

Fig. 11-6 Displacement

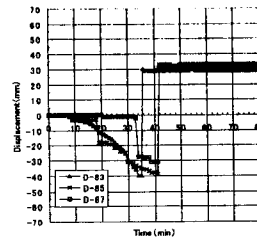


Fig. 11-7 Displacement

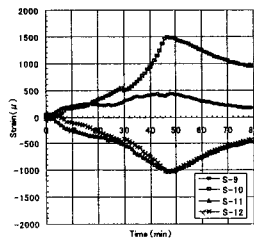


Fig. 12-1 Strain

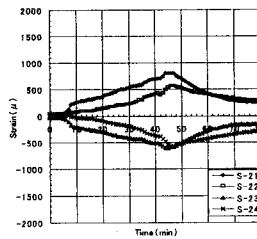


Fig. 12-2 Strain

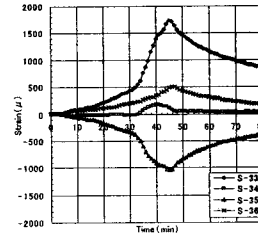


Fig. 12-3 Strain

4. Conclusions

The experiment performed in this study yields the following results.

- 1) Car fires spread one after another.
- 2) The steel temperatures of a beam located immediately above the combusted vehicle reaches from 600°C to 700°C.
- 3) The degree of structural deformation is 1/4-1/3 of the critical deformation but the strain enters the plastic region.
- 4) The structure doesn't collapse even though it is subjected to severe fire conditions. Residual deformation, such as local buckling, is not observed.

The data reported in this paper are analyzed in the middle of the data collection process. Therefore, the results of more detailed data analysis will be reported in the future.

Acknowledgment

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Experimental Study on Motorcycles Fire in the Arcade of the Building

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ABSTRACT

This paper describes motorcycles fire in the arcade of the building. Four tests for motorcycles burning were conducted in the arcade of a full-scale two-story building. Experimental results indicate the flames from the motorcycle with plastic body hull, in intense burning, may ignite any combustible materials in the arcade by radiation and flame touch, and their heating of the surroundings is quite dangerous. When there are three motorcycles fallen in a row in the arcade, and the motorcycles are fired, the flame heights from the floor is over 5m, the temperature and the radiant-heat flux of the ceiling in the arcade is separately equal to 576°C and 8.7 W/cm².

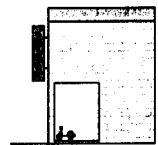
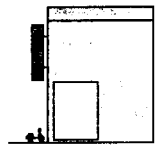
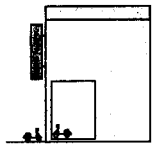
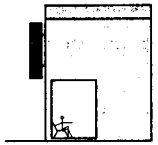
KEYWORDS: motorcycles fire, arcade

INTRODUCTION

There are now about ten million (10,503,877) registered motorcycles in Taiwan: on average, one motorcycle for every two people. Motorcycle fires have caused serious damage in Taiwan because motorcycles are improperly managed and inadequately regulated, such as motorcycle fires happened recently in the arcade of a modern complex-use building (Taipei, 1996). [1] The traditional building with arcade is often constructed in Taiwan. Therefore, motorcycle fires happening in traditional Taiwanese arcades often develop into building fires, which often spread to other buildings, even cross the street. The flames tend to curl back, impinge upon ceilings and building facades above arcades, generating radiant-heat fluxes to ceilings and building facades. The density of the radiant-heat flux is high enough to make fire hazards to the facades above the arcades and to the surrounding buildings. [1] Thus data of motorcycles fire in the arcade of building, such as flame height, radiant-heat flux and temperature were useful for the assessment of fire hazards.

The most popular motorcycles used in Taiwan are 50cc (42% of the total used) and 125cc (35%), which share about 77% of the market. [2] The main materials of them used by motorcycle manufacturers in Taiwan are metal and plastic. The metal material forms an incombustible frame. The plastic material is used for the body hull (shell) and pad, which are the main combustible parts. According to the data, the sum of the total heat release of the plastic pad and hull is 275 MJ, when one motorcycle is burned in free space. [1] It had been completed to survey how motorcycles stand around buildings on parts of roads in Taipei. The results are shown on TABLE 1. Most of people make their motorcycles stand at different positions around buildings: (1) in the arcades of buildings (62.9%), (2) facades of arcades of buildings (18.6%), (3) both of (1) and (2)(12.0%), and (4) others (6.5%). [2] Hence, this paper describes motorcycles fire in the arcade of the building of 50cc and 125cc motorcycles usually used in Taiwan. The flame height, radiant-heat flux and temperature of motorcycles burned in the arcade were measured by videocassette recorder, radiometer and thermocouple.

TABLE 1: Motorcycles stand at different positions around buildings

In the arcade	Facades of arcade	Both	Others
			
Percentage: 62.9%	Percentage: 18.6%	Percentage: 12%	Percentage: 6.5%

EXPERIMENTAL DESCRIPTION

We built a full-scale two-story building with arcade, as FIGURE 1. Motorcycles were fallen in a row on the ground floor and were arranged to locate between two columns in the arcade of the building as observed as usual situation. The length of a span between two columns' centers is 4.5m. And the gasoline tanks of motorcycles, made of steel, were filled with regular gasoline in all tests.

The FIGURE 2 illustrates measured points of temperature and radiant-heat flux in all tests. The sensors we used as follows: (1) The radiometers were water-cooled Medtherm 64 Series and the range of them are respectively two types; one is 50kW/m², the other is 100kW/m². (2) The thermocouples were 0.3mmφ K-type. (3) The flame height during burning tests was observed by a videocassette recorder. Data were read every 4 seconds. The ignition source of each burning test was 200ml kerosene poured in a 30cm-diameter basin set on the ground. [1] TABLE 2, FIGURE 3 and FIGURE 4 display the conditions of each test.

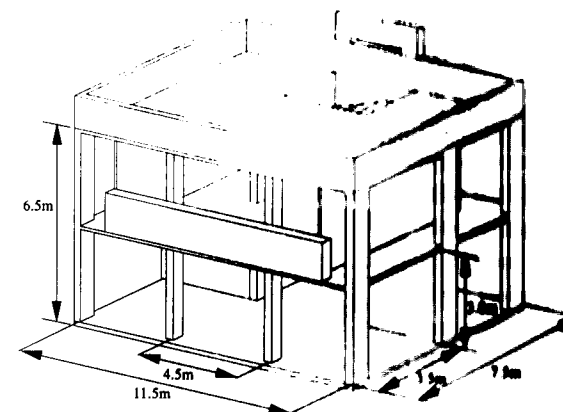


FIGURE 1: A full-scale two-story building with arcade

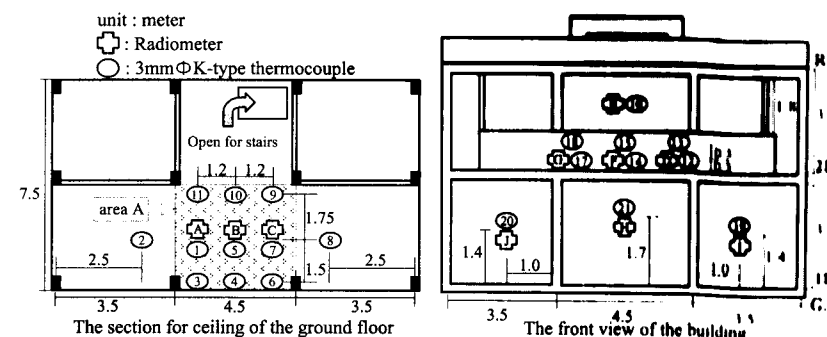


FIGURE 2 : Sensors located positions of a full-scale two-story building for motorcycles burning tests

TABLE 2: Conditions of motorcycles burning tests

No.	Type of motorcycle	Location	Numbers of motorcycle	Ignition position	Ignition source
1	50cc	In the arcade between two columns	8	IP _s *	200ml kerosene
2	125cc	In the arcade between two columns	8	IP _s	200ml kerosene
3	50cc	In the arcade between two columns	8	IP _s *	200ml kerosene
4	50cc	In the arcade between two columns	3	IP _c *	200ml kerosene

- * IPc_7 : On the ground, an intersection of the central point between two columns and beneath of the lengthwise middle of the forth and the fifth motorcycle.
- * IPs_8 : On the ground, between two columns and beneath of the lengthwise middle of the first motorcycle.
- * IPc_3 : On the ground, an intersection of the central point between two columns and beneath of the lengthwise middle of the second motorcycle.

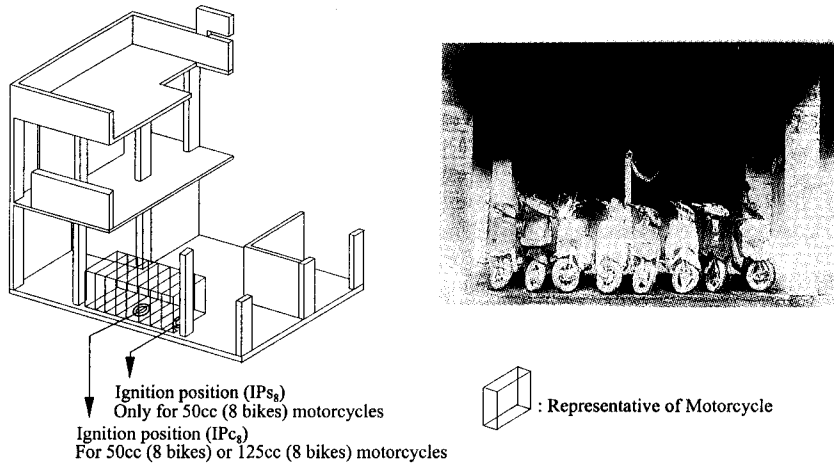


FIGURE 3 : The locations and ignition positions of 125cc or 50cc motorcycles in the arcade of a full-scale two-story building for burning tests

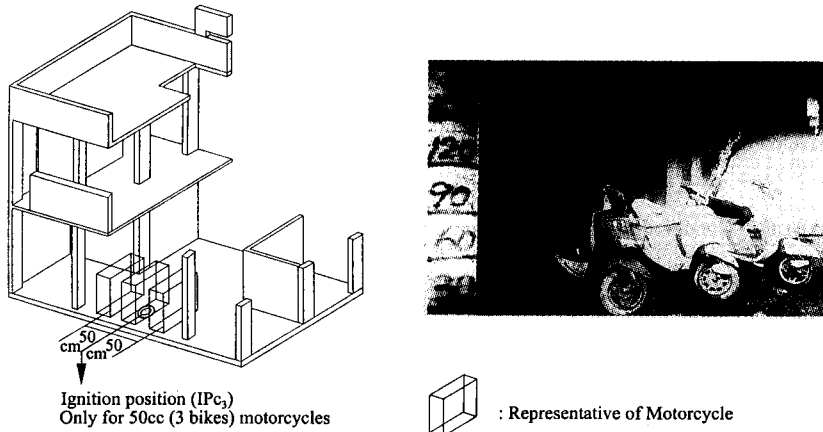


FIGURE 4 : The locations and ignition position of 50cc motorcycles in the arcade of a full-scale two-story building for burning tests

RESULTS

Decision of Motorcycles Specimen

The first motorcycles burning test discussed in this paper was to fall eight real 50cc motorcycles in a row between two columns in the arcade of a full-scale two-story building, and to ignite at IPc_8 (show in FIGURE 3). The difference between the first burning test and the second one was that the eight 50cc motorcycles burned were changed to the same amount of 125cc motorcycles. Data measured in the first test and the second one, such as the flame height, the temperature on surface of the burned ceiling (area A), and the radiant-heat flux, were almost similar in the motorcycles burning process. After getting those data from the first and the second test, we decided to use 50cc motorcycles to be the specimen in the motorcycles burning tests in the future. And the results of two motorcycles burning tests were showed in TABLE 3, FIGURE 5 and FIGURE 6.

TABLE 3: The comparison between 50cc and 125cc motorcycles in the burning tests

Test number	Type of motorcycle	Ignition position	The highest flame height	The burned ceiling surface in the arcade above motorcycles (area A)	
				The highest temperature	The highest temperature
				Measured point at 5	Measured point at B
No 1	50cc	IPc_8	6.7 m	876°C	12.3 W/cm ²
No 2	125cc	IPc_8	6.9 m	815°C	11.7 W/cm ²

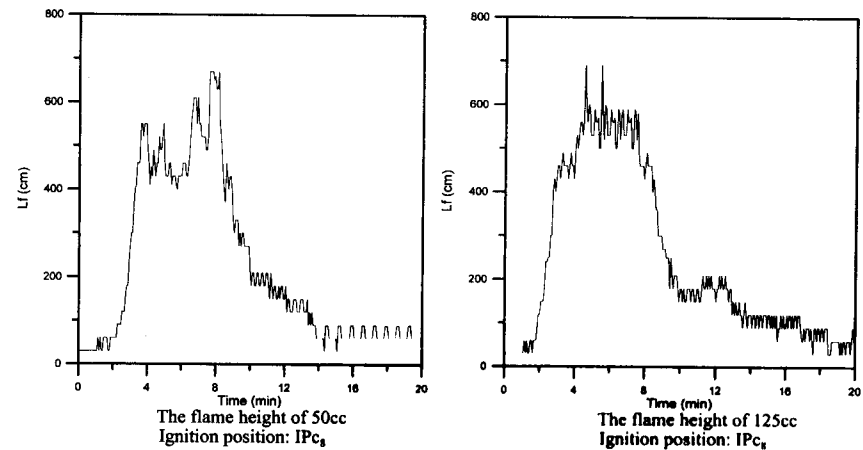


FIGURE 5: The result comparison between 50cc and 125cc motorcycles in burning tests

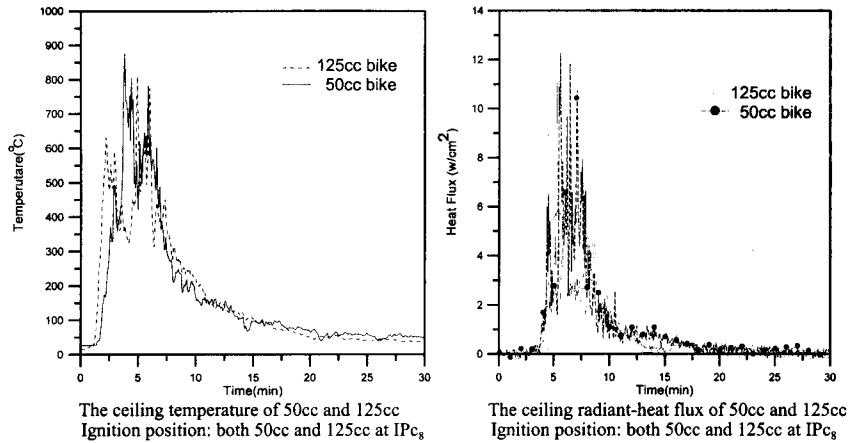


FIGURE 6: The result comparison between 50cc and 125cc motorcycles in burning tests

Decision of Ignition Position

The amount and variety of the combustible materials around the ignition source of fire may cause fire or not. However, when the fire happening, the amount and variety of the combustible materials will decide the burning speed and the direction of fire. And when the ignition source position is near to the combustible materials, the fire will be happened and spread easily.

After the first test and the second test were accomplished, we proceeded with the third test. We hope the ignition source position could be decided by the result of the third test. The comparison between the first test and the third one, the main difference point was the ignition source position was changed from IP_{c8} (the ignition source position both in the first test and the second test) to IP_{s8} (the ignition source position in the third test).

The result of the third test indicate that the data such as the highest temperature and the maximum radiant-heat flux, measured in the burned ceiling in the arcade (area A), were similar to those measured in the first test, when igniting motorcycles fire at IP_{s8} . Besides, the number of times of the flame height appearance even the highest flame height showed in the whole burning process, these data were also similar to those measured in the first fire test which the ignition was at IP_{c8} . The results of two experiments were displayed in TABLE 4, FIGURE 7 and FIGURE 8.

TABLE 4: The comparison between IP_{c8} and IP_{s8} of 50cc in the burning tests

Test number	Type of motorcycle	Ignition position	The highest flame height	The burned ceiling surface in the arcade above motorcycles (area A)	
				The highest temperature Measured point at I	The maximum radiant-heat flux Measured point at B
No 1	50cc	IP_{c8}	6.7 m	977°C	12.3 W/cm ²
No 3	50cc	IP_{s8}	6.7 m	983°C	15.1 W/cm ²

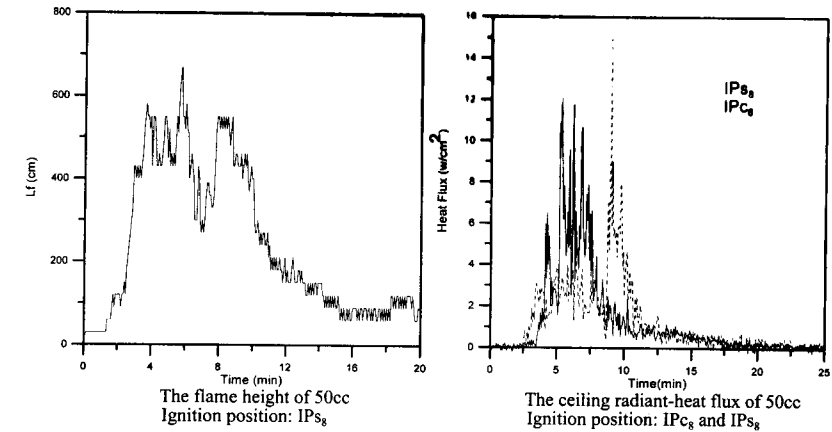


FIGURE 7: The flame height and the result comparison between ignition positions at IP_{c8} and at IP_{s8} of 50cc motorcycles in the burning tests

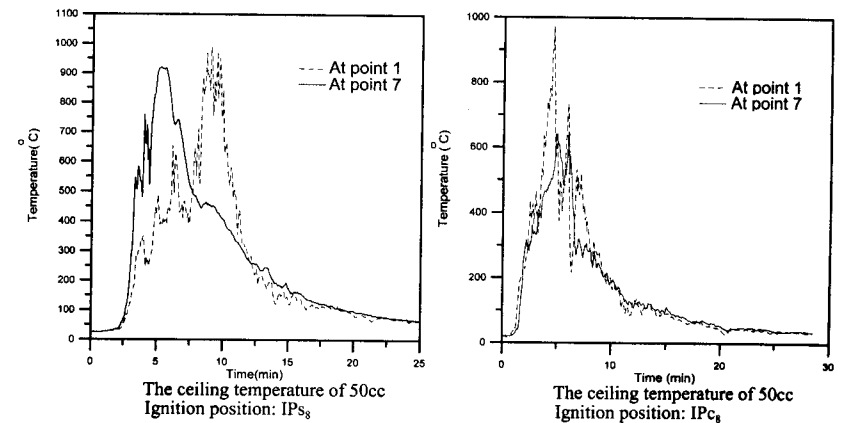


FIGURE 8: The result comparison between ignition positions at IP_{c8} and at IP_{s8} of 50cc motorcycles in the burning tests

The main difference between the two tests (the first test: the ignition position at IPC_8 , the third test: the ignition position at IPS_8) was that the taking time of those data described previously in the motorcycles burning test. That is, when the ignition position was at IPC_8 , the taking time (such as arrived the highest temperature and arrived the maximum radiant-heat flux) is shorter than the ignition position was at IPS_8 . And TABLE 5 displays the differences of the taking time of two items described previously. Therefore, the shorter the taking time is, the more dangerous the fire becomes, correspondingly the time when people escape from the fire is shorter too. As the result of the experiment showing, to ignite motorcycles fire at the central point (ignition position: IPC_8) is more dangerous to buildings and people than that at the side point (ignition position: IPS_8). Based on this concept, preventing motorcycles fire from spreading speedily and from enlarging unlimitedly, how to prohibit motorcycles fire happened is the study point in the future. For the reason, we decided that the ignition position in the following motorcycles burning tests is to set at IPC_8 .

TABLE 5: At different ignition position, the comparison of the taking time of different items

Test number	Type of motorcycle	Ignition position	The burned ceiling surface in the arcade above motorcycles (area A)		
			Up to the highest temperature time		Up to the maximum radiant-heat flux time
			Point 1	Point 7	
No 1	50cc	IPC_8	4.5 min	5.0 min	5.8 min
No 3	50cc	IPS_8	9.0 min	5.4 min	8.8 min

Amounts and Hazards of Motorcycles Fire

According as we got the results from the first test to the third one, the experimental conditions in the fourth motorcycles burning test were set as follows:

- (a) The specimens were 50cc motorcycles.
- (b) Three motorcycles located between two columns in the arcade stood in a row, and kept 50 cm in each two motorcycles.
- (c) The igniting position was at IPC_8 , and the igniting source was 200ml kerosene.

The main difference between the first test and the fourth one is the amount of motorcycles. The amount of motorcycles in the fourth test (three motorcycles) was less than the first one test (eight motorcycles). When the amount of motorcycles in two tests was not equal but other conditions were same, and when the motorcycles located in the arcade got fire, both of the temperature and the radiant-heat flux of burning eight motorcycles were higher than those of burning three motorcycles were. Those data were measured in the following areas:

- (a) The ceiling in the arcade of the ground floor (area A)
- (b) The facade of the open area in the arcade of the ground floor (area B)

- (c) The facade of windowsill above the arcade of the second floor (area C)
- (d) The facade of the open area above the arcade of the second floor (area D)

Those locations were showed in FIGURE 9. Therefore, the more huge the amount of the motorcycles fallen in rows is, the stronger the damage to buildings and people is. The results described previously can be obviously distinguished from TABLE 6. FIGURE 10 and FIGURE 11 present four photos of igniting motorcycles fires in tests.

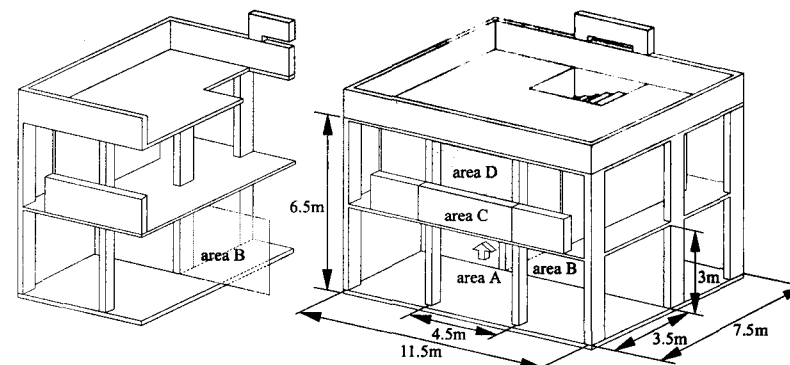


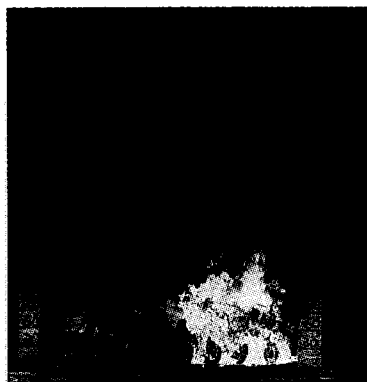
FIGURE 9: The measured areas of motorcycles fire in a full-scale two-story building with arcade

TABLE 6: The comparison between Test 1 and Test 4 in the motorcycles burning tests

Items	Test number	The ground floor		The second floor	
		Ceiling in the arcade (area A)	The facade of open area (area B)	The facade of windowsill (area C)	The facade of open area (area D)
The highest temperature (°C)	No 1	977.0	241.0	609.0	93.3
	No 4	576.0	92.3	227.0	58.0
Up to the highest temperature time (sec)	No 1	270.0	310.0	330.0	456.0
	No 4	696.0	652.0	788.0	794.0
The maximum radiant-heat flux (W/cm ²)	No 1	12.3	0.3	0.7	2.2
	No 4	8.7	0.3	0.1	0.5
Up to the maximum radiant-heat flux time (sec)	No 1	348.0	318.0	319.0	428.0
	No 4	738.0	666.0	816.0	792.0
Up to 260°C time (sec)	No 1	150.0	fail to	264.0	fail to
	No 4	654.0	fail to	fail to	fail to



Motorcycle: 50cc (8 bikes)
Ignition position: at IP_c



Motorcycle: 50cc (8 bikes)
Ignition position: at IP_s

FIGURE 10: The different ignition positions of 50cc motorcycles in the burning test



Motorcycle: 50cc (3 bikes)
Ignition position: at IP_c



Motorcycle: 125cc (8 bikes)
Ignition position: at IP_c

FIGURE 11: The burning test for 125cc motorcycles and 50cc motorcycles

CONCLUSION

1. Motorcycles fire happened in the arcade of the building; both 125cc and 50cc motorcycles fire experiment data (such as the maximum flame height, the highest temperature and the maximum radiant-heat flux of the ceiling in the arcade) are similar.
2. The ignition position was at IP_c , the taking time (such as arrived the highest temperature and arrived the maximum radiant-heat flux) is shorter than the ignition position was at IP_s .

3. The more huge the amount of motorcycles stood in the arcade is, the higher both the highest temperature and the maximum radiant-heat flux are, the shorter the taking time of both arrived the highest temperature and the maximum radiant-heat flux is, which are measured at different positions of the building.

4. Igniting fire at the central point (such as IP_c , IP_s) or locating more motorcycles in the arcade of the building, motorcycles fire will spread and expand speedily.

5. Three 50cc motorcycles in the arcade of the building got fire, the fire would ignite the combustibles of the ceiling which the ignition point is less than 576°C . Besides, the highest flame height is higher than the height of the ground floor, the flame would ignite the combustibles in the second floor.

ACKNOWLEDGEMENT

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