CONTRIBUTION OF INFILL MATERIALS TO THE FIRE BEHAVIOR OF ARTIFICIAL GRASS

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ABSTRACT

Artificial grass is mainly composed of organic polymers with a consequent potential fire hazard. However, the behavior of artificial grass in case of fire has been poorly studied and is thus misunderstood. The purpose of this study is thus to have a better understanding of the contribution of the different components of the artificial turf in the fire performances. In this work, the influence of the nature of the infill is more specifically investigated.

Key Words: artificial grass, fire properties, mass loss cone, infill material

1. INTRODUCTION

The European market for artificial grass is currently of 45 million square meters per year with an annual growth ranging from 12 to 15%. But contrary to the self-extinguishing character of natural grass, artificial turf is highly flammable as it is mainly composed of organic polymers. Thus, fire hazard is very important, with potentially catastrophic consequences on human beings (death, injury, asphyxiation…), on buildings and on the environment. Moreover, the fire behavior of artificial grass is sometimes neglected considering outdoor applications while more and more stadiums are versatile and can be transformed from open to closed structures.
Currently, protection against fire is mainly obtained by the incorporation of sand into the artificial grass structure, and occasionally using a damping infill material fire retarded with halogenated compounds. However, halogenated derivatives are suspected to present health toxicity, some of them already being banned. On the other hand, the presence of sand prevents the potential recycling of artificial grass as it can hardly be removed from the structure. The actual solutions are thus not fully satisfactory motivating the present research work.
The purpose of the GRASS Interreg FWVL project is to improve the fire behavior of artificial grass developing innovative and environmentally-friendly processes that can be applied industrially. As artificial grass is a complex and multilayered structure, it is first necessary to determine the contribution of each component of the grass structure to the fire behavior. In a first step, it was decided to focus on the infill materials used as shock absorbing system. The reaction to fire of these infill materials has been investigated thanks to mass loss calorimetry (MLC) testing. Then, these materials have been incorporated into the grass structure and the fire properties of the whole systems were evaluated. The aim is to detect potential antagonistic effects between the different components in terms of fire properties.

2. MATERIALS AND METHODS

2.1 Materials

The classical structure of artificial turf for sports application is shown in Figure 1. It consists in a textile backing with a weather-resistant backcoating, turf pile, sand and a performance infill layer. A shockpad can be added under the turf to complete the shock absorbing system.

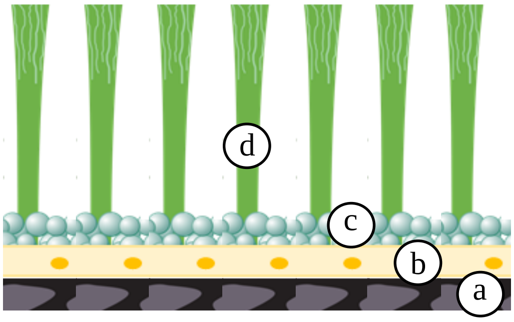

Figure 1. Artificial turf structure for sport applications with (a) the backing, (b) the sand, (c) the infill and (d) the pile

In the artificial turf structures tested in this study, the backing and the pile are both composed of polypropylene (PP). The height of the pile is fixed at 40 mm. Sand is used to stabilize the carpet and a 10 mm thickness is used in all the structures. Finally, different types of infill materials were tested: styrene-butadiene-rubber (SBR) which is by far the most commonly used infill material in the synthetic turf field as being the most economical (SBR layer thickness: 15 mm), ethylene propylene diene monomer (EPDM) (EPDM layer thickness: 10 mm), thermoplastic elastomer (TPE) (TPE layer thickness: 5 mm) and cork (cork layer thickness: 20 mm). The thickness has been fixed according to potential applications and thus corresponds to similar shock absorbing performance.

2.2 Fire testing

Mass loss calorimetry (MLC) (Mass Loss Calorimeter, Fire Testing Technology) was performed according to the ISO 13927 procedure [1]. The samples were exposed to a radiative heat flux of 25 kW/m² to simulate a developing fire. The distance between the upper part of the infill layer and the radiant conical heater is kept constant at 35 mm. Each type of structure was tested at least three times to ensure repeatability. From these experiments, time to ignition (TTi), the peak of heat release rate (pHRR), the total heat release (THR) and the time of flameout (TFO) were obtained.

3. EXPERIMENTAL RESULTS AND DISCUSSION

3.1 Fire properties of the pure infill materials

The MLC curves of the different infill materials are shown in Figure 2 and the corresponding data are given in Table 1.

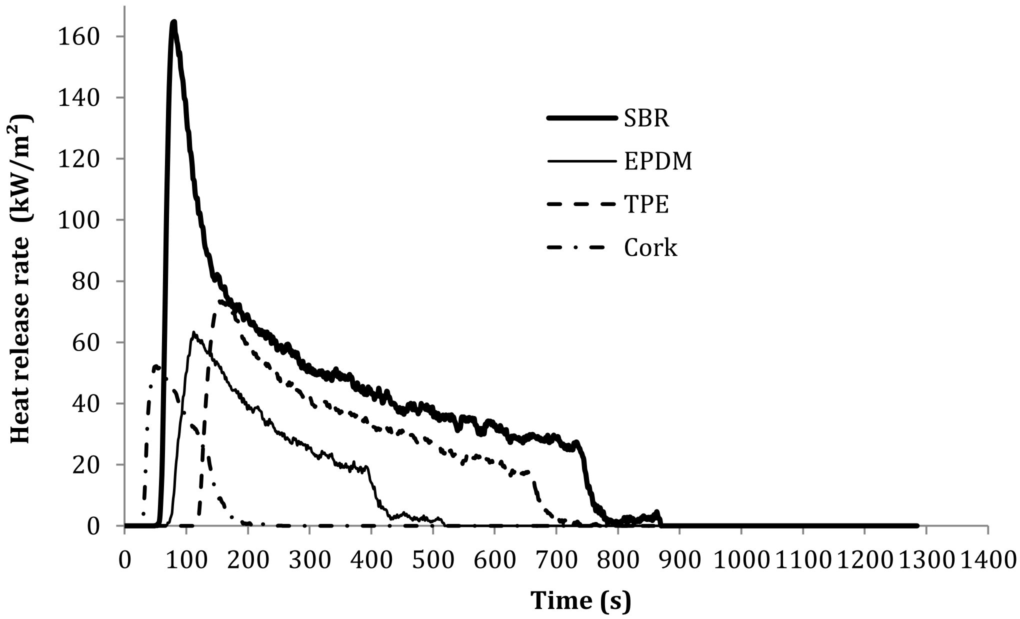

Figure 2. Heat release rate curves of infill materials obtained at MLC test

Table 1. MLC results obtained for infill materials at 25 kw/m²

Infill material	TTi (s)	pHRR (kW/m²)	THR (MJ/m²)	TFO (s)
SBR	55	170	37	742
EPDM	72	68	12	393
TPE	116	77	20	666
Cork	23	54	5	147

SBR, which is the most commonly used infill material, shows the worst fire results as the pHRR and THR values are much higher than for the other infill materials and because the combustion time is longer. PHRR values are comparable for EPDM, TPE and cork whereas the THR values are different for these three materials, which can be directly related to the combustion time. TPE has the longest TFO between the three (of the same order as SBR): approximately twice and four times more important than for EPDM and cork respectively. Finally, although cork has the shortest combustion time, the lowest pHRR and THR values among all materials, it has a much shorter time to ignition.
Thus, the infill materials behave differently when they are submitted to a radiant heat flux. The next step of the study is to see if the trends observed in terms of fire properties are similar when these infill materials are incorporated in the grass structures composed of the PP backing, the PP pile and the sand layer.

3.2 Fire properties of the complete artificial turf structures

The fire properties of the complete structures (CS) including the different infill materials previously studied were evaluated through MLC and the results obtained are given in Figure 3 and Table 2.

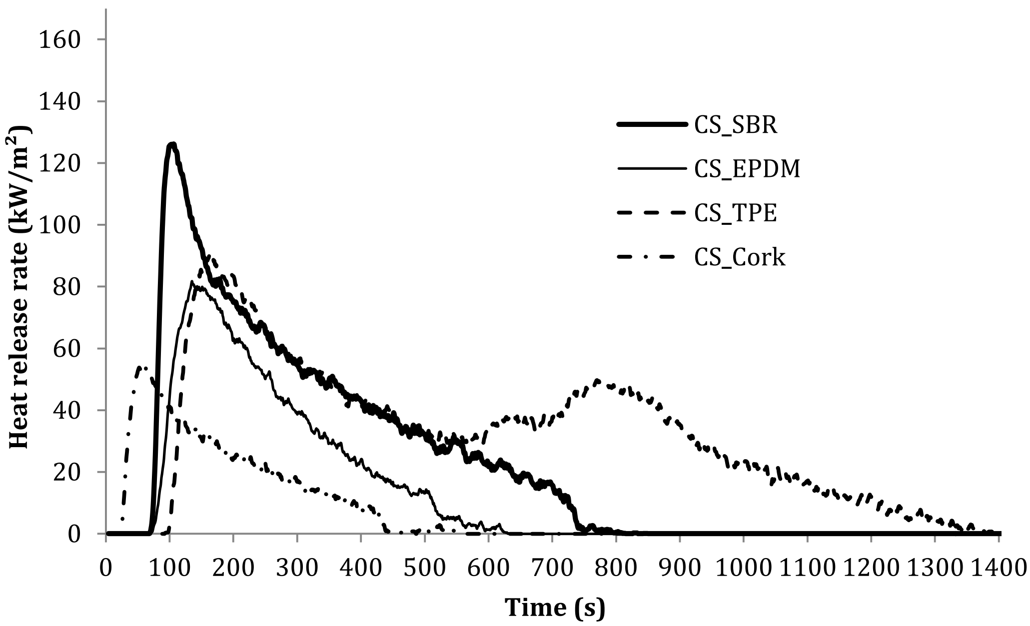

Figure 3. Heat release rate curves of the different artificial turf structures obtained at MLC test

Table 2. MLC results obtained for the different artificial turf structures at 25 kw/m²

Type of infill material in the grass structure	TTi (s)	pHRR (kW/m²)	THR (MJ/m²)	TFO (s)
CS_SBR	72 (+31%)	131 (-23%)	32 (-14%)	721 (-3%)
CS_EPDM	71 (-1%)	84 (+24%)	18 (+50%)	512 (+30%)
CS_TPE	97 (-16%)	96 (+25%)	45 (+125%)	1357 (+104%)
CS_Cork	22 (-4%)	58 (+7%)	10 (+100%)	428 (+191%)

*percentages represent the difference compared to the corresponding infill material tested alone

The MLC curve obtained for the structure containing SBR is very similar as the one obtained for SBR alone. The results are slightly better for the complete structure and the main difference between the two systems is that the pHRR value is 23% lower than for SBR alone.

On the contrary, for the other three systems, the MLC data obtained for the entire structures are worse than for the infill materials alone. For these three types of infill, the curves of the infill alone and that of the complete structure containing the corresponding infill can be perfectly superimposed until the time of pHRR of the pure infill. It can thus be concluded that the fire behavior of the complete structure is first dictated by the fire behavior of the infill and thus the choice of that component in artificial turf is crucial. This result could be surprising since turf pile is the upper material considering the whole grass structure but its nature (thermoplastic) leads to its melting and thus infill becomes rapidly the top material when the complete structure burns.
For the structure containing EPDM, the heat of heat release rate of the whole system after the time of pHRR is always superior to that of EPDM alone. It can be attributed to the degradation of the PP yarns constituting the pile whose height over the EPDM layer is of around 20 mm at the beginning of the MLC experiment. The same phenomenon is observed for the structure containing cork. However, the difference between the heat release rate of cork alone and that of the cork structure is more pronounced in the second part of the MLC experiment. In fact, as the height of the PP yarns is much smaller for the cork structure than

for the EPDM structure (10 mm compared to 20 mm respectively), the contribution of PP yarns degradation is less important at the beginning of the MLC experiment leading to comparable pHRR values for the cork and for the cork containing structure. However, the PP yarns inside the cork layer burn later, leading to a much longer combustion time (almost threefold increase of the TFO compared to cork alone) and much higher THR value (twofold increase). At the end of the MLC experiments, the backing is entirely preserved from degradation for the complete structures including EPDM and cork. Thus, the increase in the THR can be attributed to the degradation of the PP pile. This is consistent with the fact that the THR increase is similar for the structures containing EPDM and cork (respectively 6 MJ/m² and 5 MJ/m²) compared to the pure infill.
Finally, the behavior of the TPE structure is different from that of the other structures, particularly in the second part of the MLC experiment. Until around 550 seconds, the MLC curves of TPE alone and of the structure containing TPE are rather similar and the same conclusions as those previously drawn can be made. A slight increase of the heat release rate can be observed and can be attributed to the degradation of the PP yarns from the pile. However, after 550 seconds of experiment, the heat release rate increases again and this phenomenon can be attributed to the partial degradation of the backing. In fact, during the first part of the MLC experiment, the degradation of the TPE layer leads to the formation of a crust. Afterwards, cracks appear so that heat can go through the TPE layer and reach the backing. At the end of the MLC experiments, the backing has lost its flexibility and has become brittle. The THR values confirm that both the PP pile and the backing are degraded. Indeed, the THR increase is much more important than for the structures containing EPDM and cork (25 MJ/m² increase compared to 6 and 5 MJ/m² increase for the EPDM and cork structures respectively). Among the four tested structures, only the structure containing TPE showed a degradation of the backing, so that the THR value obtained for this system was the worst of all the structures tested.

4. CONCLUSION

The aim of this study was to determine the contribution of the different components of grass structure to its fire behavior. Different systems containing various types of infill materials were tested using MLC and the results obtained were compared to those of the infill materials alone. It has been shown that the fire behavior of all grass structures is similar to the one of the infill material in a first part of the experiment. For the SBR system, the MLC results are even entirely linked to those of the SBR layer. For the structures containing EPDM and cork, the fire performance is decreased compared to the infill materials alone because of the additional degradation of the PP yarns coming from the pile. Finally, the worst behavior is achieved with the TPE system as both the degradation of the pile and of the backing contributed to the increase of the peak of heat release rate and of the total heat release. Further studies will now be carried out to find the infill material exhibiting the best fire behavior, taking into account the material cost, and the end-use properties (impact absorption, UV resistance...).

5. REFERENCES

1. ISO 13927, Plastics simple heat release test using a conical radiant heater and a thermopile detector, International Organization for Standardization, Geneva, Switzerland, 2001.

6. ACKNOWLEDGEMENTS

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