Research paper

The generation characteristics of instant dusts at the time of structure demolition by explosion

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Received : October 30, 2010 Accepted : January 19, 2011

Abstract

The objective of this study was to effectively evaluate the effects of the demolition of existing structures by explosion on dust. It is difficult to estimate and control the dust generated by explosion, as compared to noise, vibration, and scattering particles, but it is very important to manage it since such dust could create direct problems such as civil petitions from surrounding areas against scattering dust as well as secondary pollution from any pollutant contained in the dust accumulated inside or outside the site.

In this study, measurements were taken every second from 10 demolition sites using the light scattering method for about 50 minutes before and after the explosion. Also, the general characteristics of the dust particle sizes and the maximum amount of dust generated at the time of the explosion were analyzed, because their effects on the human body vary significantly.

According to the experiment, even if a large amount of dust is generated at the time of the explosion, most of the dust particle sizes are large, so there is much less chance of people inhaling them ; and if the dust does not have heavy metal components, it will likely not harm the human body. The measures for controlling dust from explosive demolition work, the spraying method, taking into consideration the size of the instant dust particles at the time of water sprinkling, could provide netter control results.

Keywords : explosive demolition, dust, PM10, PM2.5, PM1.0, TSP

1. Introduction

Previous demolition works for mainly middle- and low-rise structures have changed to demolition works for high-rise structures, which started to be constructed in large quantity after the latter half of the 1970s, since 2000[1]. The demolition of a high-rise building has negative effects. First, it produces various environmental pollutants that affect a vast area ; and second, high-rise building demolition works are often carried out in a commercial area or a congested residential area, so they will likely cause public protest. Therefore, more suitable explosive demolition technologies for high-rise buildings in downtown areas must be used, and eco-friendly demolition technologies must be established. As such, technologies for controlling environmental pollutants such as noise, vibration, dust, and scattering particles must be developed.

Among the aforementioned pollutants, dust from explosion is one of most difficult problems to address in a demolition site, since the collection of measurement data is difficult and the adaptation of a normal method as a protection measure from instant dust cannot provide practical effects. The management of dust generated at a demolition site is very important. Most countries use PM 10 (Particle Matter 10, dust with an aerodynamic diameter of less than 10 μm) as the standard for floating dust, and Korea also removed total suspended particular (TSP) from the environmental quality standards for air pollution of the

Ministry of Environment in 2001, converted it to PM10, which was the standard for fine dust, and adjusted the standard to 50 μg m^{-3} annually and 100 μg m^{-3} daily on January 2007[2]. Due to the recent rapidly increasing interest in hyperfine particles with a size of less than 2.5 μm, however, which can cause asthma, chronic bronchitis, and arrhythmia through lung absorption, the U.S. EPA started applying the restriction to PM2.5 (Particulate Matter 2.5, dust with an aerodynamic diameter of less than 2.5 μm) in 1997[3]. Also, EU is planning to establish "Guidelines on environmental pollution", which restricts the annual emission of PM2.5 to 25 μg m^{-3} starting in 2015 and to 20 μg m^{-3} starting in 2020[4]. Accordingly, Korea's Ministry of Environment is also conducting a research for the establishment of PM2.5 restriction standards in the future. The influence of dust on the human body could vary significantly according to its size. Therefore, the particle size of dust must be analyzed prior to the analysis of the pollutants contained in dust. Dust with a particle size of over 10 μm is generally removed at the time of its inhalation by the inertia force from the turbulence inside the nose and the larynx ; but fine dust with a particle size of less than 10 μm (PM10) is known to cause respiratory diseases, PM2.5 is known to cause cardiovascular diseases, cancers, and early death, and dust with smaller sizes is known to have higher toxicity[5].

Actually, a large amount of explosive dust is generated intensively due to the breaking of concrete particles at the time of explosion. Thus, it is true that there is a high possibility of emotional civil petitions arising, apart from the restriction standards. Therefore, this study was conducted to examine the toxicity of explosive dust to the human body by measuring the amount of instant dust generated at the time of explosion and analyzing its particle size distribution, and based on the findings, to prepare the foundation for the establishment of effective dust countermeasures.

2. Testing devices and methods.

In this study, the measurements were taken during in 10 explosive demolition sites, where a large quantity of dust is generated within a short time. According to standard methods of atmospheric pollution testing, generally floating particles in the air should be collected with a filter, and the mass density of these particles should be measured and weighed once for over 6hours. The light scattering method was used instead of the mass analysis method, however, since much of the instant dust from an explosive demolition is generated within a few seconds at the time of the explosion and settles down within a few minutes.

The site of demolition by explosion was controlled before loading gunpowder and entrance of anyone other than related personnel was prohibited. Nothing other than water sprinkling was permitted from hours before the explosive in order to prevent accumulation of dust. The measurement tool placed at a pre−decided spot was turned around one hour before the blast so the measurements could be made, and only when the field was secure after the explosive did the researcher re−enter. To measure the locations of the dust, a place with no obstacle, such as a building or a tree, in a surrounding area that was regarded as representing the pollution level of that region was selected by considering the surrounding environment and weather conditions such as wind direction and wind speed of that area, and the measurements were taken from 4 spots according to their distances from the target building. The measurements of TSP, PM10, PM2.5, and PM1.0 (Particle Matter1,dust with an aerodynamic diameter of less than 1μm) were taken in seconds for approximately 50 minutes before and after the explosion. A summary of the measurement devices and the target sites and the specifications are shown in Table 1.

From the measurements, the maximum amounts of dust generation at the time of explosion were compared, and the particle sizes and distributions of the dust according to the TSP density were analyzed ; and based on the results, the toxicity according to the particle sizes was examined. PM10 was measured at the P1, P2, and P3 measurement points of each site, and TSP, PM10, PM2.5, and PM1.0 were measured at the P 4 measurement point of all the sites.

3. Results and discussion

3.1 Amount of explosive–demolition dust

3.1.1 Maximum amount of dust as a structural characteristics

After establishing 4 measurement points per distance and direction of separation for 10 demolition sites by explosion, and measuring the amount of instant dust generation, the maximum amounts of dust generated based on PM10 in all the sites were determined. They are as shown in Fig. 1.

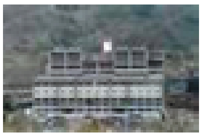
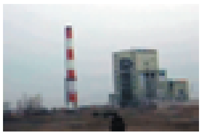
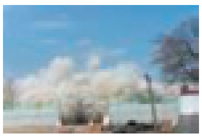
The maximum amount of dust generated is variously influenced by the size of the target building for explosive demolition, the wind direction, the direction of the building collapse, the location of the measurement point, and the weather condition at the time of explosion. Differences occur according to the characteristics and size of the building, but the amount of instant dust generated per second at the demolition site by explosion is generally up to 1,100,000 μg m^{-3} based on PM10, and the average amount of 2−300,000 μg m^{-3} is generated approximately 50 m away from the target building[6]. Moreover, the maximum amount of dust generated increased by 178 times from before the explosion[7]. The maximum amount of 1,173,400 μg m^{-3} of dust was generated at the Y thermal power plant site among the 10 target sites included in this study. The minimum was generated at D sports stadium site with 1,222 μg m^{-3}.

The study conclusions are that the size of the target structure must have been a very important variable that influenced the amount of dust. Even if similar−sized structures, however, show very different dust quantities, so the structures were prepared in advance for cleaning, much water must be sprinkled appropriately, and variable dust countermeasures technologies must be applied.

3.1.2 Duration time of explosive demolition

Shortly after the explosion, PM10 rapidly increased and

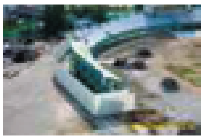
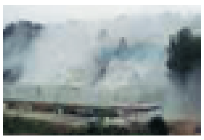
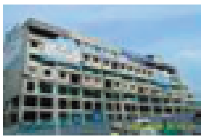
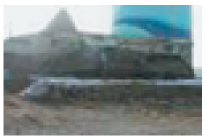
Table 1 Summary of target buildings for demolition and location of each measuring point.

Target site		C hotel	Y thermal power plant	G thermal power plant	H church	D sports stadium
Target building and summary		RC–Rahmen, 10 stories above, 2 stories below the ground	Composite, main 45 m, chimney 59.5 m	Composite, main 54 m, chimney 70 m	Composite,2stories below 9 stories above the ground	Wall–type, part of stadium stand
Applied method		Gradual collapse	Gradual collapse/ falling	Gradual collapse/fall	Gradual collapse	Gradual collapse
Measurement location	P1	Front left side 57 m	Right side 50 m	Right side 55 m	Right front side 40 m	Front side 30 m
	P2	Front right side 45 m	Front side 48 m	Right side 63 m	Right flank side 40 m	Front side 50 m
	P3	Front right side 55 m	Front side 70 m	Rear side 90 m	Right rear side 40 m	*
	P4	*	Front side 110 m	Front side 120 m	*	Front side 70 m
Maximum amount of generation	P1	260,469 μgm^{-3}	182,280 μgm^{-3}	286,708 μgm^{-3}	167,122 μgm^{-3}	1,222 μgm^{-3}
	P2	794,836 μgm^{-3}	1,173,400 μgm^{-33}	31,749 μgm^{-3}	24,215 μgm^{-3}	1,022 μgm^{-3}
	P3	529,808 μgm^{-3}	451,430 μgm^{-3}	105,442 μgm^{-3}	2,158 μgm^{-3}	–
	P4	–	4,384 μgm^{-3}	1,415 μgm^{-3}	–	436.8 μgm^{-3}
Duration	P1	120 (sec)	120 (sec)	90 (sec)	360 (sec)	120 (sec)
	P2	160 (sec)	over 20 minutes	190 (sec)	45 (sec)	60 (sec)
	P3	100 (sec)	over 20 minutes	180 (sec)	60 (sec)	
	P4	–	over 20 minutes	180 (sec)	–	90 (sec)
Scattering distance		330m	340m	100m	280m	220m
Weather condition		Cloudy, humidity 42%	Cloudy, humidity 57%, wind direction to the east side of the building	Light fog, humidity 82%, wind direction to the south–southwest side of the building	Cloudy, humidity 48%	Light fog, humidity 88%, wind direction to the west northwest side of the building
Note		Construction site where a large–scale redevelopment complex is being built	Hill at the back, 2–lane forward/ backward road, and river in front	Near seashore, site of the establishment of a complex thermal power plant	Newly constructed apartment complex is located near the target building	Downtown, roads and stores adjoining
						
						

*, Measurement failure **, The peak value is not showed

settled again after a certain time. The duration time and the amount of dust are very important to prevent civil petitions, especially in urban areas. In this study, comparative analysis was performed when the PM10 peak values were fading and summarized at Table 2. The explosive dust could not be measured at measurement P4 at the C hotel, H church, and Y silo sites, and at measurement P3at the D sports stadium site, on account of an instrument error. Further, measurement P4 at the D university library, C stadium electric scoreboard sites did not show the peak value of dust. Therefore, the results of the explosive demolition duration time analysis of these measurement points were omitted. The time of atmospheric conditions was stabilized at 160 seconds for the C hotel, more than 20 minutes for the Y thermal power plant, maximum 190 seconds for the G thermal power plant, 360 seconds for the H church, 120 seconds for the D sports stadium, 450 seconds for the S sports stadium, 710 seconds for the D university library, more than 16 minutes for the J department store, 380 seconds for the C stadium electric scoreboard, and 400 seconds for the Y silo. The stabilized time of dust was approximately6to 12 minutes, and is summarized in Table 1 according to the sites and measurement points. The J department store site, located

Table 1 Summary of target buildings for demolition and location of each measuring point (Continued).

Target site		S sports stadium	D university library	J department store	C stadium electric scoreboard	Y silo
Target building and summary		RC−Rahmen 3 stories stand, total floor area 20,000 m^2	RC−Rahmen, 5 stories above1story below, area 22,238 m^2	RC−Rahmen, 8 stories above the ground, area 8315 m^2	RC−Rahmen, 4 stories above the ground 28 m, total area 630 m^2	RC−Rahmen, height 33.3 m, outside diameter 22.9 m
Applied method		Gradual collapse/ falling	Gradual collapse	Implosion	Falling	Falling
Measure-ment points	P1	Front curved section 50 m	Right front side 40 m	Left front side corner 56 m	Left front side corner 30 m	Left side 50 m
	P2	Straight line 50 m	Left front side corner 40 m	Right front side 36 m	Left front side corner 50 m	Front side 50 m
	P3	Scoreboard front 50 m	Left side corner 40 m	Right front side corner 36 m	Left front side corner 70 m	Right side 30 m
	P4	Scoreboard front 80 m	Left side corner 80 m	Outside 100 m	Right front side corner 50 m	Right side 70 m
Maximum amount of generation	P1	12,782 μgm^{-3}	140,171 μgm^{-3}	56,778 μgm^{-3}	21,346 μgm^{-33}	1,099,399 μgm^{-3}
	P2	13,153 μgm^{-3}	86,785 μgm^{-3}	127,117 μgm^{-3}	17,264 μgm^{-3}	1,120,490 μgm^{-3}
	P3	7,652 μgm^{-3}	3,048 μgm^{-3}	130,887 μgm^{-3}	20,178 μgm^{-3}	134,059 μgm^{-3}
	P4	6,528 μgm^{-3}	**	7,829 μgm^{-3}	**	*
Duration	P1	340 (sec)	380 (sec)	360 (sec)	120 (sec)	400 (sec)
	P2	100 (sec)	710 (sec)	450 (sec)	380 (sec)	350 (sec)
	P3	450 (sec)	340 (sec)	450 (sec)	360 (sec)	170 (sec)
	P4	120 (sec)	−	over16 minutes	−	−
Scattering distance		1,250m	180m	270m	780m	320m
Weather condition		Cloudy, humidity 23%, wind direction to the left side of the building	Slightly cloudy, humidity 28%, wind direction to right side of the building	Clear, humidity 19%, wind direction to the right side of the building	Slightly cloudy, humidity 21%, wind direction to the right side of the building	Cloudy, 28.7°C, humidity 61.2%, 757.55 mmHg, wind velocity 2.3−4.8 m/s
Note		Stand and the electric scoreboard fell  	P4 is located where the dust has no effect  	A river is located under the building  	Only the electric scoreboard fell  	One silo fell  

at the center of the urban area, carried out aggressive promotions, being the symbol of the target building itself. Thus, the crowd gathered and watched the explosive demolition. Therefore, the dusts at P4, near the crowd, lasted a long time. As the Y thermal power plant site was not prepared to prevent dust, and as the coal dusts were not removed in advance, there were high amounts of dust emissions, and the explosive dusts lasted a long time (more than 20 minutes). No close correlation was observed, however, with the absolute amounts of dust in most of the sites.

3.1.3 Calculation of Dust Scattering Distance

A general index diminution equation was applied to 10 sites on a field of demolition by explosion where maximum dust was generated, and the scattering distance of dust concentration generated by the demolition was calculated Eq(1). Wind speed was set at 3 m s^{-1}and the distance where the dust concentration reduced up to 10 μg m^{-3} was judged as the scattering distance.

$$t_0 = t_1 \times ln\left(\frac{Y_1 - Y_0}{A_1}\right) \tag{1}$$

Table 2 Specifications of measurement devices.

Measurement devices	Feature		
Particulate monitor (Casella CEL Ltd.)	Measurement mode	PM10	
	Measurement capacity	15,700 data storage	
	Measurement range	0 to 2,500 mg m^{-2}	
	Resolution	0.001 mg m^{-2} (1μg m^{-2})	
	Average period	1 to 60 seconds	
	Zero stability	±0.002 mg m^{-3}	
	Span stability	<0.7% FSD	
Dust mate (Turnkey Instruments Ltd.)	Measurement mode	TSP/PM10/PM2.5/PM1.0	
	Measurement range	0 to 6,000 mg m^{-2}	
	Detection limit	0.01 mg m^{-2}	
	Indicator range	0 to 60 mg m^{-2}	
	Particle size range	0.5 to 20 um	
	Flow rate	600 cc min^{-1}	
	Averaging period	1second to4hours	

Where,
t_0=Dust scattering distance/average wind speed, sec
t_1=Dust duration, sec
Y_1=Dust concentration prediction value, 10μg/m3
Y_0=Generated dust volume before blast, μg/m3
A_1=Maximum volume of generated dust, μg/m3

According to test results, it was predicted that dust scattered from a minimum of 100 m to a maximum of 1,200 m according to field, and the values of dust scattering distance value according to field are shown in Table 1.

It is expected that dust scattering distance will be used as very important reference material when handling civil complaints in the area and establishing dust prevention solutions. However, the data presented in this study is a rough calculation reached by placing the measured values after the explosion in an index diminution equation. If future studies that can predict dust generation volume in the explosion planning stage and predict distance are conducted, the results are expected to be very important and useful for preventing environment-damaging elements from explosives.

3.2 Analysis of dust particle size distribution

3.2.1 Correlation analysis

Figure 2 shows diagrams of the dust particle size distributions according to the dust density for the examination of the toxicity of the explosion dust. Among the 10 demolition sites, C hotel, H church and Y silo could not measure dusts with a particle diameter due to an error of the measuring instrument, so measurement results of dust particles with a diameter from other 7 sites were analyzed as explained below.

In case of the Y thermal power plant site Fig. 2 (a), the portion of PM10 is increased when the amount of dust generated increased, but the correlation analysis was not significant, since R^2 was 0.14. On the other hand, the portion of hyperfine dust particles such as PM2.5 and PM 1.0 is decreased when the amount of dust generated increased similar to other sites. The rest of the sites, G thermal power plant site Fig. 2 (b) D sports stadium site Fig. 2 (c), S sports stadium site Fig. 2 (d), J department store site Fig. 2 (e), C stadium electric scoreboard site Fig. 2 (f), D university library site Fig 2 (g) show that the more the amounts of dusts generated immediately after explosion, the more rapid fine/hyperfine dusts decreased. That is, in all the sites, except with respect to PM10 in the Y thermal power plant site, the amount of large dust particles with a diameter of over 10 μm increased when the amount of dust generated increased ; and according to the correlation analysis, such increase was significant, since R^2 was 0.57–0.99. The correlation analysis between TSP and particle diameter of dusts showed R^2 of PM10 with TSP is 0.57–0.81, R^2 of PM2.5 is 0.58–0.97, and R^2 of PM1.0 is 0.68–0.99. These results indicate that as a particle becomes smaller, this relationship becomes more considerable.

In view of the above results, relatively large dust particles with a diameter of more than 10 μm were generated in quantity as the amount of dust generation increased. That is, a large amount of dust was generated at the time of the explosion, the dust was composed mostly

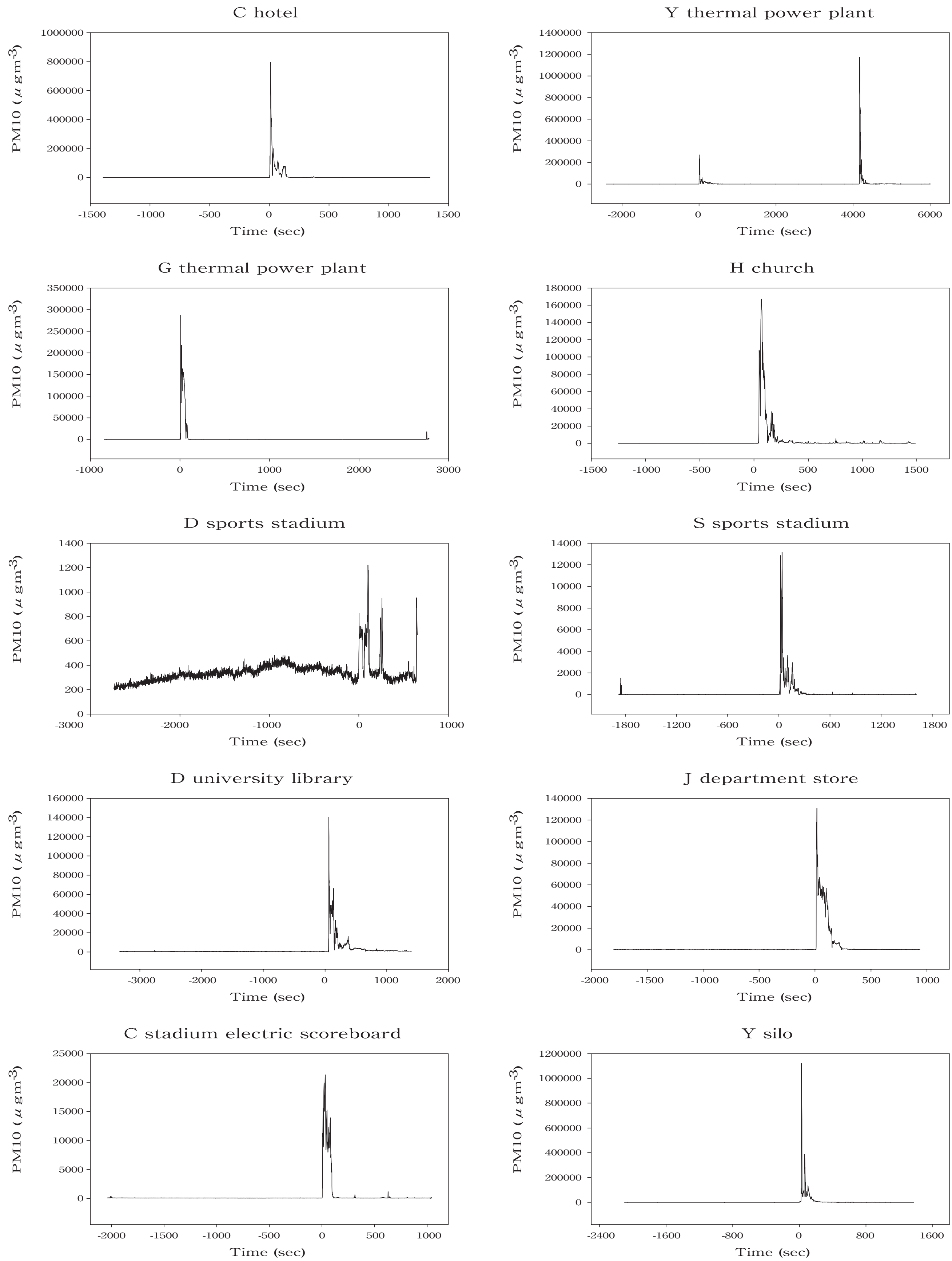


Fig. 1 Generation of the maximum amount of dusts at explosive demolition

of concrete particles, and the large particles flew around after the blast pressure and went down rapidly. As the amount of dust generated was higher, large particles dominated it right after the explosion ; and after a fixed time following the explosion, smaller particles dominated the dust.

3.2.2 Dust particle size distribution

Figure 3 shows the TSP at the time when the maximum amount of dust was generated, classified according to

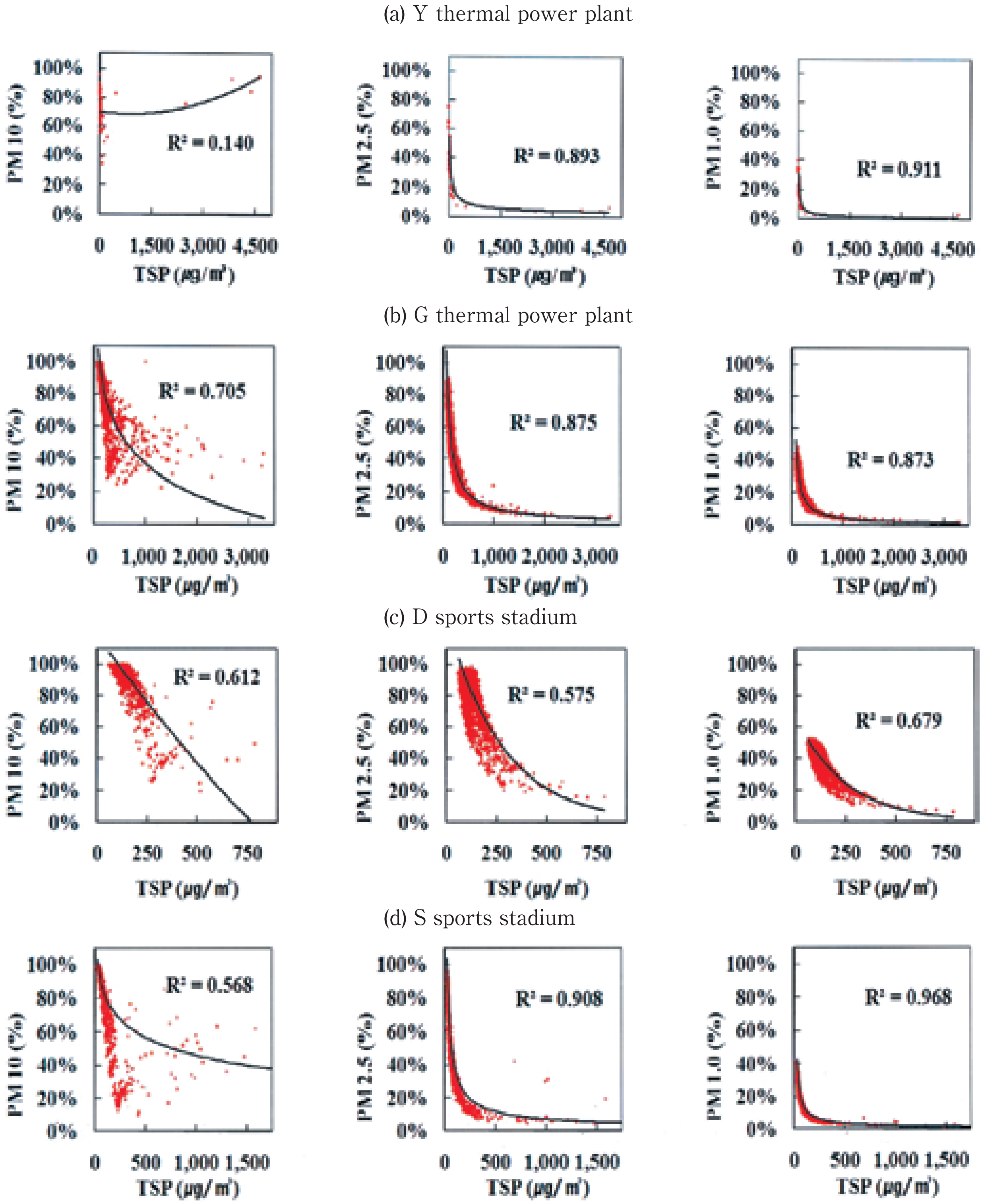


Fig. 2 Characteristics of the particle size distribution of dust according to the increase in the total amount of floating dust at the time of the explosive demolition.

particle sizes of less than 1.0 μm, 1.0–2.5 μm, 2.5–10 μm, and more than 10 μm.

Results of the analysis show that the Y thermal power plant site, with dust particles having a diameter of more than 10 μm, does not have a significant correlation analysis, fine dust particles with a diameter of 2.5–10 μm account for 88% of TSP, while hyperfine dusts with a diameter less than 2.5 μm account for approximately 7% of TSP At the G thermal power plant site, D sports stadium site, S sports stadium site, and J department store site, the dust particles with a diameter of more than 10 μm accounts for 57%, 51%, 55%, 61% of TSP, the fine dusts with a diameter of 2.5–10 μm account for 38%, 32%, 41%, 33%, and the hyperfine dusts with a diameter of less than 2.5 μm account for 5%, 17%, 3%, 4%, respectively.

On the other hand, dust particles with diameters of 2.5–10 μm accounted for approximately 32% of the generated dust, and dust particles with diameters of 1.0–2.5 μm accounted for approximately 47% of the dust generated in the D university library site. The dust particles were

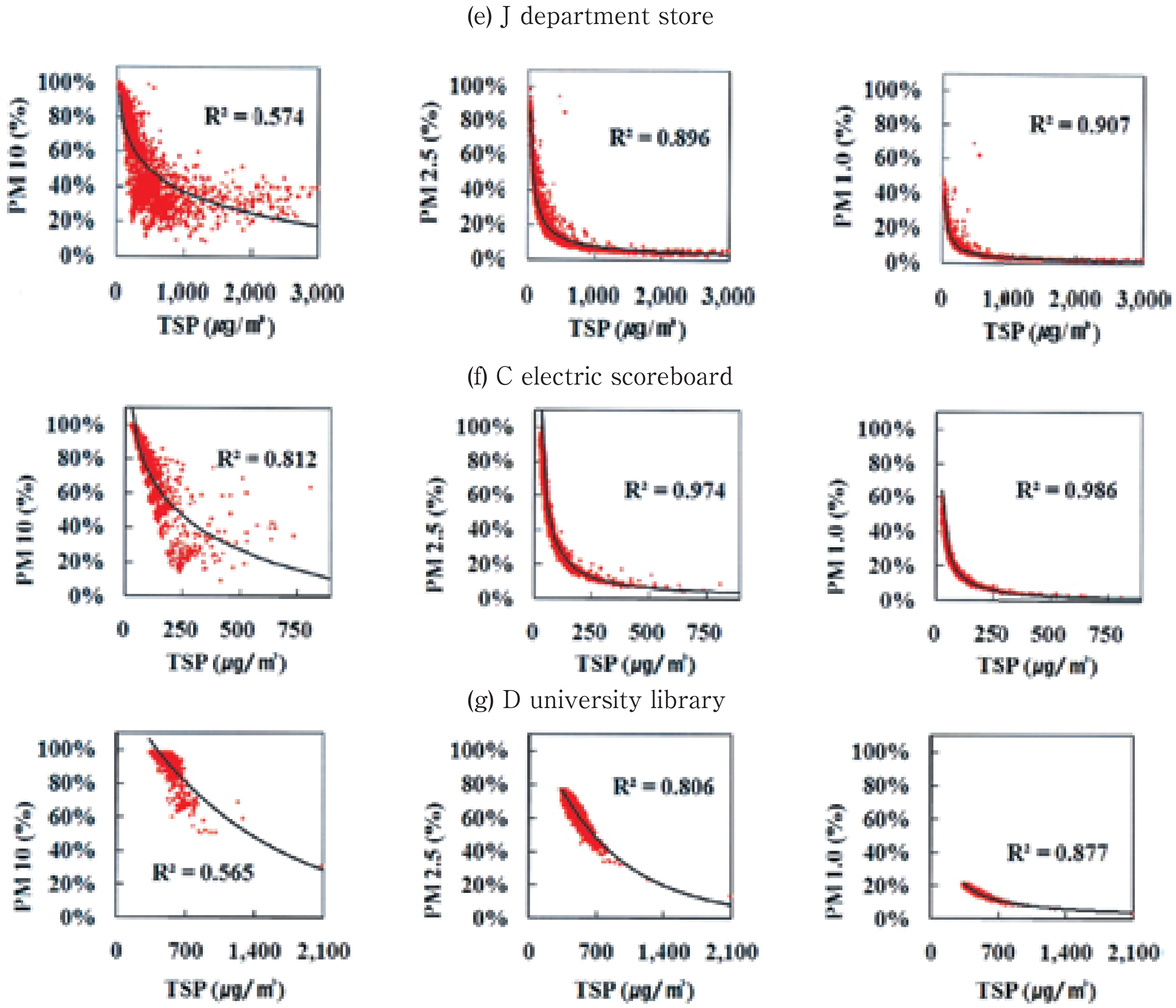


Fig. 2 Characteristics of the particle size distribution of dust according to the increase in the total amount of floating dust at the time of the explosive demolition (Continued).

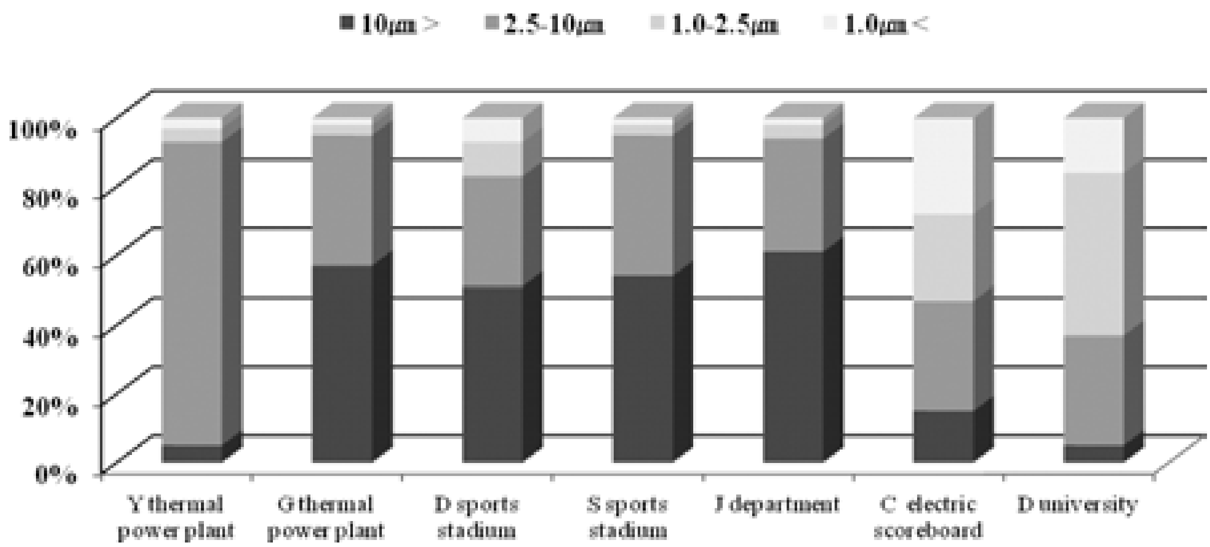


Fig. 3 Particle size distributions at the maximum generation point by explosive demolition

measured more than 80 m away from the target building for the explosion, with no influence from the explosive demolition, and showed a clear contrast to the explosion dust. Also, at the C stadium electric scoreboard site, the dust particles were measured at the direction opposite that of the collapse, with no influence from the explosive demolition. Particles with diameters of 2.5–10 μm accounted for approximately 32% of the generated dust, and particles with diameters of less than 2.5 μm accounted for approximately 53% of the generated dust.

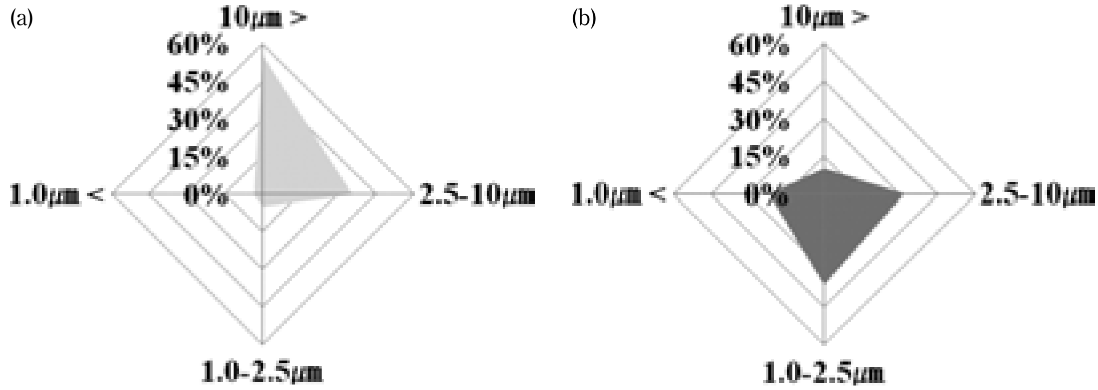


Fig. 4 Comparison of the dust particle size distributions within TSP ; the data was divided on the diameter, and the site influenced was compared with the site uninfluenced by explosion. (a) The average of dusts that were measured at the G thermal power plant, D sports stadium, S sports stadium, and J department store sites were classified as the site influenced by explosion (b) The average of dusts that were measured at the C stadium electric scoreboard and D university library sites were classified as the site uninfluenced by explosion.

These results can also be found in Fig. 4. It shows the difference of the site influenced by explosion from the site uninfluenced by explosion. Figure 4 analyzes the particle size portion within TSP ; it was divided based on the diameter, and the site influenced by explosion was compared with the site uninfluenced by explosion. The dusts that were measured at the G thermal power plant, D sports stadium, S sports stadium, and J department store sites were classified as the site influenced by explosion, while the dusts that were measured at the C stadium electric scoreboard and D university library sites were classified as the site uninfluenced by explosion. The reason for such classifications is that the measurement values of TSP, PM10, PM2.5, and PM1.0 at the G Thermal power plant, D sports stadium, S sports stadium, and J department store sites demonstrate distinct peak values immediately after the explosion, but the measurement values at the C stadium electric scoreboard and D university library sites did not show any significant difference before and after the explosion. As discussed above, measurement P4at the C stadium electric scoreboard site, located at the direction opposite that of the collapse, and the measurement point at the D university library site, located more than 80 m away from the target building, were not affected by the explosive demolition. Thus, since the explosive dust had almost no influence considering the direction of the building collapse, the wind direction, and the location of the measurement points, the peak value at the time of the explosion did not appear, and therefore, such dust could be utilized as the control group for the site uninfluenced by explosion, which was classified differently from the site influenced by explosion. Further, the Y thermal power plant site was excluded from the analysis because it did not show any significant correlation with TSP in terms of PM10.

The dust distribution of the site influenced by explosion is that the dust with particle sizes of more than 10 μm accounted for more than 51–61% of the dust generated at the time of the explosion and right after the explosion, and fine dust particles with diameters of 2.5–10 μm accounted for approximately 32–41% of the generated dust. Hyperfine dust particles, with diameters of 1.0–2.5 μm, accounting for 3–10% of the dusts formed, and less than 1.0 μm, accounting for 2–7% of the dusts formed, were not significantly produced.

While the dust distribution of the site uninfluenced by explosion is such that the dusts with particle sizes of more than 10 μm accounted for more than 5–15% of the dusts formed, and that the fine dust particles with diameters of 2.5–10 μm accounted for approximately 32% of the dusts formed the hyperfine dust particles with diameters of 1.0–2.5 μm accounted for 25–47% of the dusts formed. Those with diameters of less than 1.0 μm accounted for 16–28% of the dusts formed. Thus, approximately 90% of the dust that generated at uninfluenced site is fine or hyperfine dusts, compared with the influenced site, which makes up approximately 45% of the dusts.

Therefore, instant dust generated in an explosive demolition site is considered insignificant enough to create respiratory trouble, since a large amount of large concrete particles flew around at the time of the explosion and settled down rapidly due to gravity. Instant dust has no significant toxicity to the human body, but a large quantity of such dust is generated within a short time. Therefore, the development of technologies for reducing the generation of various types of dust is considered necessary to deal with emotional civil petitions from surrounding residential areas and to establish eco-friendly demolition technologies.

3.3 The suggestion of method to decrease the dust pollution

Actually at demolition sites the sound proof materials and other protection technique methods were used to decrease noise, vibration and particle and prepare for the safety and reduce the civil petitions. And also, the management method to decrease the dust pollution is suggested as below :

First, scatter the water sufficiently before and after the demolition to make the dust minimal, also being aware of height and size of the selected structure and estimating the possible distance of expanding dust establish dust fences with suitable distances and directions.

Second, manage thoroughly waste materials and carry away with selected to make pollutant materials that flow off the oil, various waste materials and interior decoration materials minimal.

Third, when scattering the water to decrease the amount of dust consider the harmful substances in the dust to make the indirect pollution from the scattered water least and also keep on monitoring and managing.

Fourth, when demolishing special structures or industrial structures scrutinize the possible hazardous materials and prepare the related plans based on those structures' profiles and purposes.

4. Conclusion

1) Instant dust generated at the time of a structure demolition by explosion is mostly composed of large particles right after the explosion ; and after a fixed time before/after the explosion, relatively smaller particles are distributed.
2) At the time of explosion and right after the explosion, dust particles with sizes of more than 10 μm accounted for more than 50% of the generated dust, and fine dust particles with diameters of 2.5−10 μm accounted for approximately 30−40% of the generated dust. Hyperfine dusts with diameters of less than 2.5 μm were not significantly produced. On the other hand, the dust generated at the site uninfluenced by explosion, and fine dust with particle sizes of 2.5−10 μm, accounted for approximately 30% of the generated dust, and hyperfine dust particles with diameters of less than 2.5 μm accounted for approximately 50−60% of the generated dust.
3) Even though a large amount of dust is generated instantly at the time of a explosion demolition, large particles account for much of the dust generated, and these particles are not inhaled through the respiratory organs, so they would have no significant toxicity to the human body, unlike the amount generated.
4) Therefore, among the measures for controlling dust from explosive demolition works, the spraying method, taking into consideration the size of the instant dust particles generated from the explosive demolition at the time of water sprinkling, could provide better dust control results.

Acknowledgement

This study was carried out as a part of the high−tech urban development project of the Ministry of Land, Transport, and Maritime Affairs of Korea (Project No. 06 Construction Core B04).

References

1) Ministry of Construction and Transportation, "Report on the Research and Planning of Demolition Technologies for Downtown Structures", (2006).
2) Ministry of Environment, "Environmental Quality Standards for Air Pollution", http : //www.me.go.kr, (2008).
3) EPA, "Annual Final Designations for First Fine Particle Standards", (2003).
4) EC, "Thematic Strategy on Air Pollution", (2005)
5) S. Y. Kim, et al., "Study on fine dusts in some areas and atmosphere of Seoul", The Korean Society of Environmental Health, 3, 4, pp. 301−308 (2005).
6) Korea National Housing Corporation, "The Development of Evaluation Techniques and Standards for Environmental Effects in Surrounding Areas of a Demolition Site", pp. 49−57 (2007).
7) K. H. Lee, et al., "The characteristics of the particle size distribution of the instant dust generated at a site of a explosion demolition", Magazine of the Korea Environment and Science Society, 18, 1, pp. 41−47 (2009).