Experimental Room Fire Studies with Perforated Suspended Ceiling

FIONA S.C. TSUI[1], W.K. CHOW[1], N.K. FONG[1], Y. GAO[2], H. DONG[2], and G.W. ZOU[2]
[1]Research Centre for Fire Engineering
Department of Building Services Engineering
Area of Strength: Fire Safety Engineering
The Hong Kong Polytechnic University, Hong Kong, China
[2]Department of Building Engineering
Harbin Engineering University
Harbin, Heilongjiang, China

ABSTRACT

Suspended false ceilings are commonly installed as a new interior design feature in modern buildings of the Far East. Different shapes, profiles, materials and installation methods were adopted. There are fire safety concerns on extending the activation time and disturbing the water spray pattern of sprinkler systems. Ceilings with timber products might also be ignited. It is necessary to study the differences in thermal environment of a fire in rooms with and without suspended ceiling features.

Full-scale burning tests on wood perforated ceilings were carried out to study the indoor temperature distributions in a room fire. Two small fire sources of 250 kW and 500 kW were set up in a room of size 3.6 m by 2.4 m and height 4.5 m. Air temperatures at both the solid ceiling level and the perforated false ceiling level were measured. Effect of perforated ceiling on actuation of liquid-in-bulb sprinkler heads was also studied. The time to actuate the sprinkler heads mounted at the solid ceiling level and the perforated ceiling level were measured.

Tests results indicated that the perforated ceiling would affect the room fire behavior. Both the ceiling layer temperature and the maximum room temperature are affected. Effect on the room air temperature depends on the configuration of the perforated ceiling such as the degree of perforation, materials and mounting height. The orders of magnitude of the fire sources used in these tests would represent the room temperature distribution in the early stage of an accidental fire. Information in the early stage of a fire is useful to study its effect on thermal activation of fire service installations. For a larger fire size, the combustible cell ceiling was ignited and burned. Further tests on the effect of heat contribution from a combustible cell ceiling are recommended.

KEYWORDS: suspended false ceiling, temperature, perforated ceiling, sprinklers.

INTRODUCTION

Suspended false ceilings are commonly found in modern buildings in the Far East. Conventionally, they are made of gypsum material and are usually flat, continuous, square or rectangular in shape in standardized dimensions. False ceilings are usually regarded as an interior lining for decorative and finishing purposes in the built environment. The potential fire hazards are of concern. Ignitability (e.g. AS/NZS 1530.3 [1]), combustibility (e.g. AS 1530.2 [2]), spread of flame (e.g. BS 476 Part 7 [3], BS EN 13501-1:2002 [4]), extent of contribution to fire growth and spread from the lining materials (e.g. ISO 9705 [5], NFPA 286 [6]) are specified in some overseas fire codes [7–9]. However, only spread of flame (e.g. BS 476 Part 7 [3], BS EN 13501-1:2002 [4]) and non-combustible construction materials are specified in the Hong Kong building fire regulations [10,11]. Appropriate fire tests [12] are required to evaluate the fire behavior of the materials. These tests vary internationally [13] from small or bench-scale tests to full-scale room fire tests [14–16].

In the past few decades, a wide variety of suspended ceilings with various shapes, profiles, materials and installation methods has evolved to suit the ever-changing interior design trend, to match any indoor design theme and to meet the community's increasingly desired aesthetic expectations. Perforated suspended ceilings as in Fig. 1 are now commonly used to give an open visual impression and/or to allow proper functioning of smoke control systems [17]. Perforated suspended ceilings vary in a wide range of shapes and profiles such as square, curved, parallel strip, panel or wire mesh types. To suit the design needs, materials also vary greatly including aluminum, paper, wood, steel and fabric.

The presence of perforated ceiling leads to various questions in relation to the effect on fire service installations as well as fire growth contribution inside the rooms. Very limited studies [18,19] concerning the effect of

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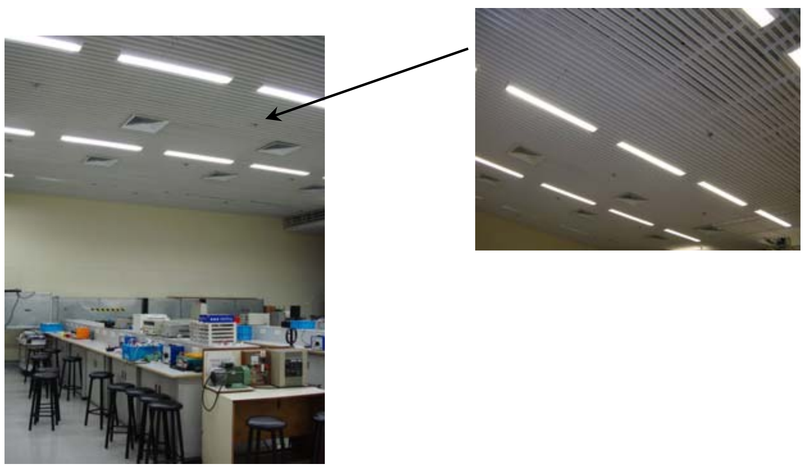
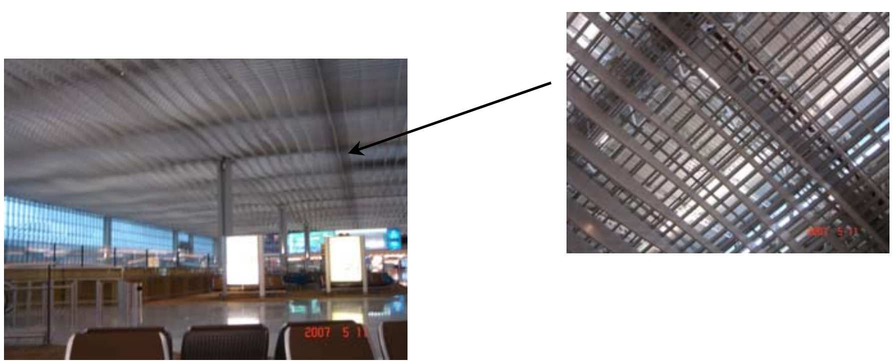
perforated ceiling such as on sprinkler actuation and smoke filling process are reported in the literature. As realized, it is not simple or easy, without sufficient full-scale experimental tests, to quantify those effects so as to prescribe the wide range of design configurations of perforated ceilings to minimize the effects. Sprinkler design standards (e.g. BS EN 12845 [20]) have specified that the suspended ceiling configuration should be regular in shape having more than 70 % free area and have the minimum opening dimension more than 0.025 m and installed more than 0.8 m from the ceiling soffit, to take into account the effect of open cell ceilings on efficient fire control by sprinklers. On the other hand, the use of materials is controlled by international building codes [7–10], focusing on flat continuous false ceilings rather than open type cell ceilings. In Hong Kong, there is no specific clause in the building fire safety codes [10,11,21,22] to inhibit interior decoration within escape staircases except that the escape staircases should be constructed by non-combustible materials [11] and any decorative linings inside should be of BS 476 Part 7 [3] Class 1 or 2 rate of surface spread of flame. For most accommodation uses, materials for interior decoration, including false ceilings, have not been restricted except that for some premises subject to licenses including restaurants, catering areas, karaoke establishments and places of public entertainment. Different designs of interior ceilings have evolved quickly as a modern design trend. It is necessary to understand the effect of perforated ceilings on building fires and possible impact on the functioning of fire service installations, particularly the sprinkler system.



(a)



(b)

Fig. 1. Examples of perforated ceilings: (a) a laboratory; (b) an airport terminal.

FULL-SCALE BURNING TESTS

Full-scale burning tests were carried out in a room of length 3.6 m, width 2.4 m and height 4.5 m. Air temperature distributions inside the room were measured with and without an open cell false ceiling for two fire sizes of 250 kW and 500 kW. The open cell ceiling is made of bare wood located 3 m above floor and hence, a 1.5 m ceiling void as shown in Fig. 2.

Common liquid-in-bulb sprinkler heads rated at 68 ºC were installed inside the room. Two layers of sprinkler, a total of 4 sprinkler heads, were installed in the open cell false ceiling. Configuration of the experimental