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Annex A – Floor Voids

General

In order to investigate the potential for unseen fire spread to occur through voids in suspended floor systems, a series of experiments have been undertaken utilising a commercially designed and installed suspended floor system. Work has also been undertaken to look at the potential for unseen fire spread arising from standard timber floor systems and also potential transmission routes for fire spread from radiant heat sources from the room of fire origin into the floor void.

Experimental

The experimental programme for this stage of the project has been undertaken in three phases:

Phase One : Chipboard and steel commercial floor system.

Phase Two : A single test on a standard timber floor system.

Phase Three: Potential ignition scenario.

Phase One: Commercial Floor system.

An 8.4m square floor system was designed and installed for this phase of the project, see photograph A1. Table A1 summarises the experimental programme for this phase of the project. Two void heights were considered; 150 and 300 mm together with the location of and performance of a commercially purchased cavity barrier system, see photograph A2.

Photographs A1 and A2 show the design of the steel and chipboard floor panels. The floor was a screw fixed system, comprising of fully steel encapsulated high density chipboard panels of 600mm square and 26 mm thick. The cavity was formed by attaching the panels to height adjustable pedestals, which were set to give the floor an overall height of either 150 or 300mm.

Phase Two: Timber Floor

For this phase of the work a single test was undertaken using a 300 mm deep void with a Class 2 (as defined in BS 476 part 7) floor grade chipboard, supplied as 1200mm x 2400mm sheets, fitted to the same pedestal system as used in phase one, see Photograph A3. The total area of floor was also reduced to 4.2m square to reduce the quantity of potentially combustible material exposed to the fire source.

Phase Three: Ignition Scenario

Four of the steel cased floor panels were exposed to a radiating heat source and their transmission response was monitored. This is discussed in detail below.

Experimental Setup - Floor Voids

Instrumentation

Temperature measurements were made throughout the system on both sides of the cavity barrier as well as within the cavity barrier.

Thermocouples were spaced at 1.8m intervals with two thermocouples at each measuring point at heights of 20mm and 80mm from the lower surface of the tile. Further measurements were taken at the cavity barrier with measurements on the fire side, in the core and on the unexposed side of the cavity barrier. A further two measurements were taken over the top of the burner, with one thermocouple at 80mm and one thermocouple in the core of the floor tile. Two thermocouple trees were also installed to determine the temperature profile within the cavity. Figures A1 and A2 show the location of the instrumentation and the experimental set ups.

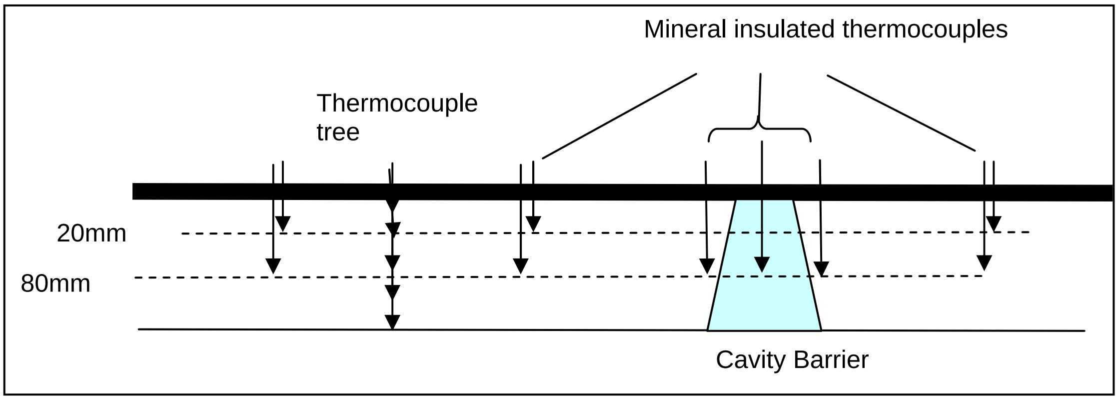


Figure A1. Thermocouple and cavity barrier locations.

Ignition Source

A 200 kW ignition source was used for this study, this was achieved by using a 300mm by 300mm gravel box burner, with the propane fuel supplied using a mass flow controller. The burner was ignited under the floor, with the tile above the burner removed. Once ignition of the burner had been established and was giving a steady flame, the burner was pushed into position and the floor tile was replaced. The burn time was defined as thirty minutes from the time the burner was in its final position.

Smoke measurement

Measurement of the smoke penetration through the cavity barrier was undertaken using a laser smoke system. This was setup on the unexposed side of the cavity barrier at 2.1m from the barrier and had a path length of 2.4m.

Cavity Barrier

A nominal 50 mm thick foil faced mineral wool cavity barrier was used in these tests. The cavity barrier was oversized to give a tight fit when the floor tiles were placed into position. To ensure a proper seal, aluminium tape was used to seal all the joints and to fix at the top and bottom of the barrier.

Scenarios

Table A1 summarises the experimental scenarios considered in Phases one and two of this study.

Table A1. Summary of Experimental Programme for Phase One and Two.

Test	Void depth (mm)	Burner position	Barrier position	Floor size and material	Duration of test	Photograph Reference (A)	Graph Reference (A)
1	300	Figure A2	No barrier	8.4 m steel and chipboard	8mins 31secs (511sec)		1,2,3
2	300	Figure A2	Centre of floor	8.4 m steel and chipboard	30mins (1800secs)	4,5,6	4,5,6
3	300	600mm from barrier	Centre of floor	8.4 m steel and chipboard	30mins (1800secs)	7,8	7,8,9
4	300	600mm from centre of floor	No barrier	8.4 m steel and chipboard	30mins (1800secs)	9,10,11	10,11,12
5	150	Figure A2	No barrier	8.4 m steel and chipboard	20mins (1200secs)		13,14,15
6	150	Figure A2	At edge of floor	8.4 m steel and chipboard	30mins (1800secs)	12,13	16,17,18
7	150	Figure A2	Centre of floor, and also edge of floor	8.4 m steel and chipboard	30mins (1800secs)	14,15,16	19,20,21
8	300	Figure A2	600 mm from edge of floor	4.2 m Class 2 chipboard	20mins (120secs)	17,18	22,23

Discussion and Recommendations

The results from the tests on the steel encapsulated panels show, as expected, that the flames are very elongated laterally when restrained within the floor void leading to some spillage around the edges of the floor plate. For both void heights, with both direct flame impingement and solely hot gases acting upon the cavity barrier, the integrity of the barrier was retained for the duration of the test exposure.

Smoke production from the floor panel materials was highly visible above the floor plates within the laboratory space, particularly directly above the burner location, see photograph A10. The smoke measurement within the floor void on the unexposed side of the barrier picked up only limited smoke levels, this may be due in part to the fully ventilated conditions within the void area which would not be untypical of those seen in practice and may also be a reflection of the performance of the cavity barrier in restricting smoke movement.

The results from the chipboard floor deck test showed that whilst the flooring material achieved a Class 2 surface spread classification when tested to BS 476 part 7, the exposed surface combustion within the void did not develop to flashover within the cavity during the test, although the fire did break through to the upper surface of the floor deck at around 20 minutes from ignition, leading to the termination of the test. During this test, a significant quantity of smoke was released from the flooring material and again this was observed on the upper surface of the floor plate with the cavity barrier effectively mitigating the transmission of both smoke and flames beyond the barrier within the void space, see photograph A17. It should also be noted that all visible flaming both on the upper and lower surfaces of the timber floor plate ceased once the ignition source was removed, although the material continued to smoulder until it was manually extinguished.

The results from this work confirm that cavity barriers, when effectively designed and installed, appear to offer a suitable means of mitigating potential fire and smoke spread through unseen cavities.

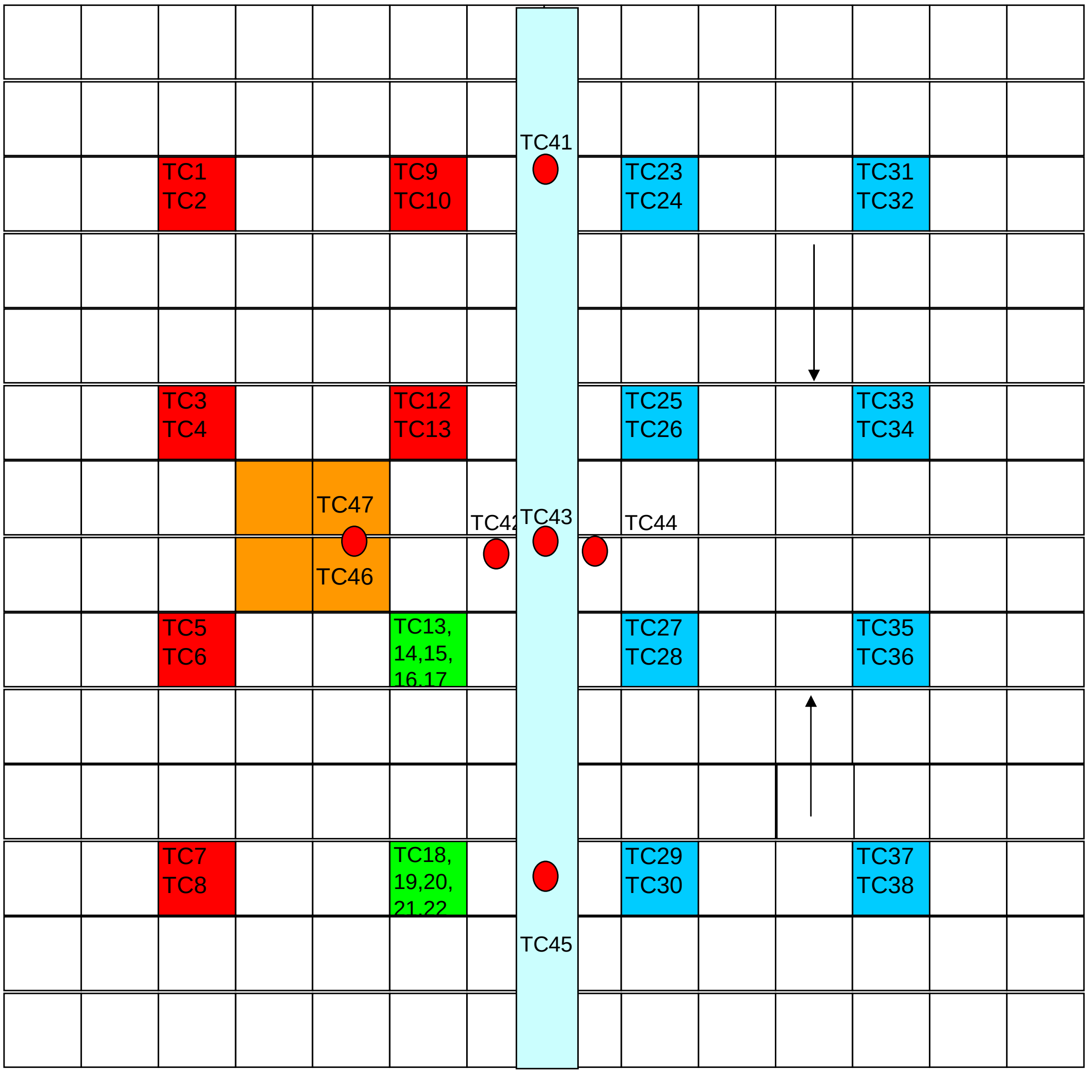
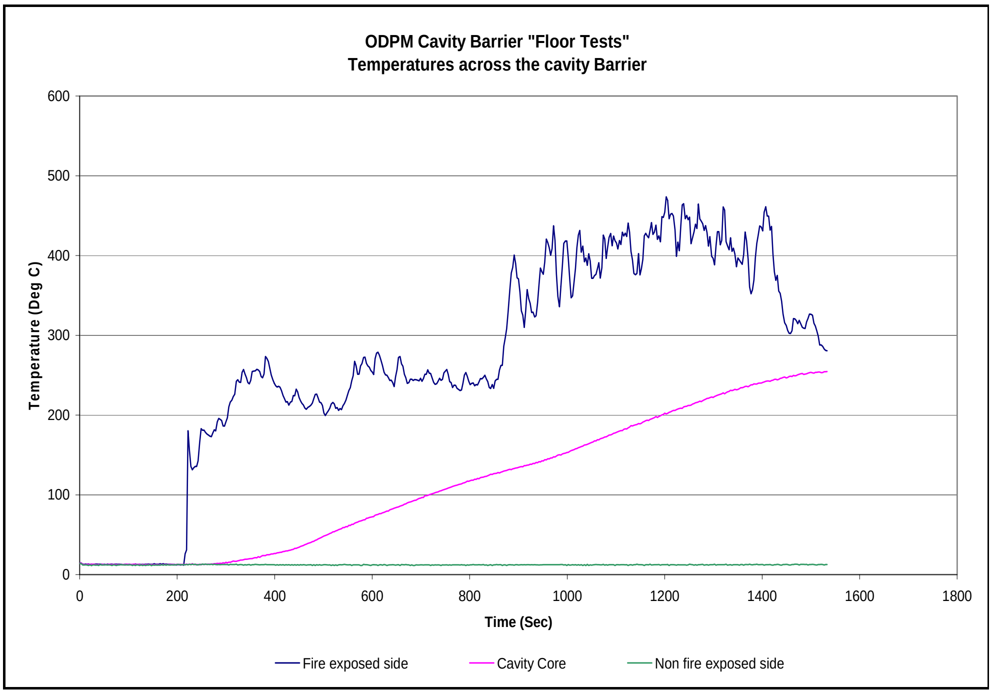


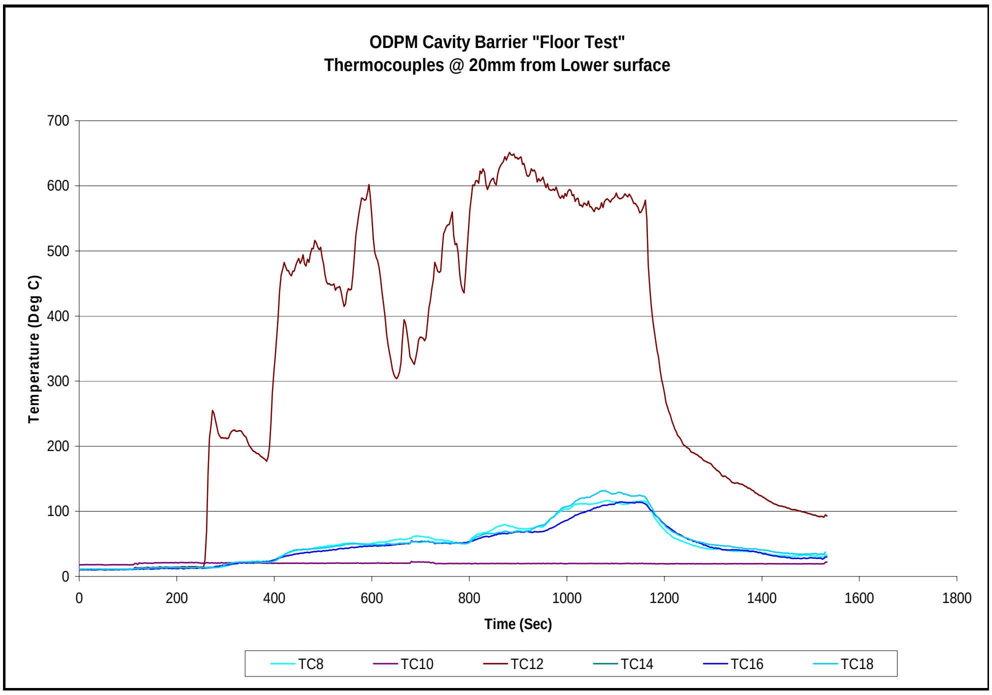
Figure A2. Plan view of instrumentation and experimental set up for phase one tests with the cavity barrier centrally located.

- Thermocouples in centre of panel @ 1.8m centres, 20mm and 80mm from lower surface (Red & Blue squares).
- Five bare wire thermocouples at 30, 60, 90, 190, 230mm and 30, 60, 90, 220 and 270mm spacing (Green squares).
- Burner position (Orange squares).
- Cavity Barrier (light blue rectangle).
- Arrows show position and path length of laser.

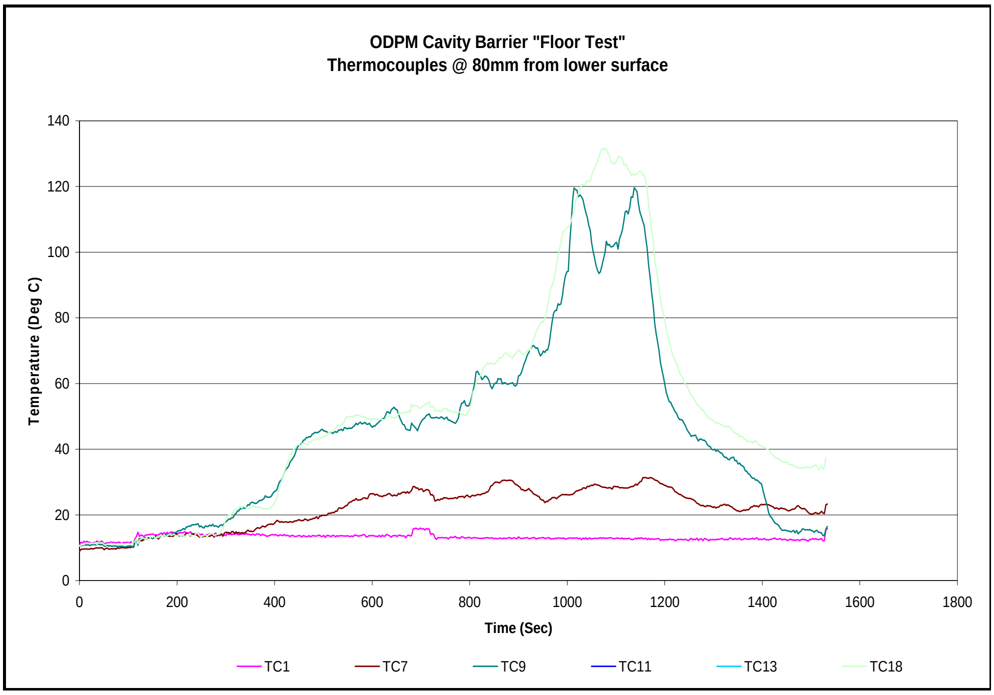
Graphs



Graph A1. Test 1 temperatures across the barrier

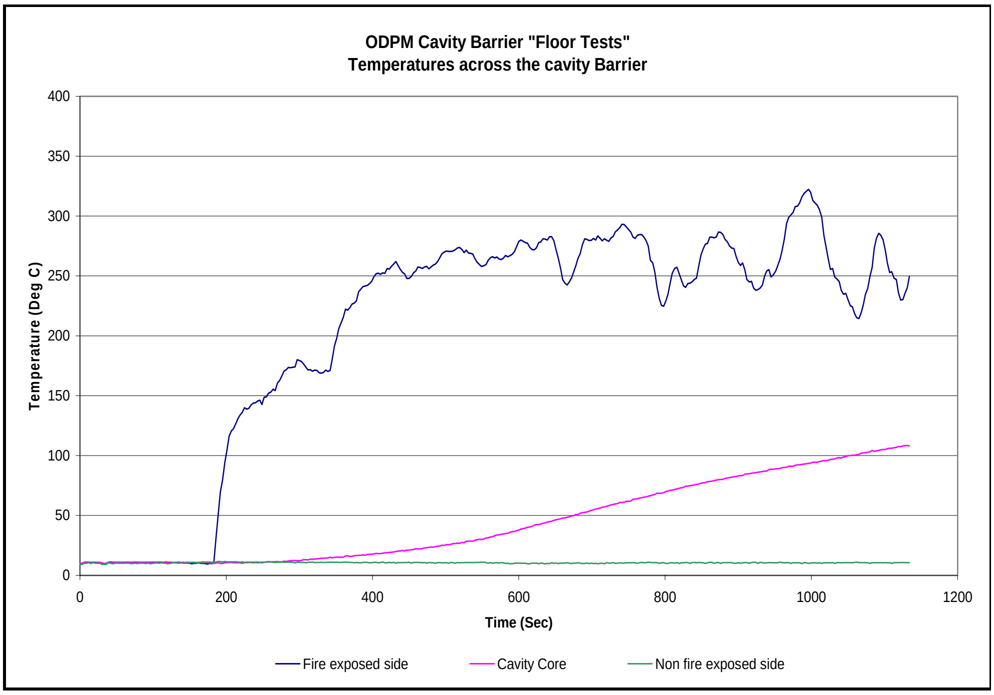


Graph A2. Test 1 temperatures at 20mm

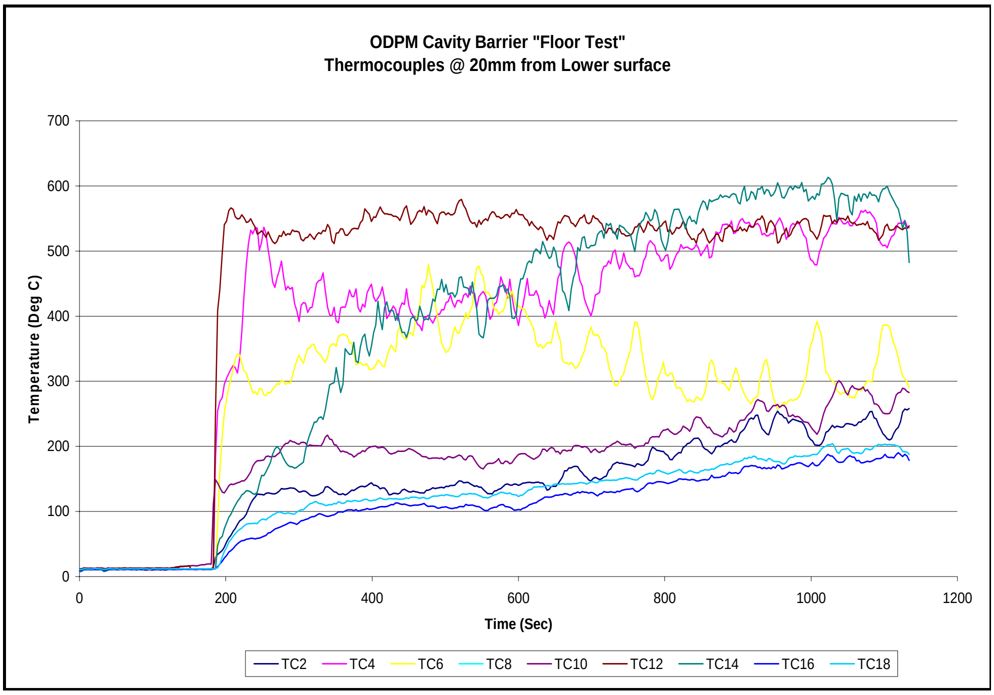


Graph A3. Test 1 temperatures at 80mm

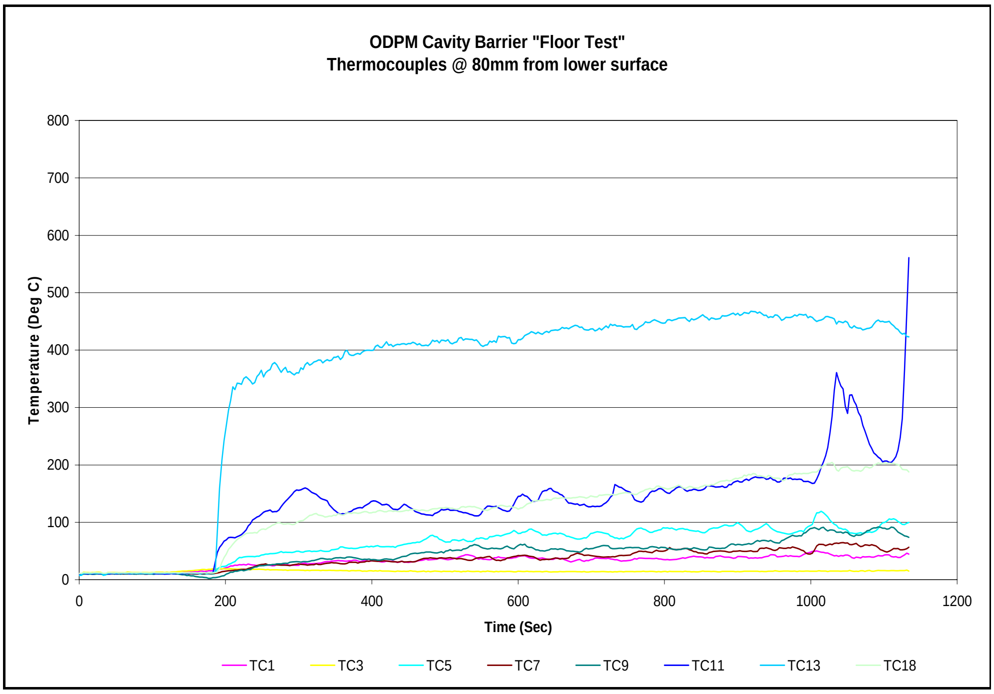
Test 2 300mm floor with cavity barrier



Graph A4. Test 2 temperatures across the barrier

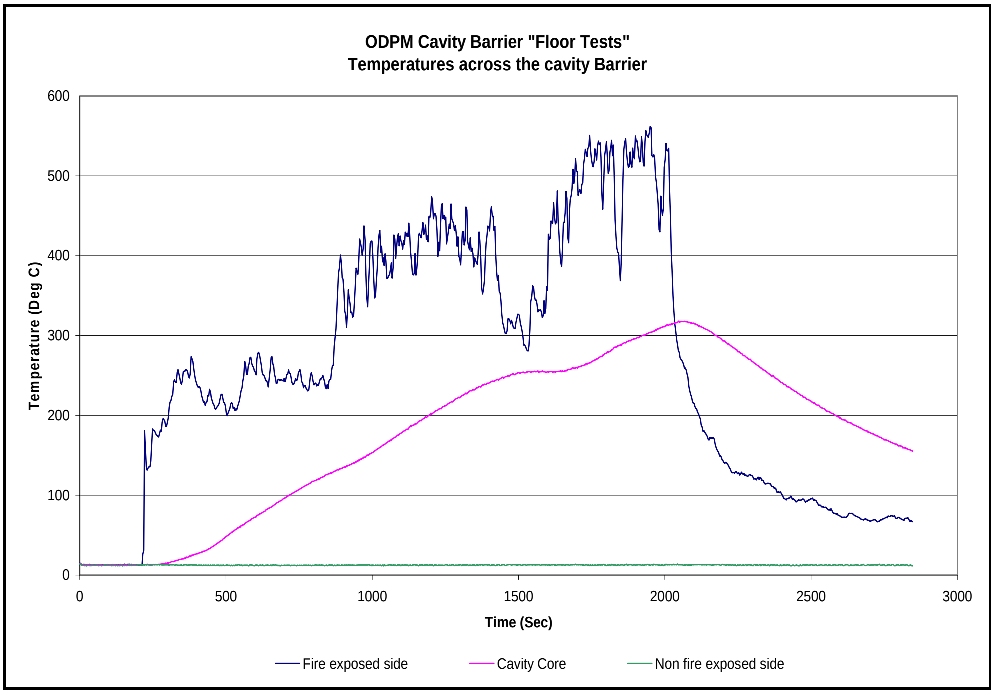


Graph A5. Test 2 temperatures at 20mm

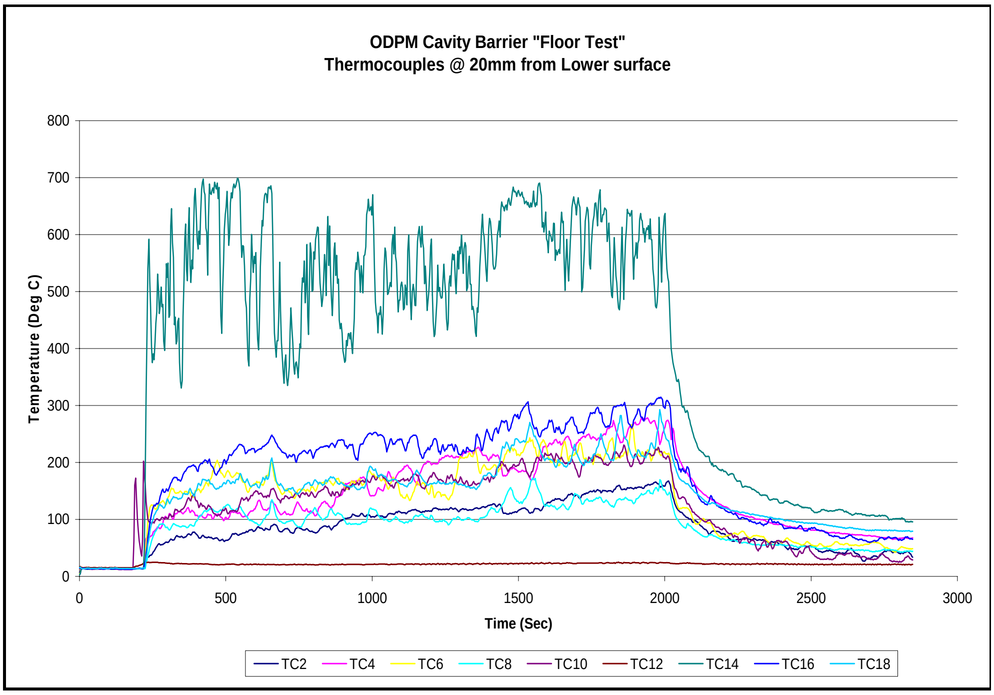


Graph A6. Test 2 temperatures at 80mm

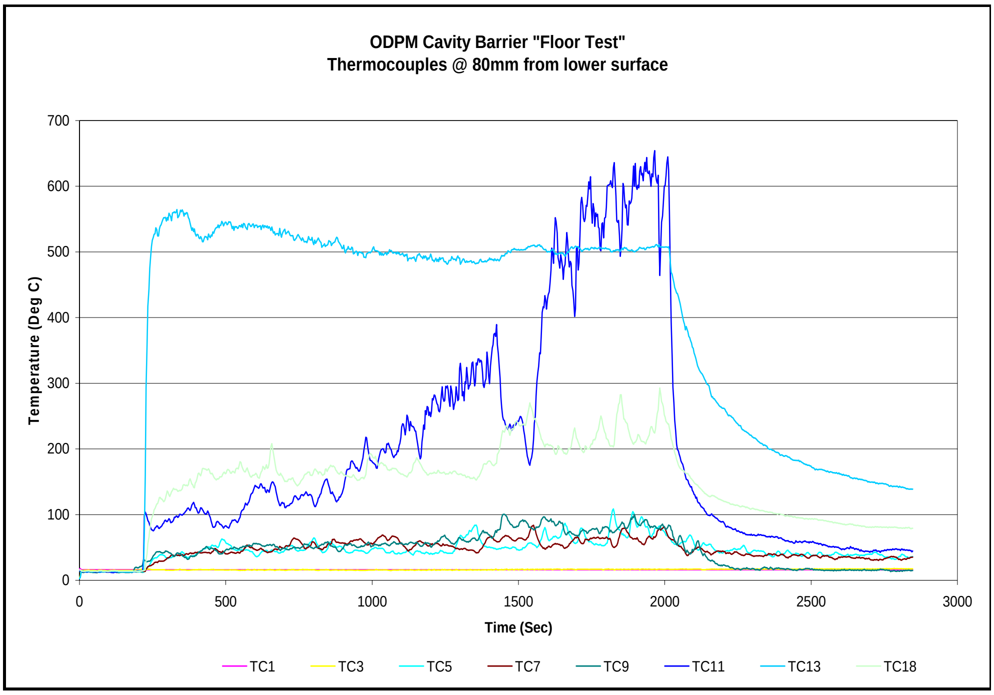
Test 3, 300mm floor with cavity barrier, burner 600mm from cavity barrier



Graph A7. Test 3 temperatures across the barrier

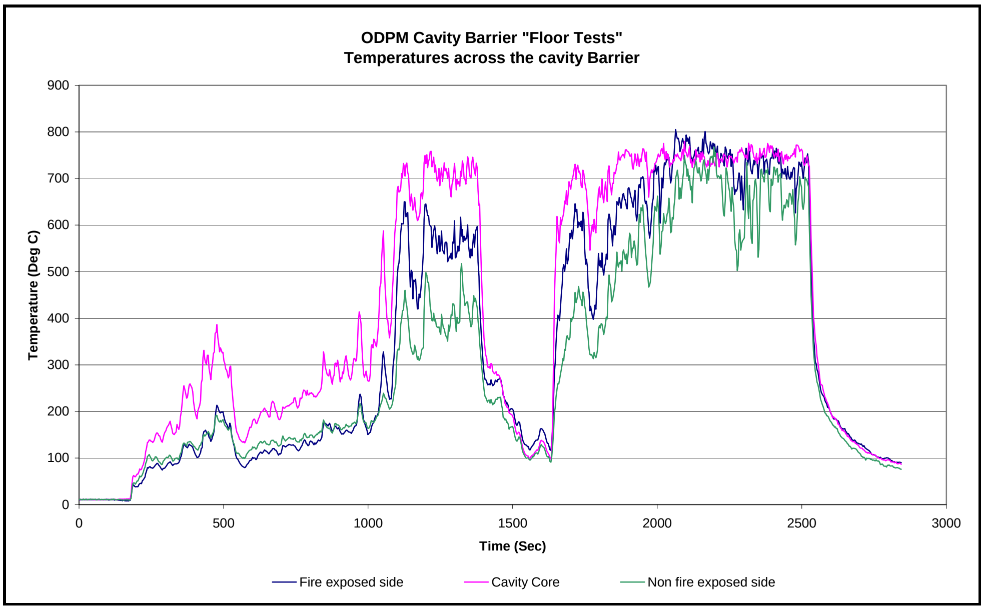


Graph A8. Test 3 temperatures at 20mm

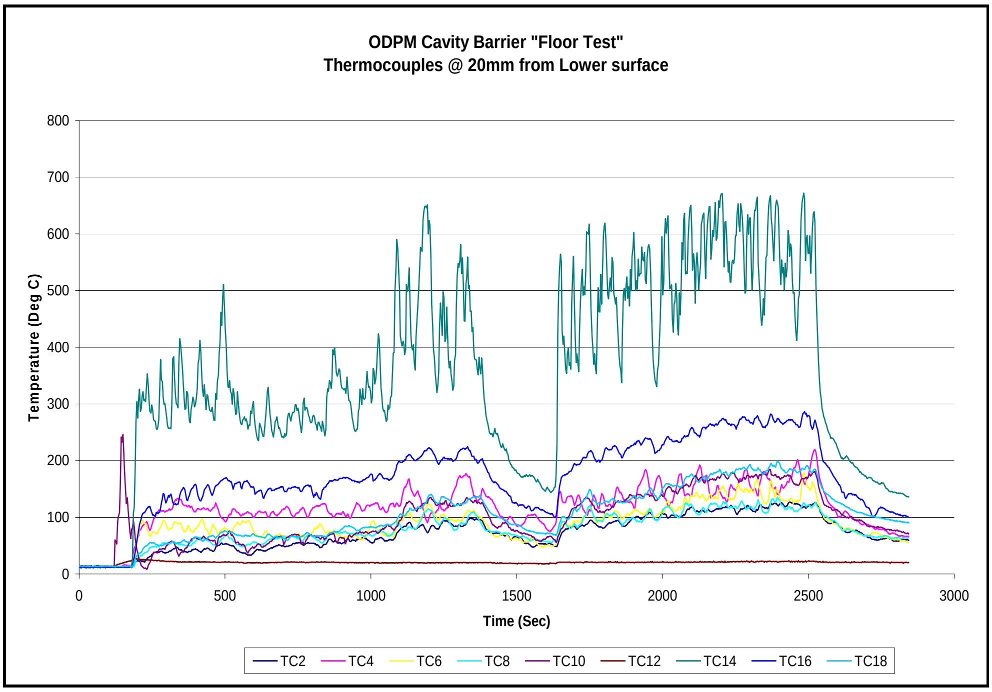


Graph A9. Test 3 temperatures at 80mm

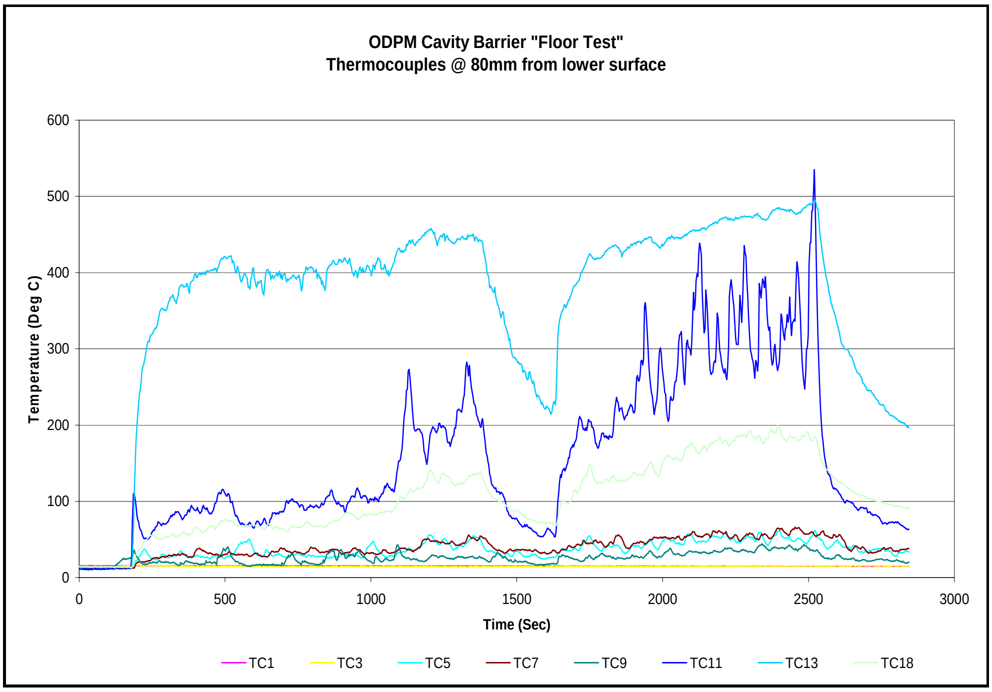
Test 4, 300mm floor with no cavity barrier



Graph A10. Test 4 temperatures across the barrier

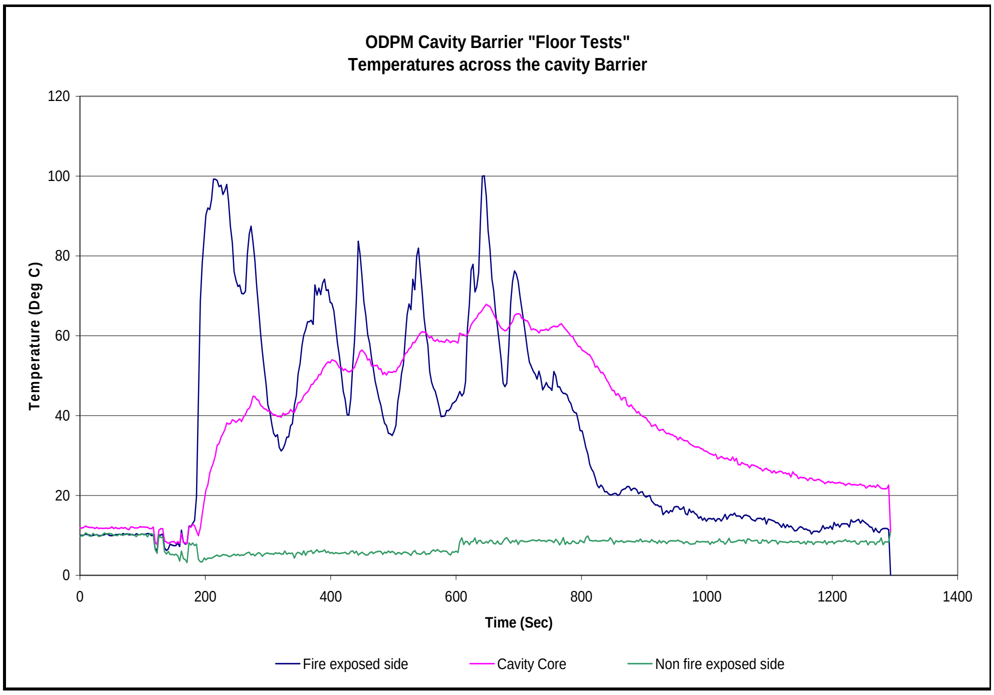


Graph A11. Test 4 temperatures at 20mm

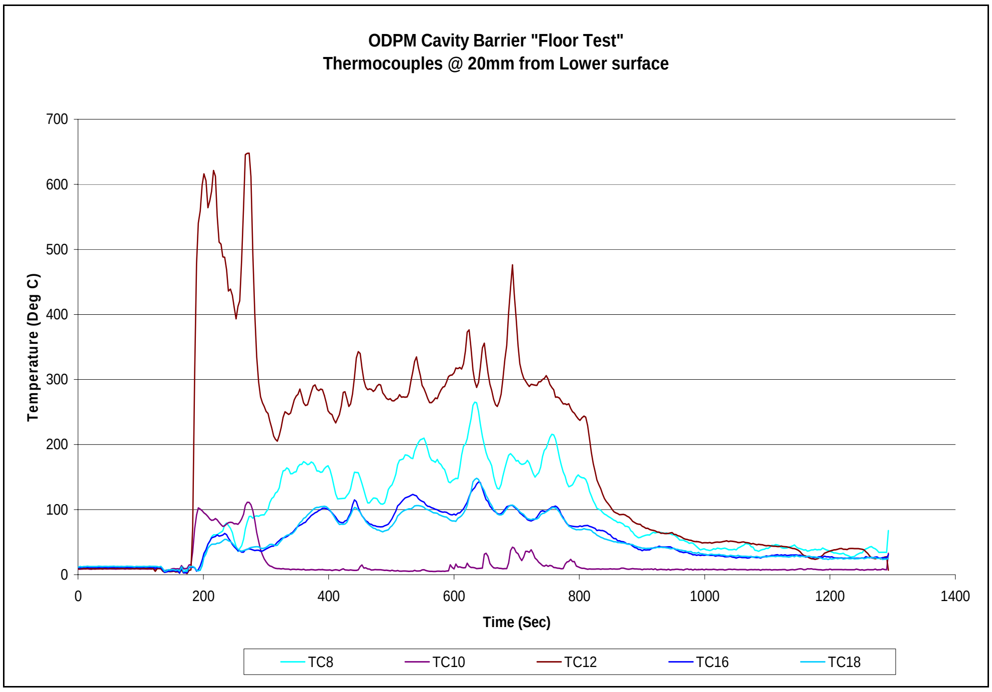


Graph A12. Test 4 temperatures at 80mm

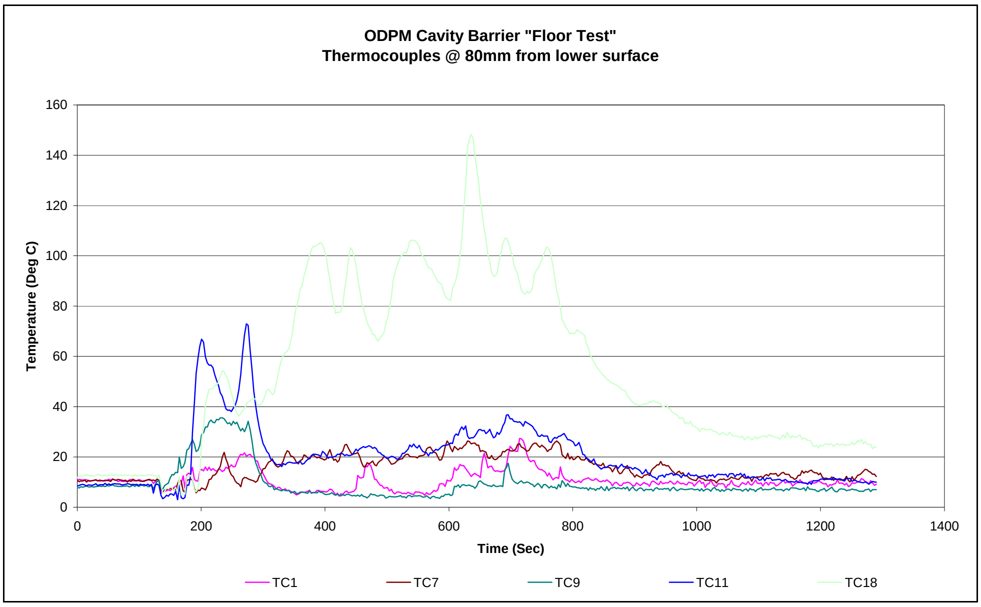
Test 5, 150mm floor with no cavity barrier



Graph A13. Test 5 temperatures across the barrier

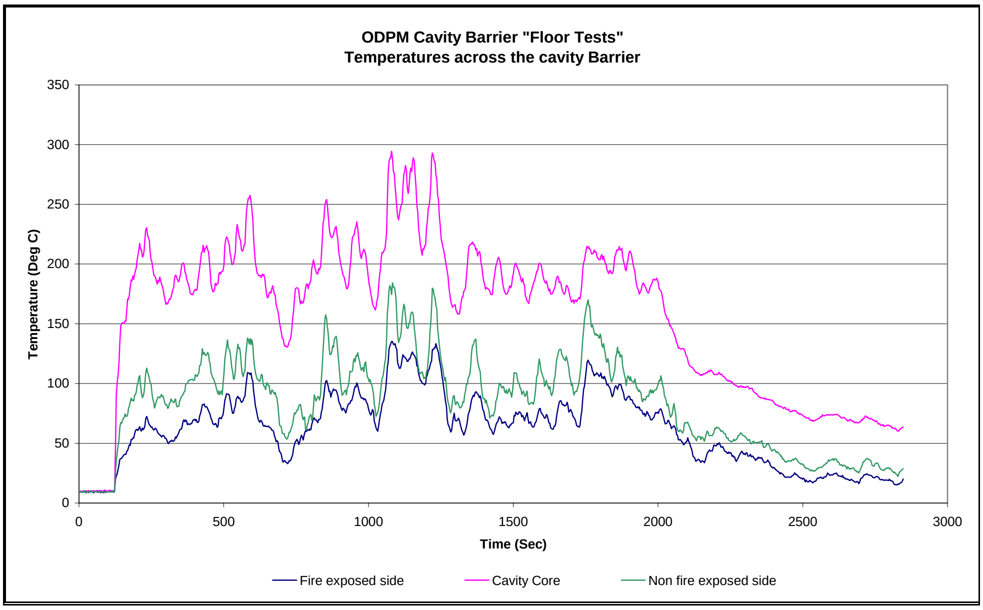


Graph A14. Test 5 temperatures at 20mm

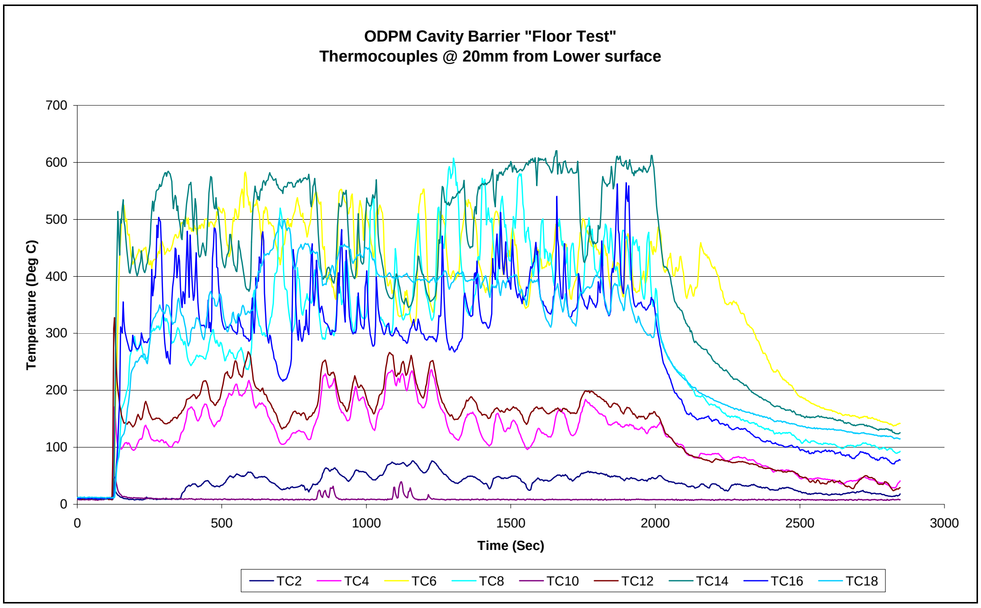


Graph A15. Test 5 temperatures at 80mm

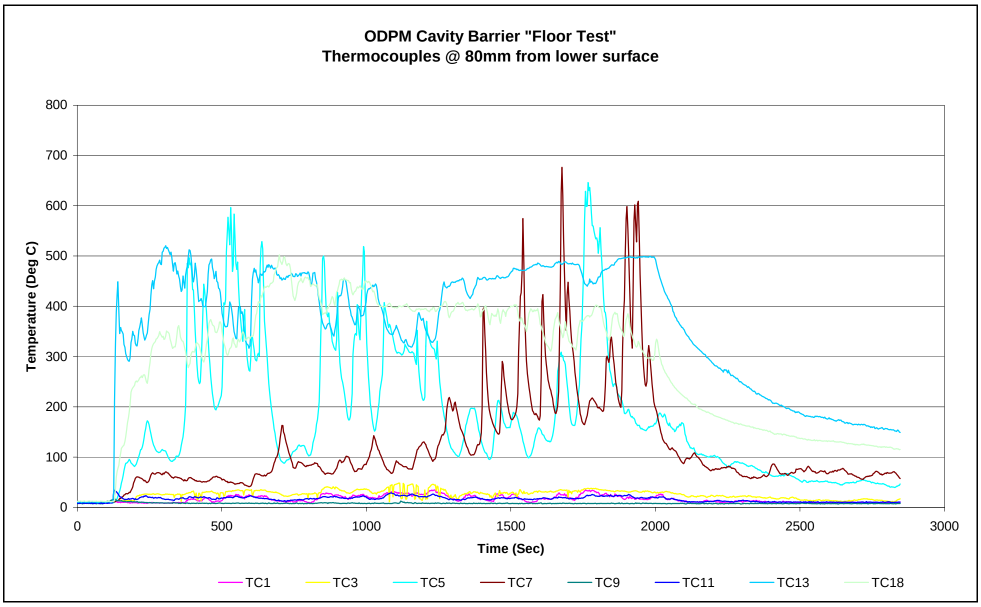
Test 6, 150mm floor with cavity barrier at the edge of the floor



Graph A16. Test 6 temperatures across the barrier

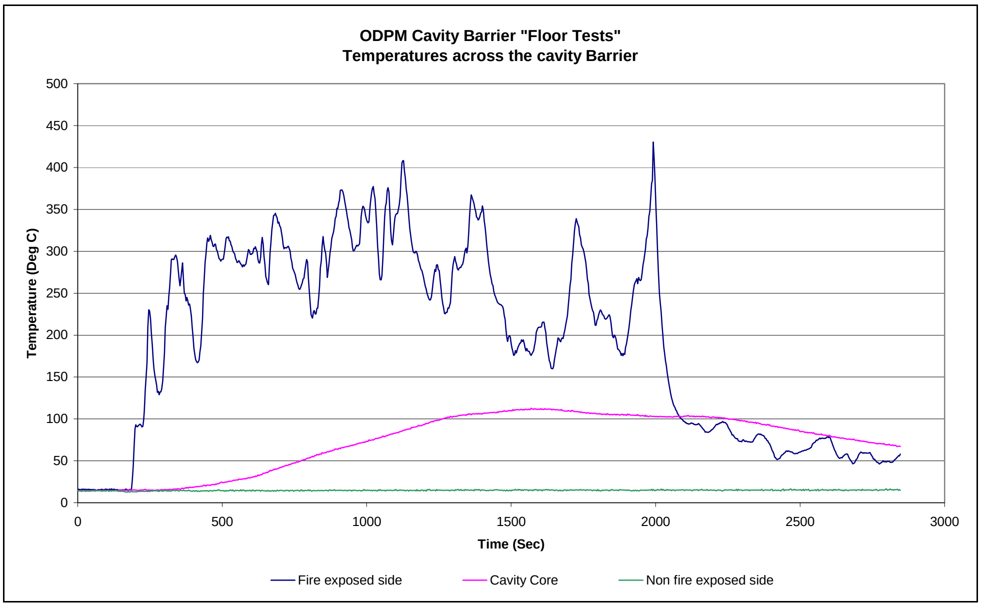


Graph A17. Test 6 temperatures at 20mm

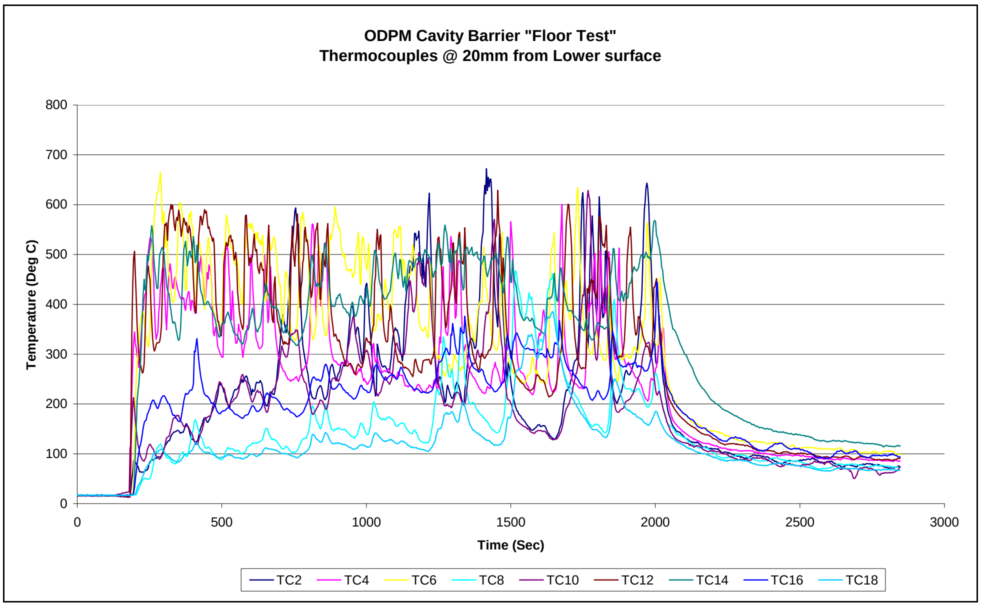


Graph A18. Test 6 temperatures at 80mm

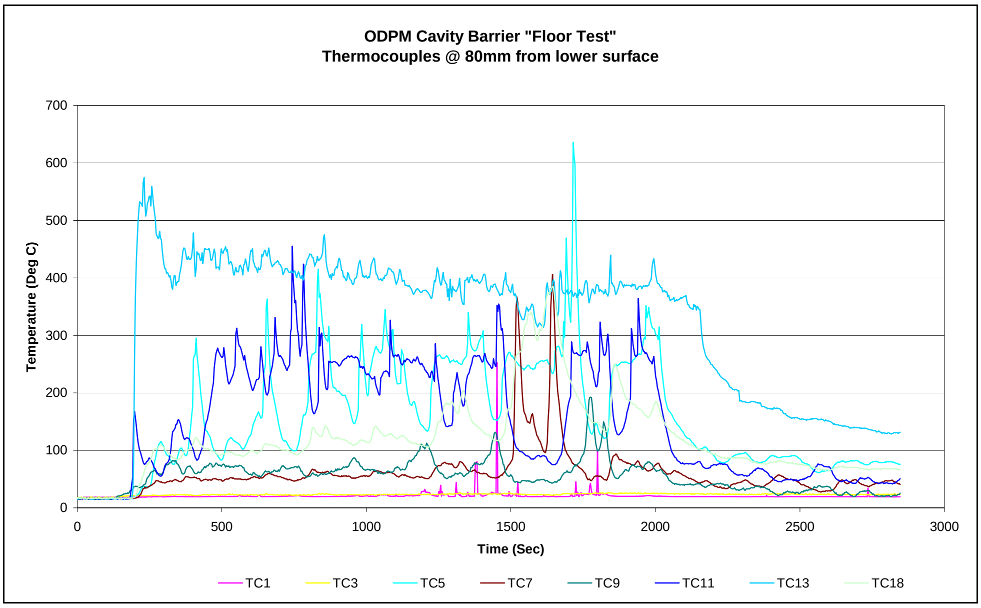
Test 7, 150mm floor with cavity barrier in the center and at the edge of the floor



Graph A19. Test 7 temperatures across the barrier

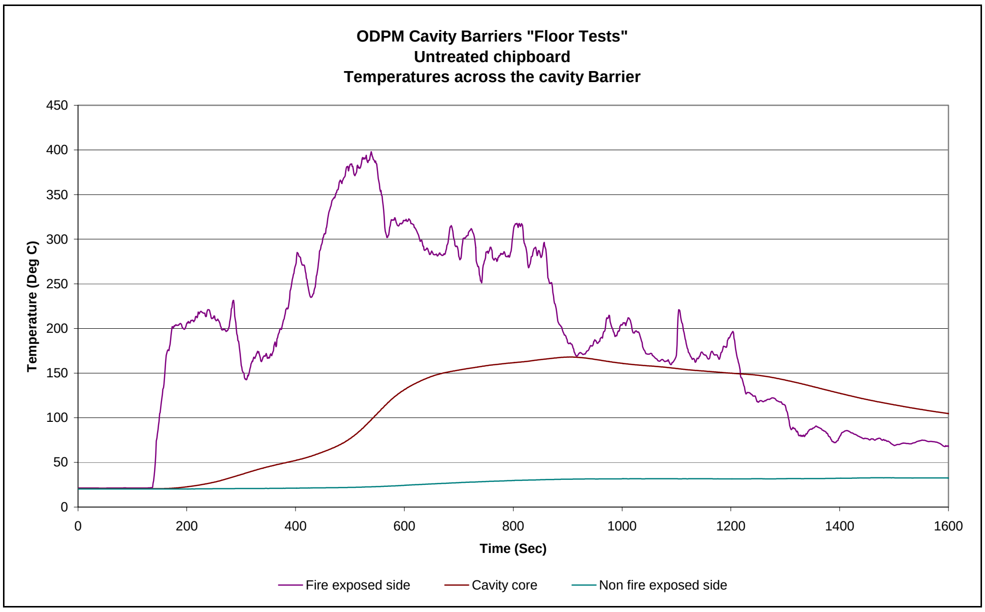


Graph A20. Test 7 temperatures at 20mm

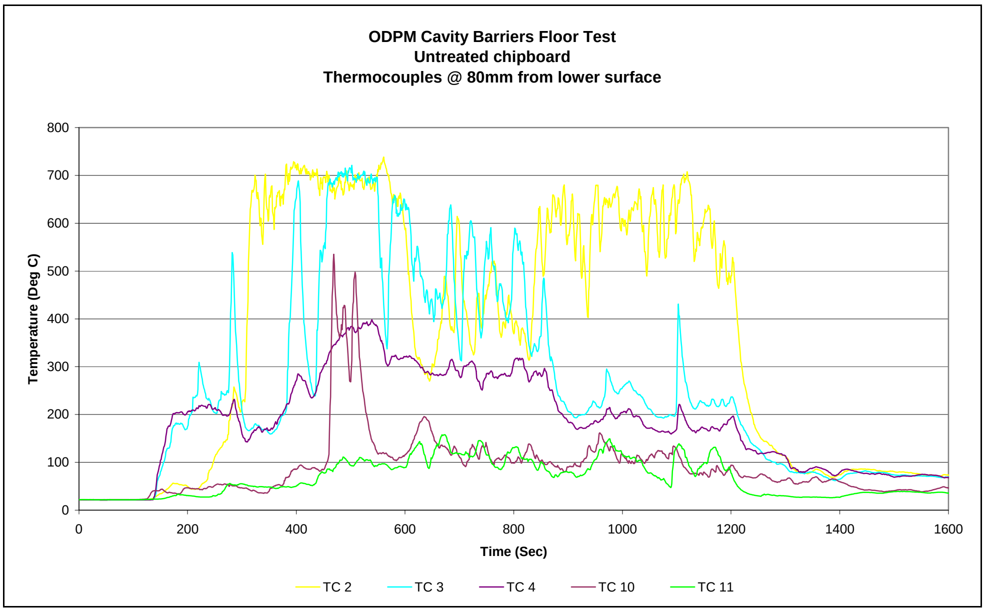


Graph A21. Test 7 temperatures at 80mm

Test 8, 300mm chipbaord floor with cavity barrier



Graph A22. Test 8 temperatures in the cavity barrier



Graph A23. Test 8 temperatures at 80mm

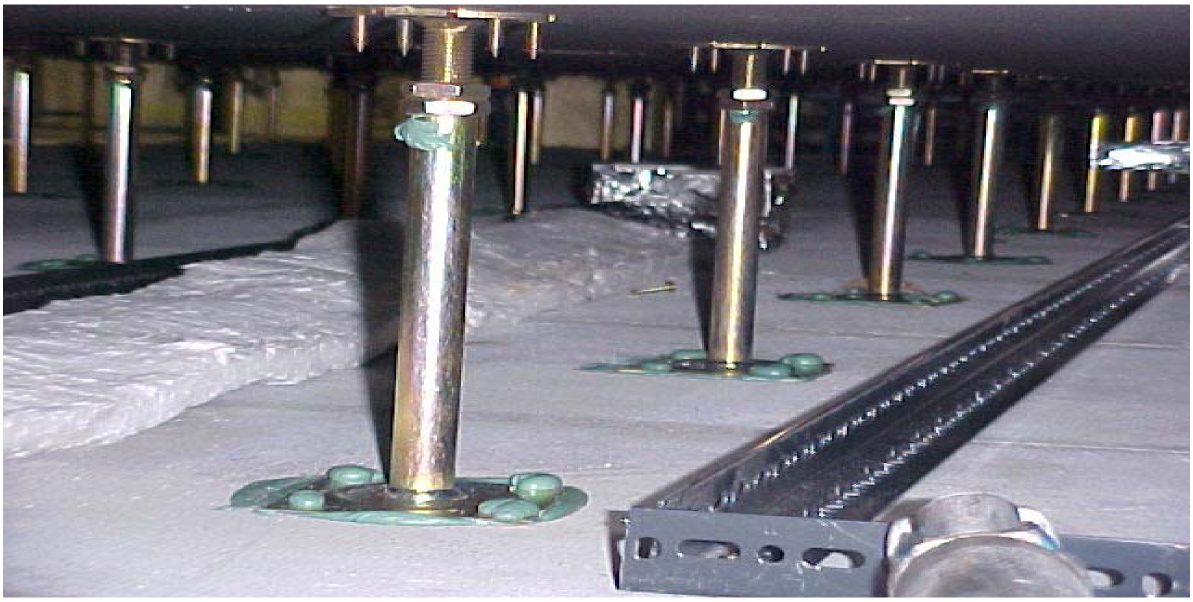
Photographs of floor void tests

Photograph A1. Suspended floor under construction.

Photograph A2. Cavity barrier in floor void. (Tile removed)

Photograph A3. Chipboard Floor.

Test 2. 300mm floor with cavity barrier



Photograph A4. Shows the layout of the underfloor

Photograph A5. Shows the burner being ignited, before being pushed under the floor.

Photograph A6. Shows the flame spread under the floor, the cavity barrier can be seen on the left.

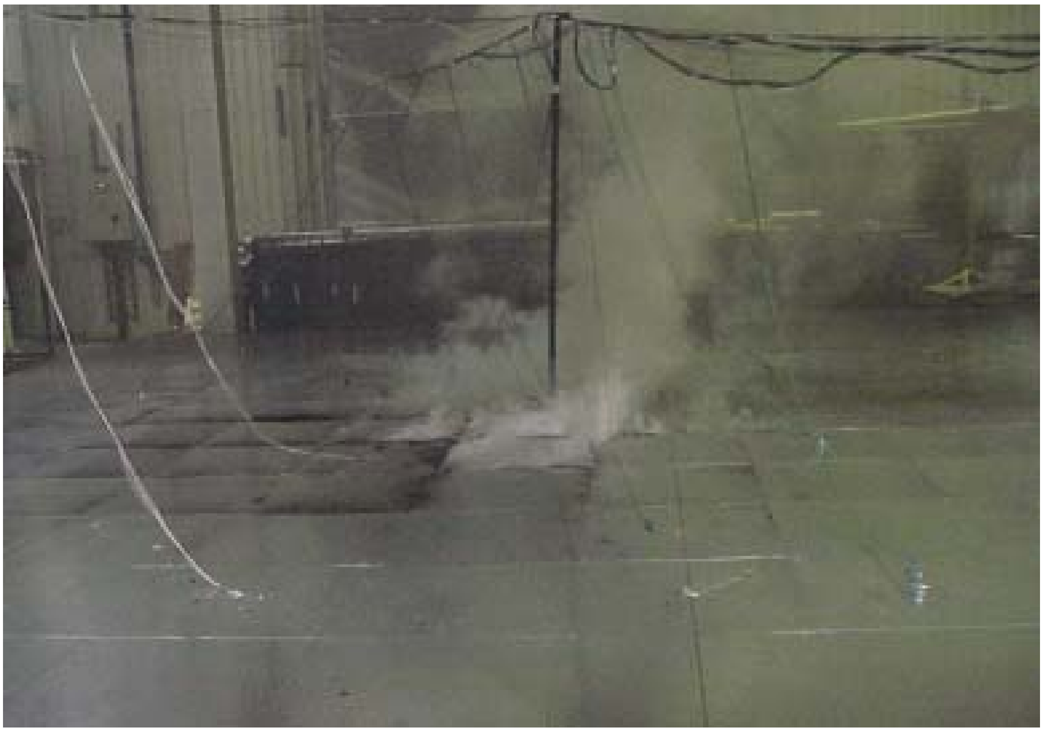
Test 3, 300mm floor with cavity barrier

Photograph A7. Shows flames impinging onto the cavity barrier.

Photograph A8. Smoke on the unexposed side of the barrier.

Test 4, 300mm floor with no cavity barrier

Photograph A9. Shows the flames spread away from the burner.



Photograph A10. Shows smoke emitting from the floor above the burner.

Photograph A11. Shows damage to an exposed floor panel.

Test 6, 150mm floor with cavity barrier at the edge of the floor

Photograph 12. flames emerging from the edge of the floor.

Photograph A13. Shows flames emerging from the edge of the floor.

Test 7, 150mm floor with cavity barrier in the center and at the edge of the floor

Photograph 14. flames impinging on the cavity barrier.

Photograph A15.Shows flames emerging from the edge of the floor.

Photograph A16. Shows flames emerging from the edge of the floor.

Test 8, 300mm floor chipboard floor

Photograph A17. Smoking from the chipboard floor.

Photograph A18. Shows flames emerging from the edge of the floor.

Heating by Exposure to a radiant heat source

A section of floor of area 1.2m by 1.2m with a height of 150mm, consisting of four 600mm x 600mm steel encapsulated chipboard floor tiles, was subjected to heating from a radiant heat source for a period of 30 minutes, using the BS 476 part 3 roof test heat surface. The sample was exposed to a radiant exposure of 12 to 15 kW/m^2 at a distance of 500mm from the burner surface.

Instrumentation

The floor was instrumented using 0.5mm mineral insulated type K thermocouples, with four thermocouples under the floor at a height of 38mm from the surface and four thermocouples on the upper floor surface. The lower floor was constructed using 12.5mm x 1.2m x 1.2m calcium silicate board. Each thermocouple was positioned in the centre of a tile and nominally in the centre of each radiant panel.

Thermocouple	Position	Distance from edge (mm)
1	Under floor	300 x 300
2	Under floor	300 x 600
3	Under floor	600 x 300
4	Under floor	600 x 600
5	Above floor	300 x 300
6	Above floor	300 x 600
7	Above floor	600 x 300
8	Above floor	600 x 600

Photograph 19 shows the setup of the floor and the position of the radiant panel.

Photograph A19. Shows setup of test on radiant panel.

Photograph A20. Shows upper surface of floor being exposed to radiant heating.

Results

The exposure of the floor to radiant heating shows the upper surface experiencing progressive heating through the absorption and re-radiation of heat from the radiant panel. The lower void remained at or around ambient temperature. Throughout the test there was no visible damage to the surface of the floor tiles, with only a small amount of light smoke visible towards the end of the heating process.

Photograph 20 shows the floor panels being heated, Figure 33 shows the heating profile of the floor when exposed to a radiant heat source

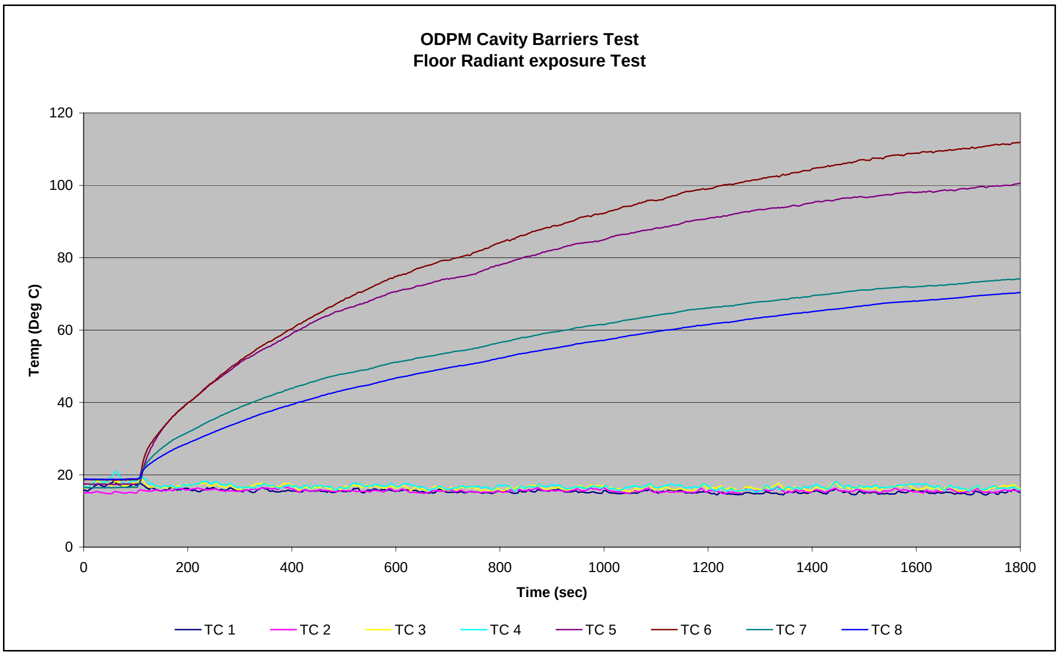


Figure A3. Temperature rise on floor panel when exposed to radiant heating.

Conclusion

Ignition transfer via the upper surface of this floor panel type at radiation levels around 15 kW/m^2 did not occur.