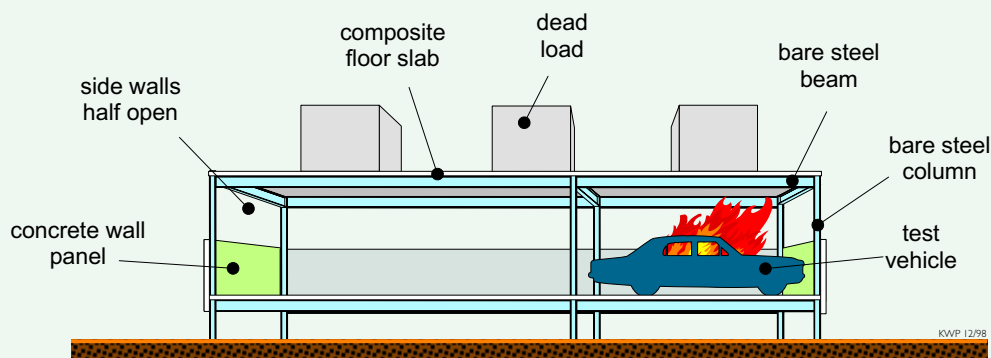


# Experimental Program

From 1985 to 1989, BHP Research conducted three separate series of fire tests on carpark structures. The first series considered the behaviour of fire in open-deck carparks [6], the second series looked at the situation in closed carparks [7], and the third series looked at fire in partially-open carparks [8] and those forming part of a multiclassified building [9].

## OPEN-DECK CARPARK



This test program followed a number of overseas test programs but used vehicles and building construction more typical of the Australian environment. The test program involved two fire tests in an open-deck carpark constructed of bare steel. Multiple cars were used in each test with the fire being initiated in vehicles with both steel and plastic petrol tanks. An LPG tank was also incorporated in one of the vehicles in which the fire was initiated. Cars were closely spaced and windows were left down. The floor above the cars was loaded to simulate the presence of a full carpark level above. Spread of fire between the vehicles took some time with eventually three cars being involved. The test structure supported the loads throughout both tests and the measured temperatures showed that a significant factor of safety could be associated with bare steel construction under fire conditions. Large quantities of dense smoke were generated but this vented through the open sides.



↑ test structure

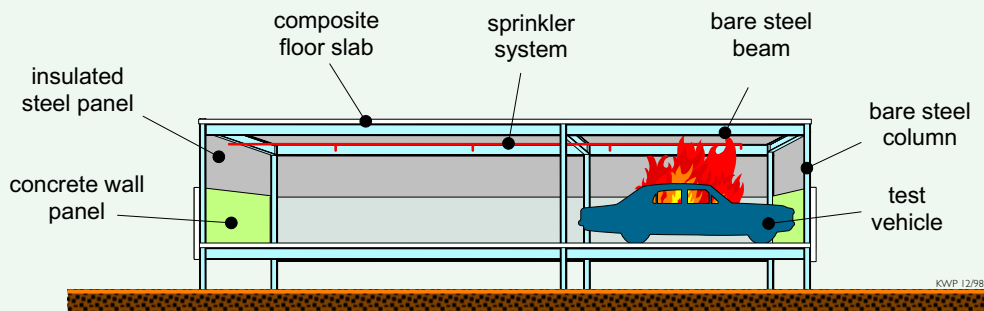


↑ view showing smoke produced during test



← view showing test vehicle alight

# CLOSED CARPARK



A series of nine tests were conducted in a closed carpark. The tests were conducted using the same test structure as for the open-deck tests but the side walls were closed and a sprinkler system fitted. Again, bare steel members were used. The majority of tests were conducted with five cars within the test structure with a spacing of 400-500 mm between vehicles. In each test, the fire was initiated in a large sedan with either a plastic or steel fuel tank. Tests were conducted with and without sprinklers.

The tests demonstrated that *without* a functioning sprinkler system, the fire will spread to other vehicles with very large quantities of dense toxic smoke being generated. Not only will this expose occupants to life-threatening smoke but visibility will be rapidly reduced. In contrast, the tests where the sprinklers operated automatically resulted in suppression of the fire, no spread to adjacent vehicles, a greatly reduced volume of smoke, and a significant reduction in the toxicity of the smoke. It was on the basis of these findings that the BCA provision for closed carparks to be protected with sprinklers if more than 40 cars were accommodated was incorporated.

It was also found that with a functioning sprinkler system, the temperature of the steel beams and columns was low (less than 100°C) and therefore it was concluded that in a sprinklered closed carpark, no protective coating is required for the structural steelwork.



↑ test structure



↖ view inside test structure showing test vehicle alight



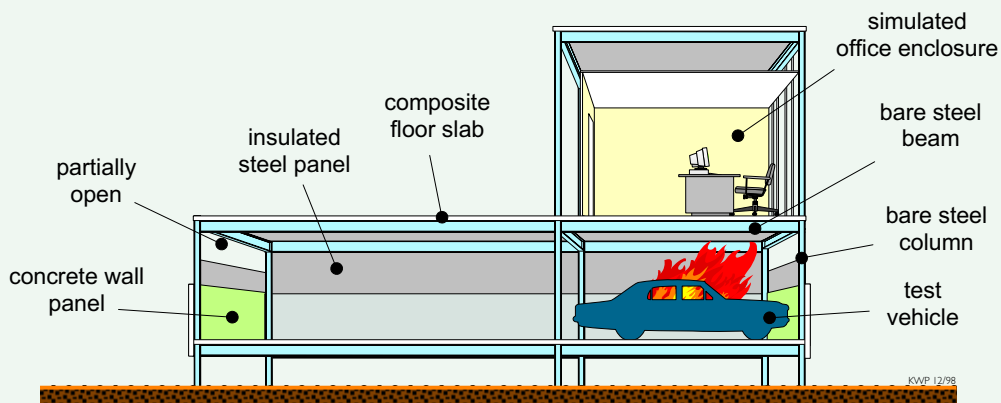
↑ view inside test structure showing vehicles before test



↑ view outside test structure showing thick smoke produced during test



## PARTIALLY OPEN CARPARK



A series of tests were conducted with the side wall partially open. These tests were initiated in order to observe the effect of burning cars in a carpark with ventilation conditions between those of the open-deck and closed carparks previously tested. Three of these tests were conducted with vehicles and a further eleven using trays of fuel and a fuel tank to gain a better understanding of the effect of various ventilation conditions. Of particular interest was the rate of the spread of the fire and the conditions created within the carpark. The building structure used for the tests was identical to that used for the open-deck and closed carpark tests with the exception that a small office was constructed above the carpark as these tests were also used as part of a research project on fire in multiclassified buildings. These tests found that fire could spread rapidly in a partially-open situation with large amounts of smoke being generated. It is considered therefore that such carparks should be treated as closed carparks. The smoke associated with the burning of a 60 litre plastic tank of petrol is shown below and serves to illustrate that smoke from a significant carpark fire may present a major hazard to life.



view of test structure during test



view inside test structure showing test vehicle alight



3 storey building



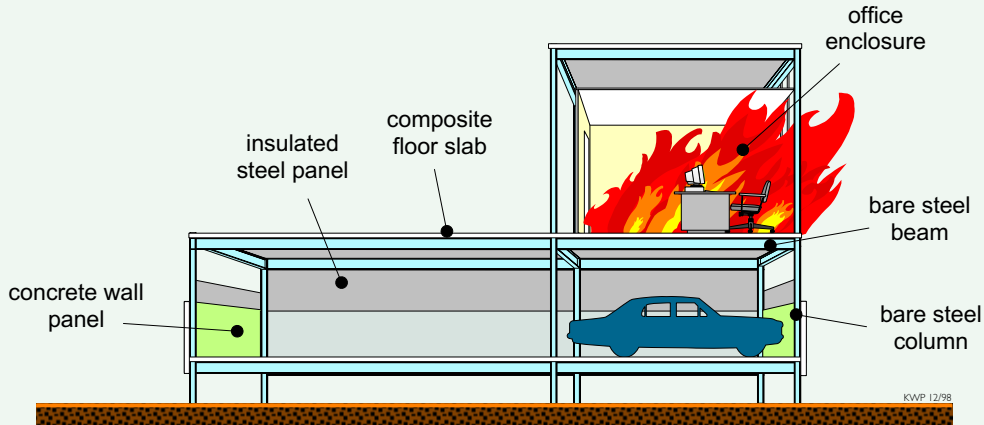
view outside test structure during test showing flame



60 litres of petrol in a plastic tank placed inside test structure

view outside test structure showing large amount of thick smoke produced

# CARPARK IN MULTICLASSIFIED BUILDING



A series of tests were conducted to study the situation where a carpark is located below levels of another class of building. The multiclassified building in this case was the carpark structure used for the carpark tests with an office level directly above the opening to the carpark. The carpark tests conducted were those described previously for the partially open carpark situation. The office above the carpark was furnished as an office and was penetrated by bare steel columns from the carpark below. No edge spandrel was provided at the edge of the floor between the carpark and the office. Conditions within both the carpark and office were monitored throughout the tests. In addition to the carpark tests, an office fire test was conducted. The testing demonstrated that adequate separation of the storeys will be achieved even when the floors are penetrated by bare steel members. The tests also illustrated that the effects of a fire in one storey are only experienced in the storey(s) above the fire, and that there is no threat to the storey(s) below the fire. The temperatures attained by the steel members in the enclosure of fire origin were a function of the fire temperatures in *that* enclosure. However, the effect of the fire on the steel members in the adjacent enclosure was negligible. It was concluded that the *support of another part* provisions of the BCA (the requirement for the supporting construction to have equal fire resistance to that which it supports) are not appropriate to structural members in different enclosures.

In addition to the test program, research was undertaken into the risks associated with multiclassified buildings incorporating carpark with bare steel members, and this work forms the basis for the alternative solutions presented earlier in this publication.



↑ view inside simulated office enclosure before test



↖ view of office enclosure at full involvement

↙ view of test structure showing fire in office above imposed little threat to the carpark below

view of test structure before test





# ECONOMICAL CARPARKS

## A Guide to Fire Safety



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### Abbreviations used:

- ESA/M** = The ratio of exposed surface area to mass per unit length (see Appendix A for ESA/M of steel sections).
- FRL** = Fire-resistance level—the grading periods in minutes determined in accordance with BCA Specification A2.3 for the following criteria -
- (a) *structural adequacy*; and
  - (b) *integrity*; and
  - (c) *insulation*,
- and expressed in that order.
- Note: A dash means that there is no requirement for that criteria. For example, -/- means there is no requirement for an FRL.
- FSF** = Fire-source feature— means-
- (a) the far boundary of a road adjoining the allotment; or
  - (b) a side or rear boundary of the allotment; or
  - (c) and external wall of another building on the allotment which is not a Class 10 building.

**Definition:** **Bare steel** — steel members which have no fire-protective coating.

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