t_{sp} = 6\ min$) had the length $r = 2.1\ m$. At the arrival of the fire-fighting unit the radius of the fire was already $r = 9.8\ m$,

whereby the fire was already affecting the building structures $t = 0.9$ *min.* The fire reached the western side of the fire section in the distance $r = 6.3$ *m* in $t = 7.5$ *min* since it occurred.

Until the fire extinguishing agent began to be supplied to the fire ground $I_p = 8.6\ l{\cdot}m^{-2}{\cdot}m^{-1}$ the fire spread across the whole fire section on the 3rd floor. The surface of the fire at the time t_{vr} was $S_p = 150.8\ m^2$. The surface of fire-fighting was $S_h = 153.9\ m^2$ with the fire circumference $O_h = 6.6$ *m*.

The fire will be extinguished with combined nozzles C 52 with flow rate $q_{pr} = 220\ l{\cdot}min^{-1}$, offering effective extinguishing of solids up to the fire depth of 5 m. The required supply of the extinguishing agent $Q_p^h = 1323.1\ l{\cdot}min^{-1} \Rightarrow$ the extinguishing agent (water) can be supplied from the hydrant network. The required number of streams $N_{pr}^h = 6.1 = 7$ pcs. The required supply of the extinguishing agent for cooling the adjacent objects is $Q_p^o = 1006.2\ l{\cdot}min^{-1}$, where the cooling will be carried out using B nozzles with the flow rate $q_{pr} = 400\ l{\cdot}min^{-1}$. The required number of streams $N_{pr}^h = 2.5 = 3\ pcs \Rightarrow$ the overall water supply is $Q_p = 2329.3\ l{\cdot}min^{-1}$. The required number of fire trucks from the viewpoint of the man-power need $N_A = 3.8 = 4$ pcs (water tender CAS located at the fire station of the Fire and Rescue Corps in Bardejov, AHZS 1B MB Atego 1529 and water tender CAS 30 – IVECO TRAKKER, the third water tender CAS T148 will be called according to the needs from the external workplace of Fire and Rescue Corps in Raslavice, the fourth water tender CAS 25 Š 706 will be called from the Voluntary Fire Brigade Zborov). For possible evacuation of people the aerial ladder AR 30 – MB Atego 918 from the Regional Directorate of the Fire and Rescue Corps in Bardejov will be needed.

Two water tenders (AHZS 1B MB Atego 1529 and CAS 30 – IVECO TRAKKER) of the first intervention group will be used directly for the action; other will be prepared as a back-up. The crews of the mentioned vehicles will be used for individual intervention.

Providing that the conditions stated in subchapter 3.1 equation 9 met the need for fire-fighters to operate the streams is $N_p = 29$ fire-fighters, including the 25% back-up. The assumption of using 6 back-up fire-fighters is grounded due to a multi-floor building, the use of self-contained breathing apparatuses, possible evacuation or rescue of building occupants and obstructed access to the attic part of the Council House no. 4.

4.2. Recalculation of the risk of the fire spread from the decorative vegetation

When inspecting the Council Square from the point of view of the decorative vegetation and its possible effect on the fire spread it was found out that altogether 32 trees are located on the square. Thereof 24 are younger and smaller and 8 are older reaching bigger dimensions. The final analysis pointed out that the conditions of fire safety regarding the methodology in subchapter 3.5

are met in case of 29 trees. All these trees grow on the circumference of the historical square and their distance from buildings is 1.5 to 2 times greater that the projection of their tree-tops. 3 trees were labelled as at risk at the direct vicinity of the Basilica located on its western part in the direction from the park. Projections of their tree-tops are bigger than the distance of their trunks from the Basilica; however, the individual trees are separated from Basilica by fire resistant paved walkway. Following a complex evaluation it can be stated that the risk of fire spread from the decorative vegetation is currently minimal.

5. Conclusions

The model fire regarding the final calculations points out at a sufficient technical equipment of the fire-fighting units for the case of a possible fire in the objects of the Council Square in Bardejov. Anticipated number of fire-fighters points out at the need for training of the voluntary fire-fighters within the town Bardejov, who can significantly decrease the loading of the members of the Fire and Rescue Corps in case of a real intervention.

Considering the fact that the decorative vegetation does not exceed, with its growth parameters, the criteria given by the equation 10 in subchapter 3.2 (it depends on the regular maintenance – trimming) there is no assumption for a possible fire spread from this source. The structures on the Square are covered with climbing plants, which decrease the risk of possible fire spread as well. The distribution of the vegetation does not interfere with the principles of fire protection and complements sacral and historical monuments in a suitable way, whereby it helps create a positive aesthetic experience when visiting the Council Square.

Current technical equipment, modern materials used during the reconstruction of the square and the reconstruction itself meeting the newest fire protection and civil engineering regulations together with organisational measures in the reconstructed buildings decrease the potential risk of fire in this location. There is an assumption that when preserving this complex of measures and its subsequent complementation the Council Square should be free of fires in the forthcoming years.

Acknowledgment

The study was created with the financial help of the APVV agency within the research project APVV-0744-12.

References

[1] A. Zaušková, R. Miklenčičová, A. Madleňák, Z. Bezáková and D. Mendelová, Eur. J. Sci. Theol., **9(6)** (2013) 153-159.
[2] D. Petranová, Communication Today, **5(1)** (2014) 71-85.
[3] S. Gálik, *Filozofia a médiá. K filozofickej reflexii vplyvu médií na utváranie (súčasnej) kultúry*, Iris, Bratislava, 2012, 17–20.

[4] M. Solík and J. Mináriková, Communication Today, **5(2)** (2014) 21-31.
[5] A. Zaušková, A. Madleňák, D. Mendelová and Z. Bezáková, Eur. J. Sci. Theol., **10(3)** (2014) 81-87.
[6] M. Solík and J. Laluhová, Human Affairs, **24(4)** (2014) 481-491.
[7] Ľ. Čábyová, *Marketing a marketingová komunikácia v médiách*, Księży Młyn Dom Wydawniczy Michał Koliński, Łódź, 2012, 17-23.