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Effect of insulation material on the fire performance of composite panels

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Background

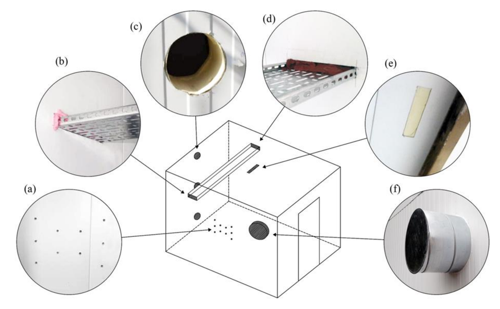
Commercially available sandwich panels have been involved in several large fires costing insurance companies millions of Euros [1]. It is widely believed that sandwich panels containing polyisocyanurate (PIR) are able to provide an effective fire barrier. However, the fire tests that are carried out are on pristine panels often more carefully constructed to perform well in the test and do not have the large fire loads which are found in actual buildings.

The main objectives of this study were to investigate:

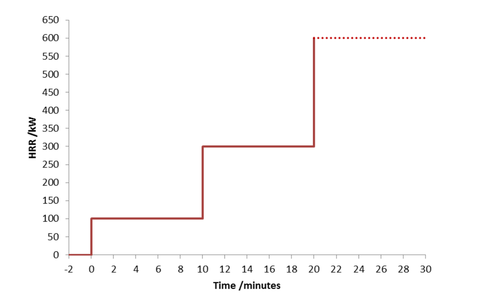
1. Whether or not insulation materials contribute to a fire
2. The toxicity of the gases generated
3. How more realistic and imperfect conditions affect the results

Modifications to the standard test

Four tests were conducted in rooms constructed according to the ISO 13784-1 standard [2], subject to minor alterations. Firstly, superficial damage was added to simulate observed modifications in real buildings, such as damage due to fork lift trucks, installation of pipework and cable trays, and screw holes. The rooms were also constructed by builders as opposed to fire technicians.



Secondly, the fire loading of the test was increased to be more representative of fuel loads found in real buildings. Thus, the burner used in the test was increased from 300 kW to 600 kW after 20 minutes, and a separate test with a substantial wooden crib was carried out.



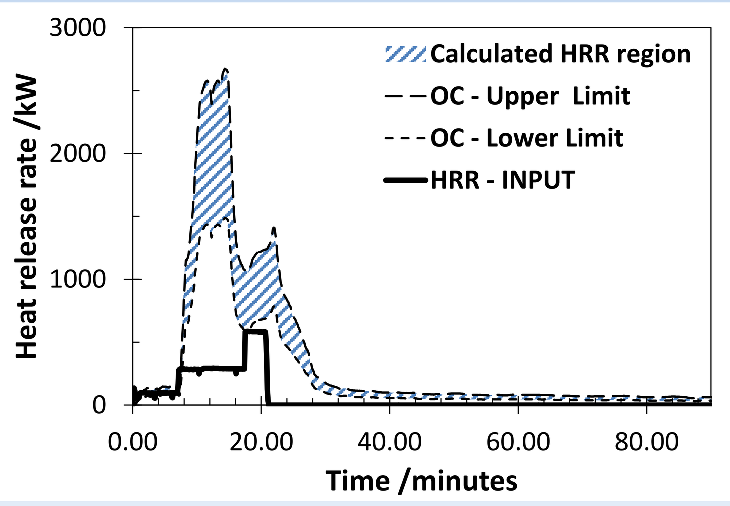
These modifications were conducted on two types of sandwich panels one with a core of polyisocyanurate (PIR) and the other with a core of stone wool (SW). Both types of panels have achieved the highest FM (Factory Mutual) Fire Safety Rating of Class 1 [3].

Tests conducted

Propane burner only

Test 1: PIR

Figure: Room before burner shut off

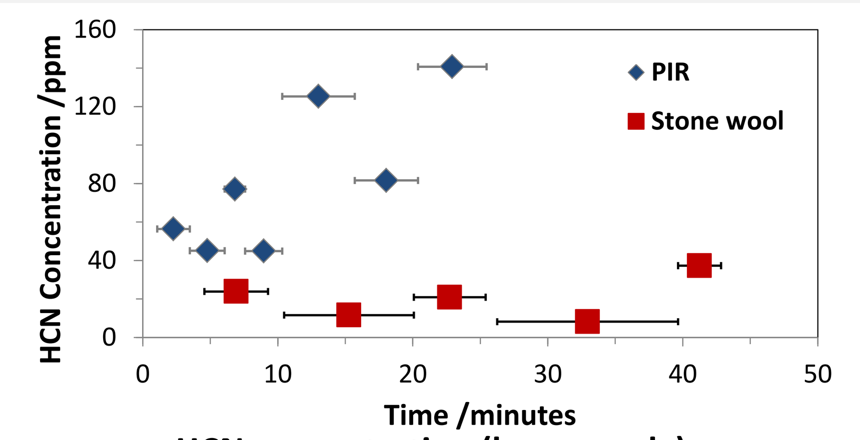


HRR of PIR room (burner only)

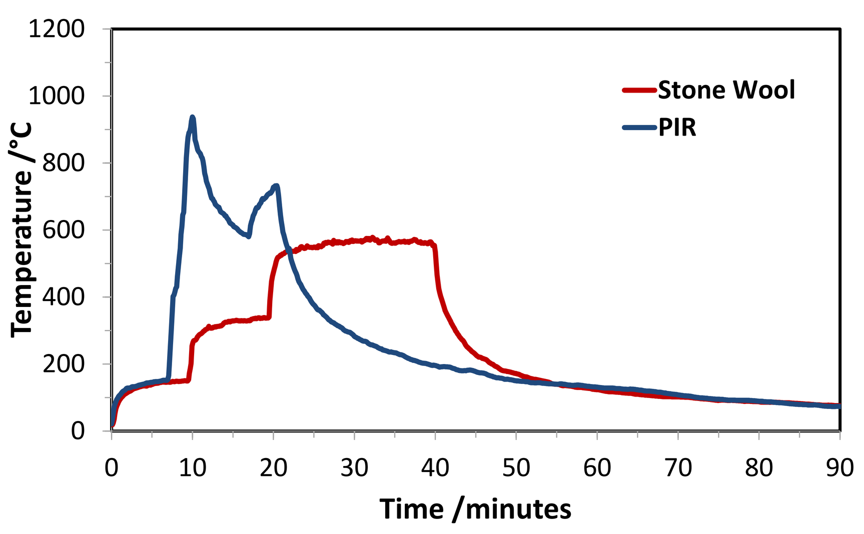
Test 1: A burner was placed in the corner of the room surrounded by PIR sandwich panels. The Heat Release Rate (HRR, above) shows the output of the burner, as well as the calculated HRR based on O_2 consumption through the doorway. The contribution of the PIR can be seen as the calculated HRR increase over the burner input.

The toxicity of gases leaving the door is shown (above, right) which shows presence of HCN due to under-ventilated combustion of PIR. Average temperature of the upper thermocouples is shown to the right.

HCN and temperature comparison

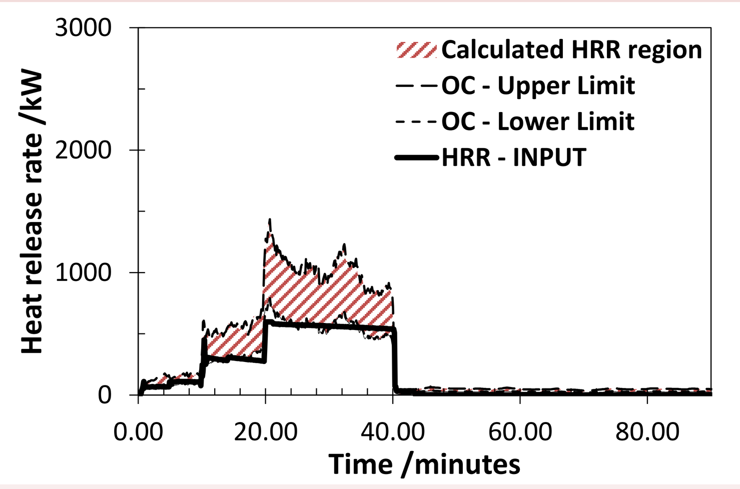


HCN concentration (burner only)



Average upper temperature of room (burner only)

Test 2: Stone wool



HRR of SW room (burner only)

Figure: Room before burner shut off

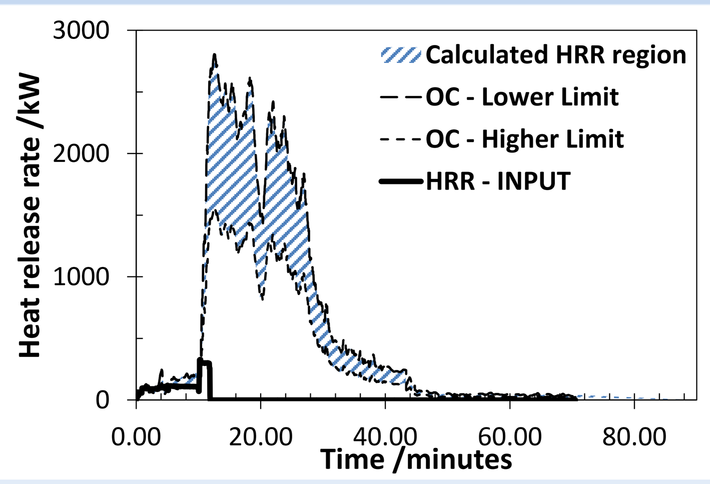
Test 2: Stone wool panels were used in a test otherwise identical to test 1 (where PIR was used). The total calculated HRR (above) closely followed the calculated amount from the burner, suggesting negligible contribution from the stone wool.

The levels of hydrogen cyanide (HCN, above left) were much lower than those noted in the PIR room. The average temperature in the upper layer compartment was lower overall despite longer burner time at 600 kW and increased test duration (left).

Propane burner and wooden crib

Test 3: PIR

Figure: Under ventilated burning in room

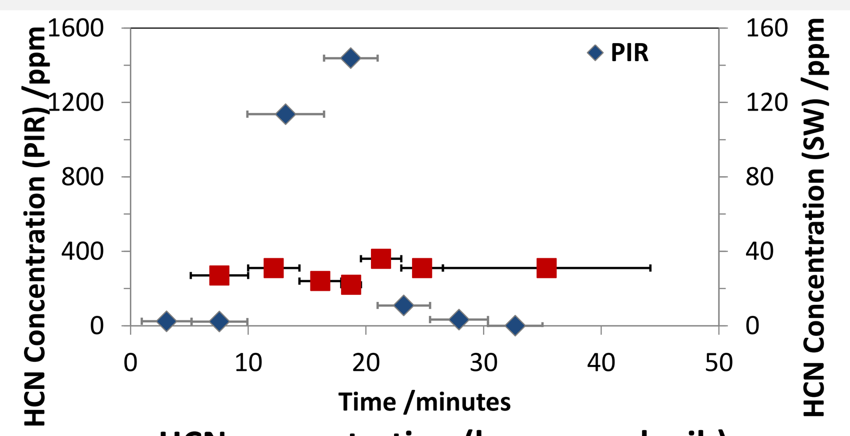


HRR of PIR room (burner and crib)

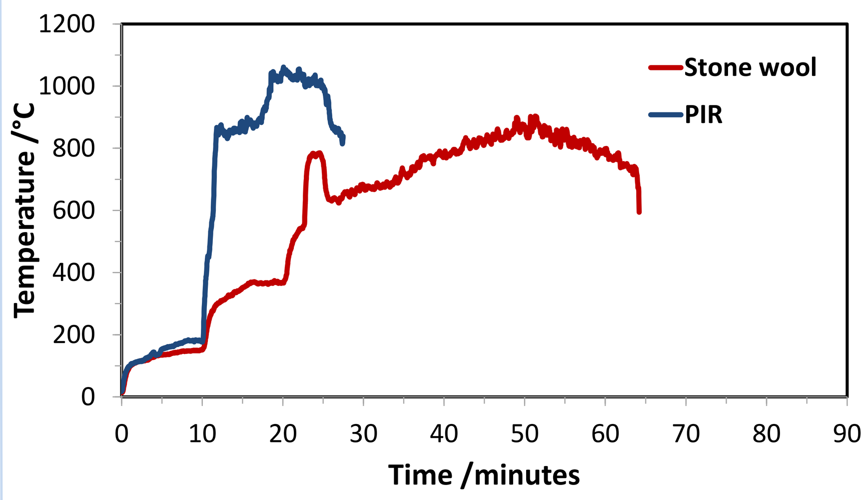
Test 3: A 169 kg wooden crib was placed on the opposite side of the enclosure, in addition to the burner. The crib ignited after 11 minutes (1 minute after stepping the burner up to 300 kW) from radiation above, and took 2 minutes for the flames to reach the bottom of the crib.

Measurements of HRR, HCN and average upper temperature are shown above, above right and right, respectively.

HCN and temperature comparison

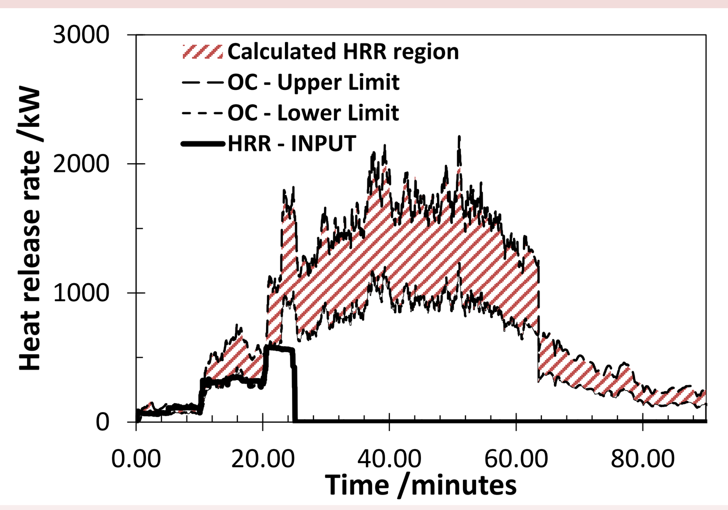


HCN concentration (burner and crib)



Average upper temperature of room (burner and crib)

Test 4: Stone wool



HRR of SW room (burner and crib)

Figure: At peak HRR; no contribution from SW

Test 4: A larger wooden crib weighing 297 kg was placed in the same location as test 3. This took 22 minutes to ignite (2 minutes after stepping the burner up to 600 kW), and the flames reached the bottom after 10 minutes.

Measurements of HRR, HCN and average upper temperature are shown above, above left and left, respectively.

Discussion

The difference in fire behaviour dependant upon the insulation material used in the walls and ceiling was substantial, despite the fact that both materials have achieved the same certification. In the burner-only tests the PIR contributed significantly to the calculated HRR but in the stone wool room the contribution was negligible. The HCN concentration in the PIR room was 10x greater than the lethal level, and a factor of 40 greater than in the SW room.

Flaming through gaps and outside the room for PIR was substantial which would present the risk of fire travelling through walls in the event of a real fire. In the SW room there was a small amount flaming through holes, but this was due to the high flames from the burner.

Conclusions and future work

1. PIR composite panels can contribute significantly to a fire despite having the same fire safety certification as SW.

2. High levels of toxicity were recorded in the PIR tests, particularly HCN.

3. The use of more realistic fire loadings and the introduction of imperfections caused external flaming which would otherwise not be present in the standard test.

It is intended to analyse the remaining data gathered from the tests (CO, CO_2, temperature profiles) and publish them in a journal. Repeat tests to investigate the effects further may be carried out in future.

References

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3. FM Approvals, 2010. *Approval Standard for Class 1 Fire Ratings of Insulated Wall or Wall and Roof/Ceiling Panels, Interior Finish Materials or Coatings and Exterior Wall Systems. Class Number 4880* [online].

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