Korean experience with management of transport noise

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Contents of presentation

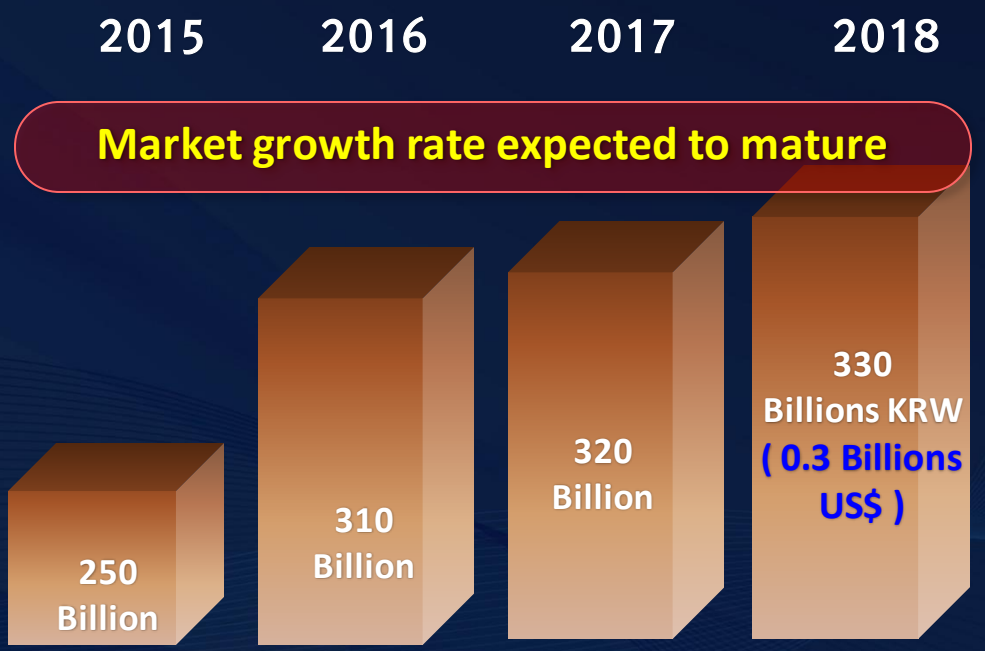
1 Domestic Soundproofing Facility and Noise Management Standard

Definition of soundproofing facility

- It is a public facility installed for the purpose of preserving the living environment of the neighboring area by blocking or absorbing the noise generated by the noise source (vehicle, road, railway, machinery, etc) reducing the noise by the diffraction of noise

Market Size of Domestic Soundproofing Facility

- About 330 billion KRW in the soundproofing market and about 90 specialized companies
- Soundproofing market is steadily increasing
- Market size is expected to increase over the next few years, but market size is expected to be stagnated due to market demand contraction and saturation of related companies.



1 Domestic Soundproofing Facility and Noise Management Standard

Types of Domestic Soundproofing Facilities

- There are soundproof tunnels & walls, *soundproof walls are classified into transparent & sound absorption type
- Soundproof walls are classified into concrete, synthetic resin type, and wood type by materials.
- In Korea, sound absorbing walls are installed most frequently(35%), sound tunnels are installed the second (26%).

Soundproof Tunnel

Transparent type

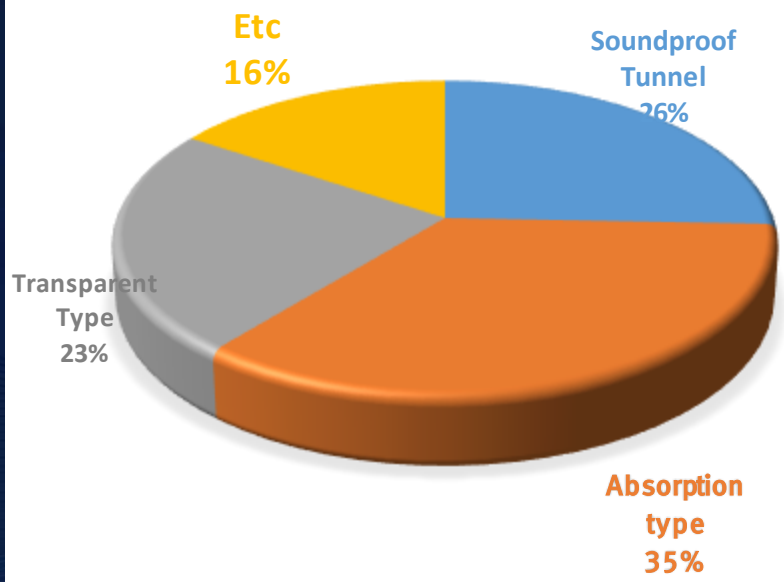
Absorption type

Concrete

Synthetic resin type

Wood type

Market share of Soundproofing



1 Domestic Soundproofing Facility and Noise Management Standard

Status of noise standards

① The「Environmental Policy Basic Law」standard
(Law Article 10, Enforcement Decree, Article 2 "Annex 1")

(Day: 06: 00 ~ 22: 00 / night: 22: 00 ~ 06: 00)

Area types	General		Roadside	
	Day	Night	Day	Night
Area"A"	50	40	65	55
Area"B"	55	45		
Area"C"	65	55	70	60
Area"D"	70	65	75	70

<Target area by region>

- Area"A": Conservation & agricultural and forest, urban green, private residential, schools, hospitals, and libraries
- Area"B": Production management, general and semi-residential
- Area"C": Planning management, semi-industrial
- Area"D": General, private industrial

1 Domestic Soundproofing Facility and Noise Management Standard

② 「Noise & Vibration Control Law」 (Article 26, Regulation Article 25 "Annex 12")

(Day: 06: 00 ~ 22: 00 / Night: 22: 00 ~ 06: 00)

Target area	Classification	Day	Night
Residential area, greenery area, settlement area in administrative area, area within 50 meters from site boundary of school, hospital, public library etc.	Noise (dB(A))	68	58
	Vibration (dB(V))	65	60
Commercial areas, industrial areas, agricultural and forestry areas, production management areas and management areas Industry, distribution development promotion district, Mie Koshi area	Noise (dB(A))	73	63
	Vibration (dB(V))	70	65

③ According to 「Housing Law」
(Article 42 of the 「Act on Housing Construction Standards」, Article 9 of the Decree)

Classcation	Large-scale apartment	Small apartment house
Target	Development area more than 300,000 ㎡	Development area less than 300,000 ㎡
Noise criterion	Application of 「Basic Law on Environmental Policy」 · 65dB outside the day, 55dB at night	Applying 「Housing Law」 · 5 layers or less: 65 dB or less · 6F or more: indoor 45dB or less
Note	· According to the Housing Law, indoor noise is measured when window is closed. · The indoor noise of 45 dB is equivalent to the outdoor noise of 70 dB or more when considering window penetration performance.	

1 Domestic Soundproofing Facility and Noise Management Standard

④ Comparison of domestic highway related noises

Classification	Environmental Policy Basic Law	Noise and Vibration Control Law	Housing Law (Regulations)
Implementing body	▪ Concession company (road, house, etc.)	▪ Noise generator	▪ Housing company
Purpose	▪ Goal criteria of noise environmental policy	▪ Roads, railways, etc. Noise Prevent vibration damage	▪ Noise reduction and blocking at the sound source side
Noise criterion	▪ Outdoor noise – Weekday: Less than 65dB – Night : Less than 55dB	▪ Outdoor noise – Weekday : Less than 68dB – Night : Less than 58dB	▪ Outdoor Noise: Less than 65dB ▪ In door Noise: Less than 45dB
Object of application	▪ Business subject to environmental impact assessment – Road: new 4km, extended 10km or more – Housing: more than 300,000 square meters	▪ Public highway	▪ Housing business not subject to environmental impact assessment

2. Noise Reduction Facilities

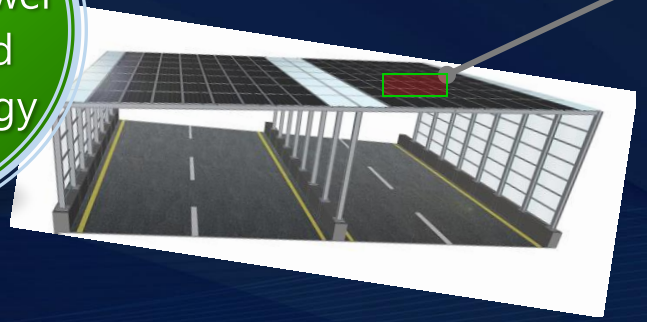
Problems and solutions of existing soundproof tunnels

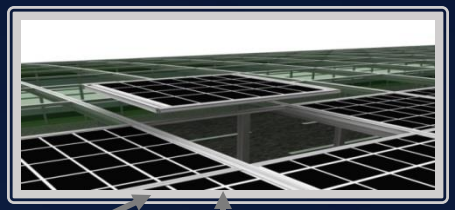
Utilization of solar photovoltaic soundproof tunnels

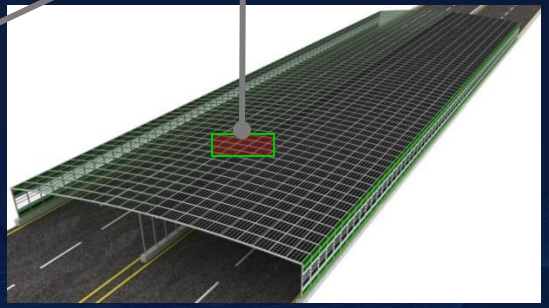
- The currently used soundproofing tunnels have soundproofing effect, but there is a problem that obstructs the aesthetics of the road.
- Research on solar tunnels is actively under way to solve the problem of aesthetics and secure environment-friendly energy.
- Solar photovoltaic soundproof tunnels are soundproof tunnels that are made by integrating general soundproof tunnels and solar power facilities.
- The use of solar photovoltaic soundproof tunnels has the advantages of securing safe and sustainable eco-friendly energy while playing the role of existing sound-proof tunnels. It also has advantages such as light weight, cost reduction, beauty improvement through application of various designs

In solar panel (module) By applying sound insulation performance Instead of soundproof panels By installing **solar panels Integrated** sound insulation tunnels Technology to install

Sound insulation tunnels Solar power plant Integrated Fusion technology



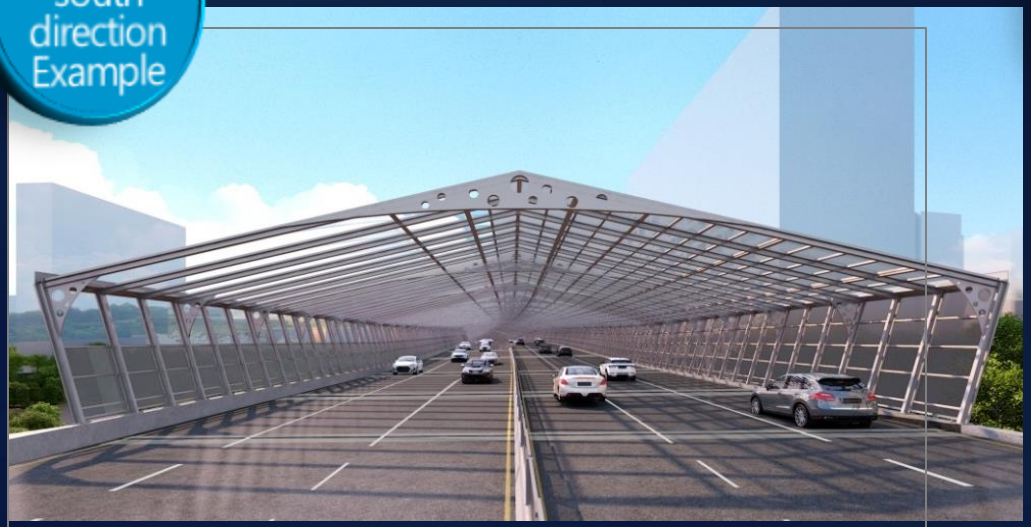




To solve the problem of aesthetics inhibition, it is necessary to utilize solar noise tunnel

2. Noise Reduction Facilities

North-south direction Example



East-west direction Example

2. Noise Reduction Facilities

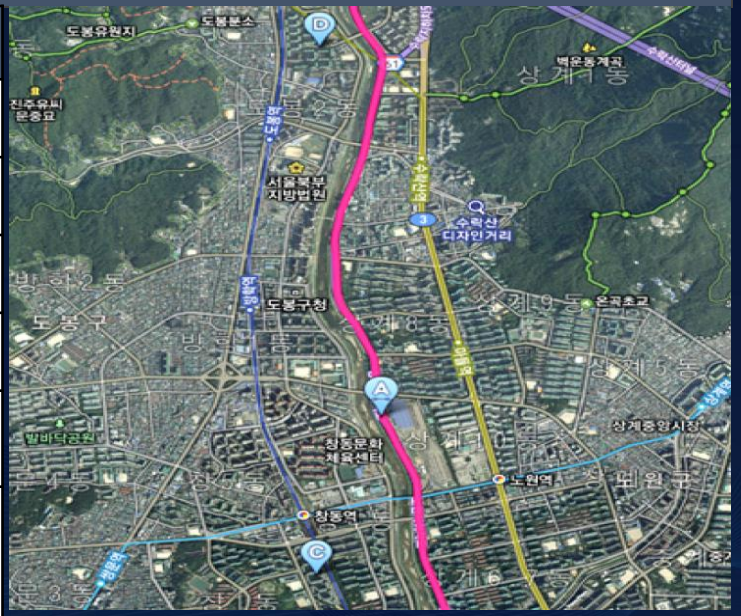
Analysis of solar photovoltaic soundproof tunnels Effect

Simulation Overview

- In order to verify the effectiveness of solar tunnels, we plan to construct solar tunnels in the direction of Sungsu Daegyo, Dongbu Highway, Sanggye-dong, Nowon-gu, Seoul and predict the effects by simulation analysis before construction
- Simulation results of shading analysis show that it is possible to supply 993.6kw of electricity.

Simulation Overview

Classification	Contents
Name	• Dongbu Highway Tunnel Solar Noise Tunnel Power Generation Project
Location	• Dongbu highway , Sanggye-dong, Nowon-gu, Seoul
Place of installation	• Dongbu Highway 3sector
Capacity	• Photovoltaic power generation equipment 993.6kw
Content scope	• Installed integrated solar power plant with soundproof wall utilizing sound-proof tunnel
Business period	• Construction : Installation completed within 12 months from contract date • Operation : 20 years after completion



Simulation of shading analysis results in 993.6kw power supply

2. Noise Reduction Facilities

Enter shading analysis data

- Considering the yearly value of meteorological data such as wind speed and sunshine time, the shade of the spot where solar photovoltaic soundproof tunnels was installed is analyzed (2016)
- Weather data utilizes meteorological data of Seoul Metropolitan City including business branch
- Date of Analysis: June 21 (not based) ~ December 22
- Analysis time: 10:00 ~ 6:00 (every hour interval)

Enter wind speed data

Classifc ation	Jan	Feb	Mar	Apr	May	Jun
Average wind speed (m/s)	2.5	2.8	2.4	2.4	2.4	2.1
Classifc ation	Jul	Aug	Sep	Oct	Nov	Dec
Average wind speed (m/s)	2.1	2.1	2.0	2.1	2.2	2.2

Average wind speed in Seoul for the past one year: 2.4m / s

Enter the daylight-saving time data

Classifc ation	Jan	Feb	Mar	Apr	May	Jun
Daylight hours (hr)	196.1	195.2	235.1	219.5	280.1	229.7
Classifc ation	Jul	Aug	Sep	Oct	Nov	Dec
Daylight hours (hr)	160.4	236.1	191.6	195.7	173.3	166.4

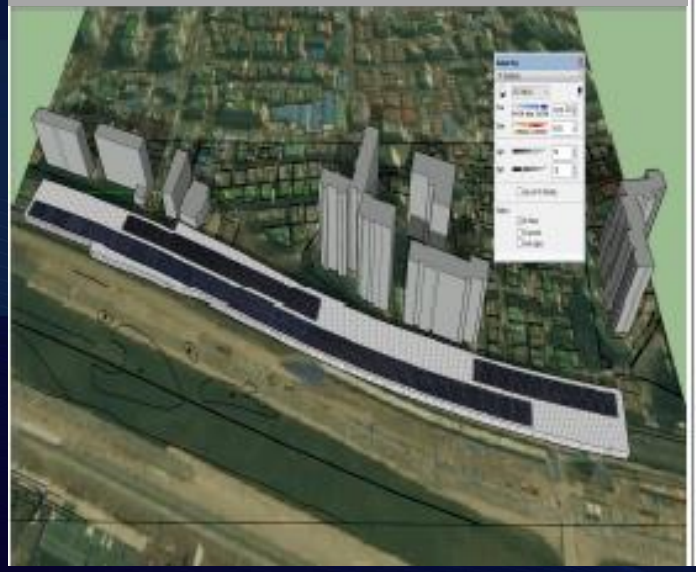
Average hours of sunshine per month in Seoul: 208.15hr

2. Noise Reduction Facilities

Result of shading analysis

- In consideration of the most time, the result of the review from 0:00 to 16:00 (June 22) is not influenced by the spirit, but at the time of the comrade (December 22), some shades Occur
- Considering the shaded areas, the arrangement of the photovoltaic modules in the soundproof tunnels on the front of the apartment was avoided.

Example of shading analysis

6/ 21 PM 4:00	6/ 21 PM 3:00	12/ 22 AM 11:00
		

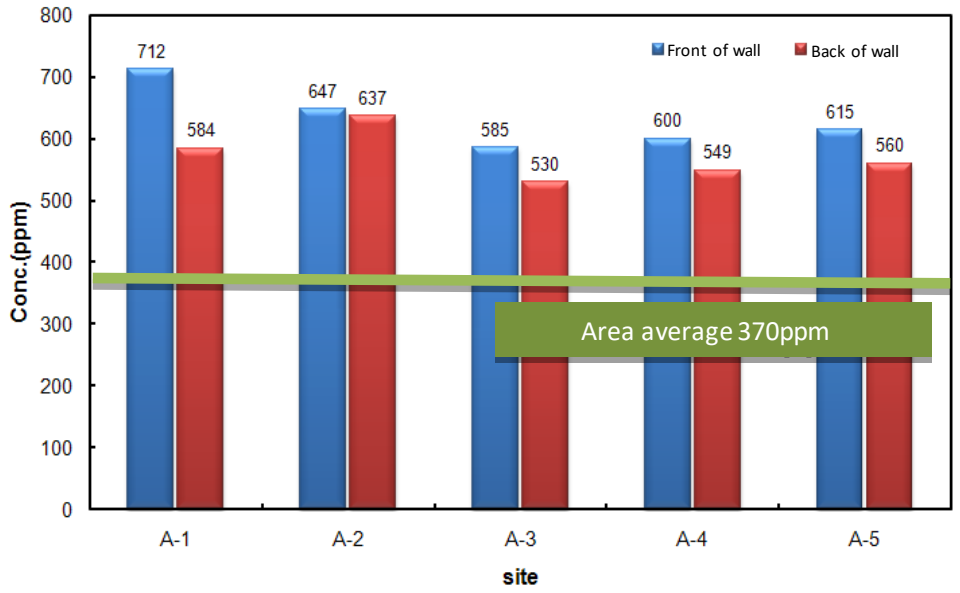
2. Noise Reduction Facilities

Problems of existing sound barrier

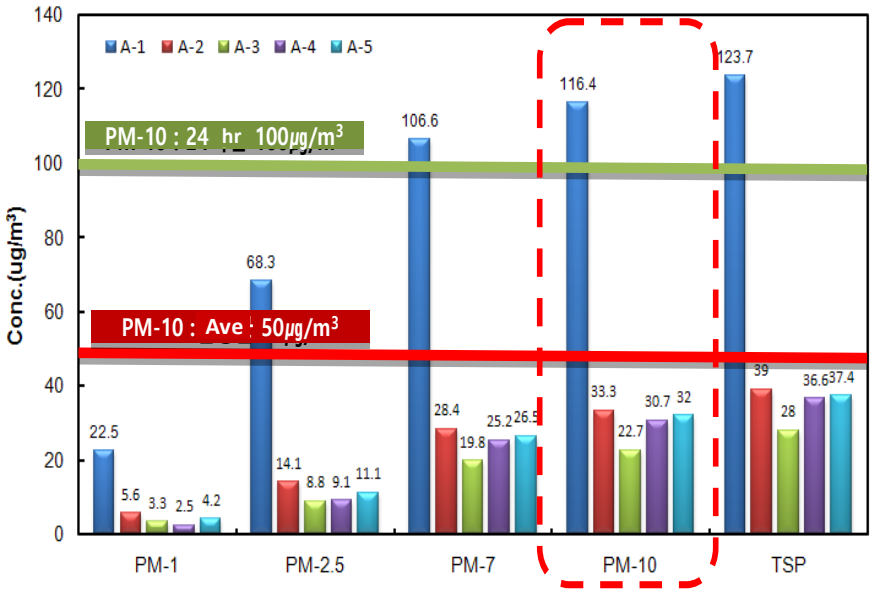
Atmospheric pollution

- There is a side effect that pollution of the air quality is polluted by the soundproof wall which is currently used.
- The concentration of CO2 around the sound barrier wall is higher than that of other areas, and the amount of fine dust is also higher
  - Roadside CO2 concentration: 600 ~ 700ppm above the global mean 370pmm
  - Roadside fine dust concentration: near Gyeongbu Expressway Seoul toll center PM-10 concentration 116.4 μg / m3

Result of CO_2 measurement



Result of fine dust measurement



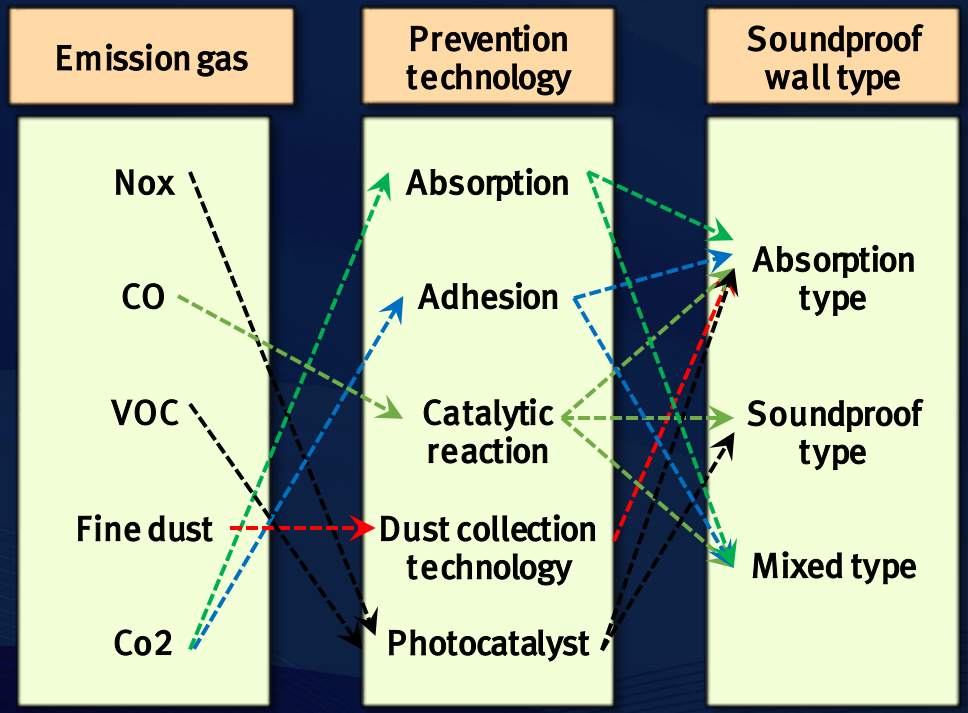
Increase the necessity of development of technology to improve air quality on the road side and need eco-friendly multifunctional soundproof panel

2. Noise Reduction Facilities

Eco-friendly multi-function soundproof panel

Eco-friendly multi-function soundproof panel development process

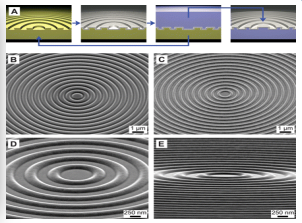
Applicable technologies for reducing air pollutants



- Mechanism setting that can design eco-friendly soundproof wall considering solubility of air pollutant and reactivity at room temperature

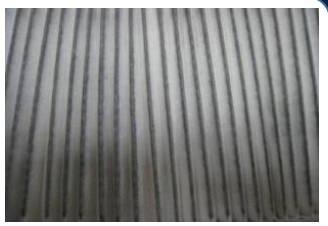
Air pollution removal mechanism setting

CO_2 removal



Application of adsorption method using zeolite, copper oxide and activated carbon fiber

Fine dust removal

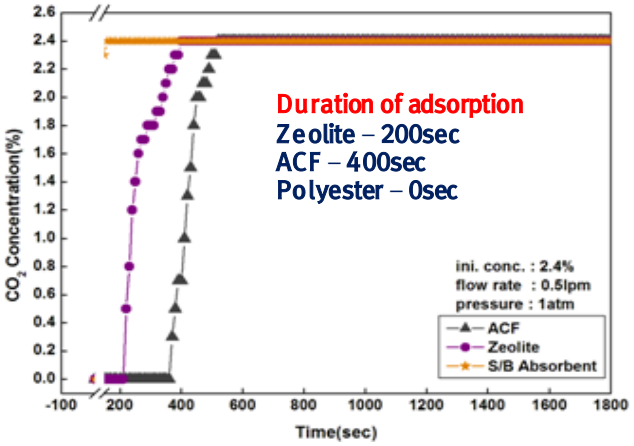


Using HEPA (High Efficiency Particulate Air) Filter and small blower

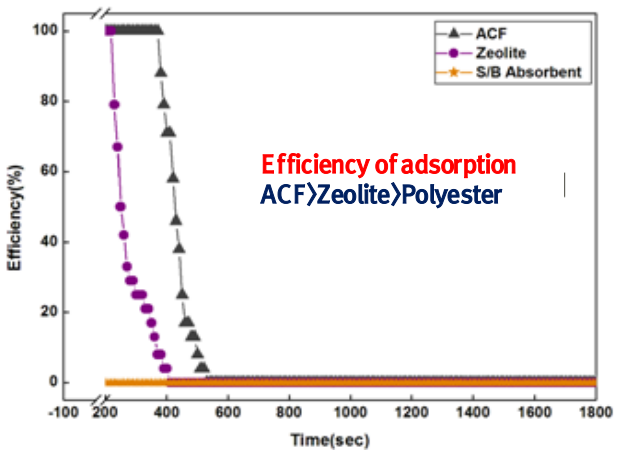
2. Noise Reduction Facilities

Performance test by air pollution abatement mechanism

CO2 removal

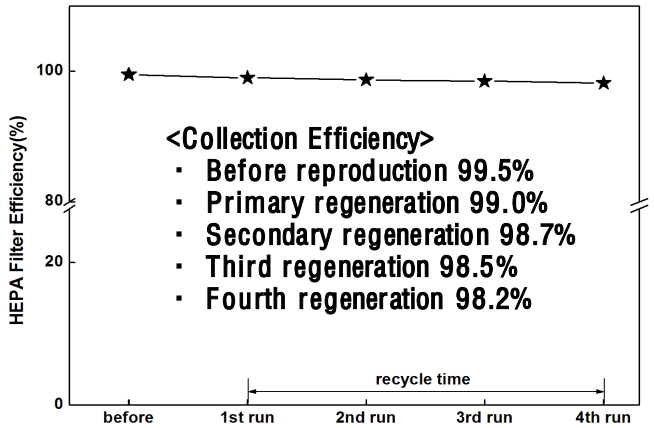


<Breakthrough curve for each adsorbent>



<CO2 removal efficiency by adsorbent>

Fine dust removal

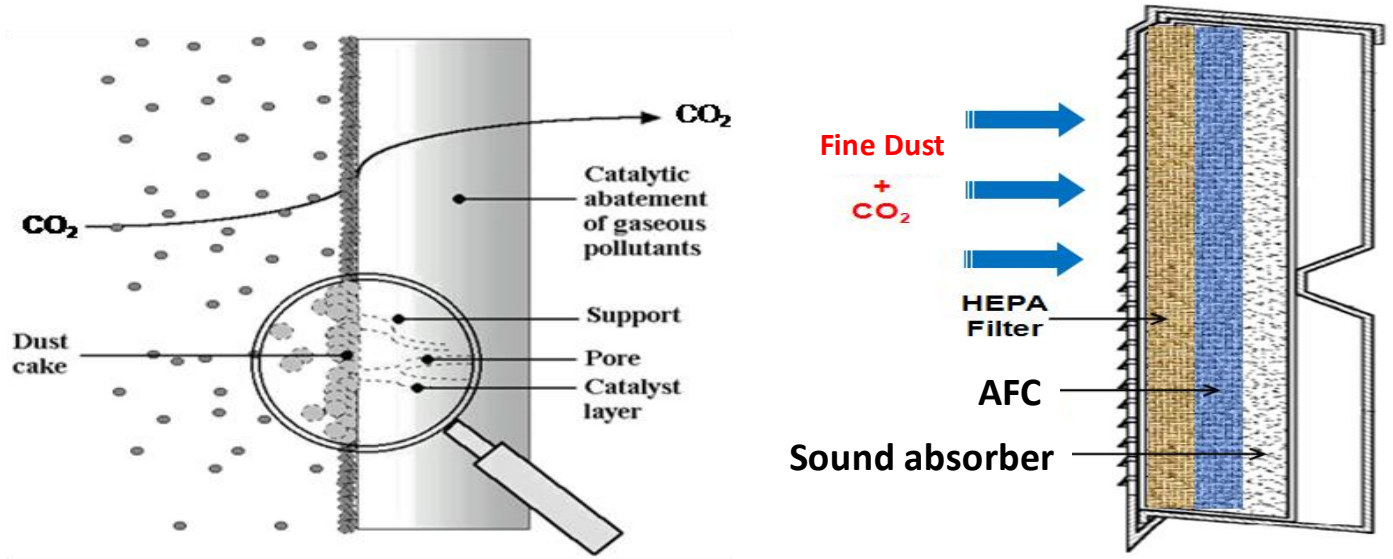


<Fine dust collection efficiency>

- Carbon dioxide adsorption performance test (Activated Carbon Fiber (ACF), Zeolite, Polyester)
- Efficiency of adsorption : ACF>Zeolite>Polyester
- The larger the specific surface area of the adsorbent, the longer the adsorption duration
- Polyester which is main material of sound absorbing material is not applicable as absorbent.
- Fine dust removal performance test using HEPA filter: Fine dust removal efficiency 99.5%
- Decrease efficiency of fine dust removal before and after regeneration: 0.5% or less

2. Noise Reduction Facilities

- CO2 and PM10 collection and removal module



<Basic concept of CO2 / fine dust removal using multi-function>

- Air Pollution Purification Soundproof Panel Composition: ACF (Activated Carbon Fiber) absorber, HEPA filter, Sound absorbing material
- Elimination of CO2 by ACF after secondary removal of fine dust through HEPA filter
- It is necessary to maximize the contact area and remove the CO2 using the adsorption method, and to apply maintenance-friendly retractable panel
- Further research to improve the efficiency of adsorbents and HEPA filters through long-term monitoring in the future

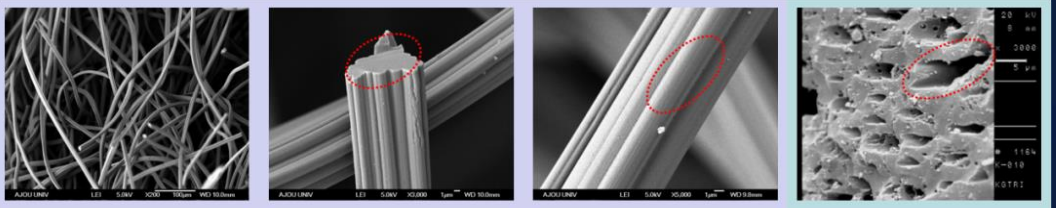
2. Noise Reduction Facilities

- Property analysis of ACF and pre-filter

Most of the pores developed in the ACF are micropores

BET surface area (m^2/g)	Micro pore surface area (m^2/g)	External surface area (m^2/g)	Total pore volume (cc/g)	Micro Pore Volume (cc/g)	Pore diameter (Å)
1,057	761	296	0.63	0.4	11.74

SEM (Scanning Electron Microscope) Analysis of ACF



ACF AC

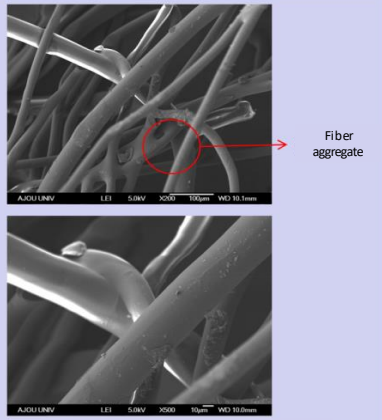
In order to trap stable CO2 gas, it is advantageous to use ACF having a large number Of micro pores.

- Reduction of greenhouse gas (CO2): ACF adsorbent
- Fine dust reduction: Pre-filter use

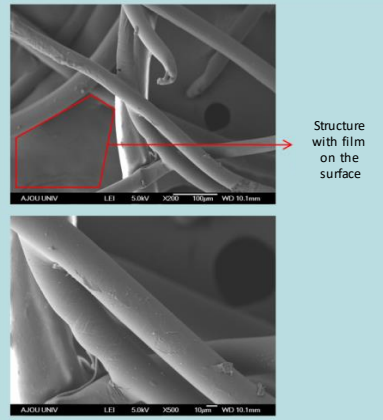
Pre-filter VS HEPA filter

Classification	Pre Filter	HEPA Filter
Performance evaluation method	ASHRAE std. 52.1	DOP method
Application dust diameter(um)	<8~10	<0.3
Collection efficiency (%)	<95	>99.97
Filter media	Polyester fiber	Water proof glass fiber
Recycle	Yes (wash)	No
Unit price	10,000~20,000 won	100,000~150,000 won

Pre-filter VS Sound absorbing material



Pre Filter filter media(Polyester) SEM image

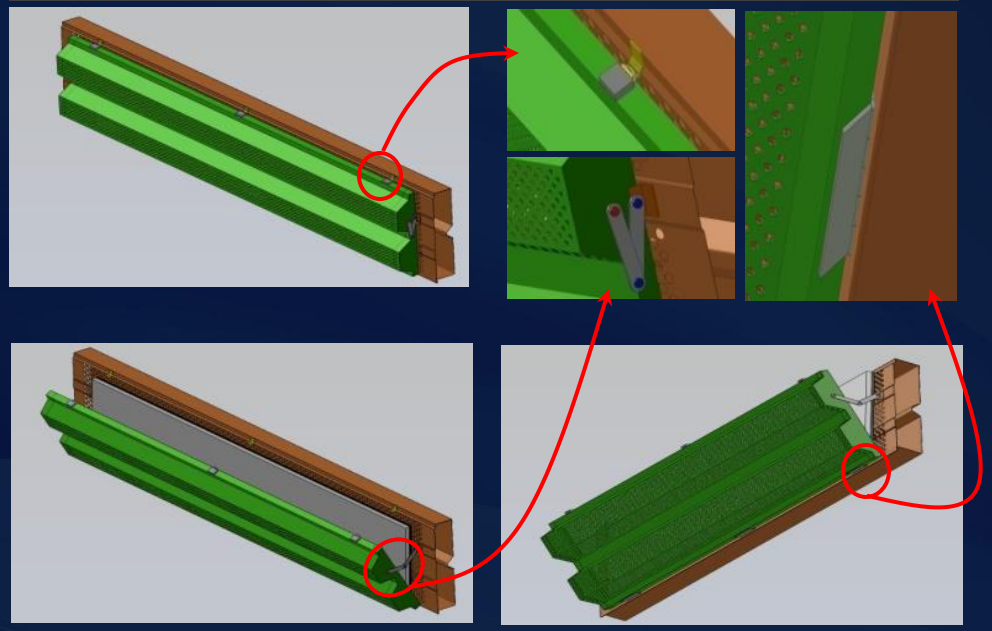


Soundproof wall absorbing material(Polyester) SEM image

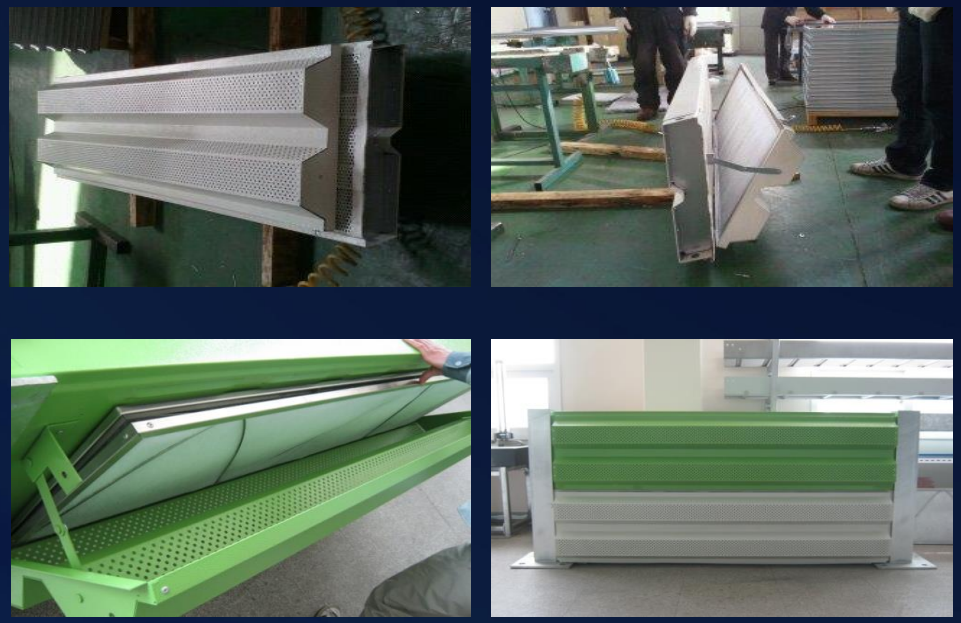
2. Noise Reduction Facilities

- Prototype development

Eco-friendly multi-function soundproof panel design



Produced eco-friendly multi-functional soundproof panel prototype



- Air Pollution Reduction Module (ACF Adsorption Module and Pre Filter Module)
- Strengthen ventilation of the reduction modules on the front side (more than twice as much as general soundproof panels)
- Maintain soundproofing performance by using general type sound absorption panel on the rear part

2. Noise Reduction Facilities

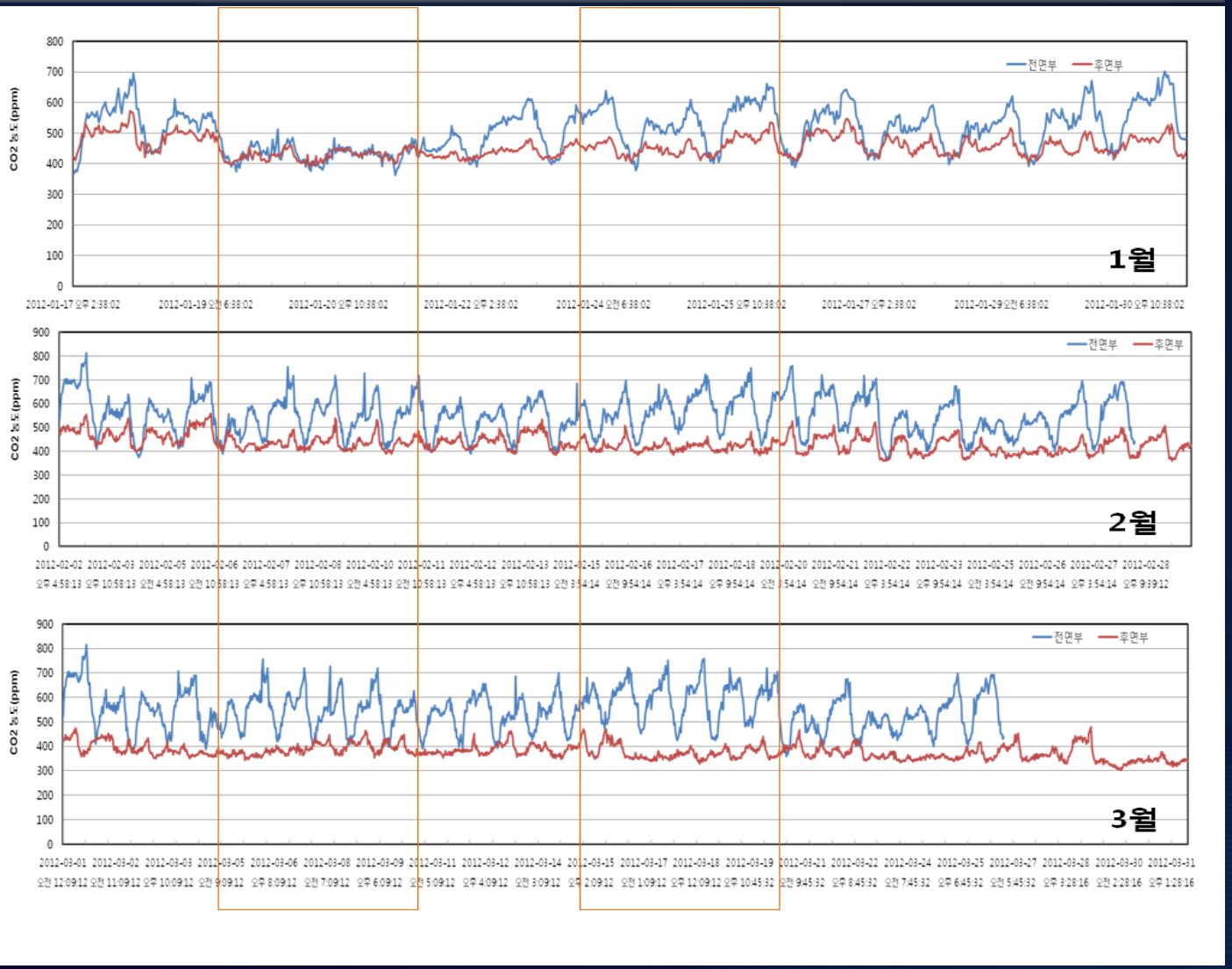
On-site installation test

- Test construction in smart highway experience road
  - Test construction in smart highway experience road
  - Construction and PR panel installation at 10m between elevated bridge
  - Use it as promotional road for project team
- Construction of public road test for performance verification
  - Gyeongbu Expressway Upper line Near Seoul tollbooth (403.6km)
  - Replace existing installed soundproof wall (5m) with developed eco-friendly multi-function soundproof panel (3 ~ 4m height)
  - 50m section installation (total of 100 panels installed)
  - Monitoring before and after installation and investigation of adsorption amount

2. Noise Reduction Facilities

- Field monitoring and performance analysis

CO_2 concentration monitoring



CO_2 concentration

→ **Up to 850 ppm**

Front and rear comparison

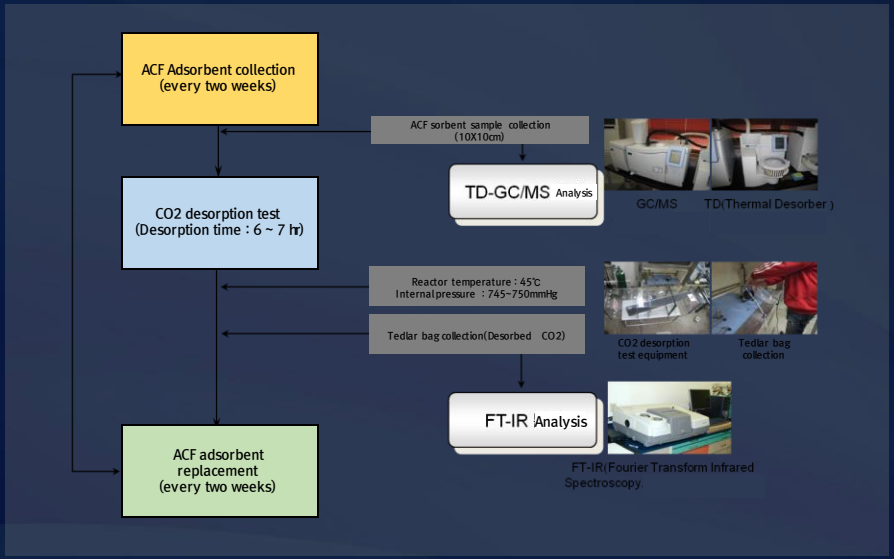
→ **Up to 300 ppm difference**

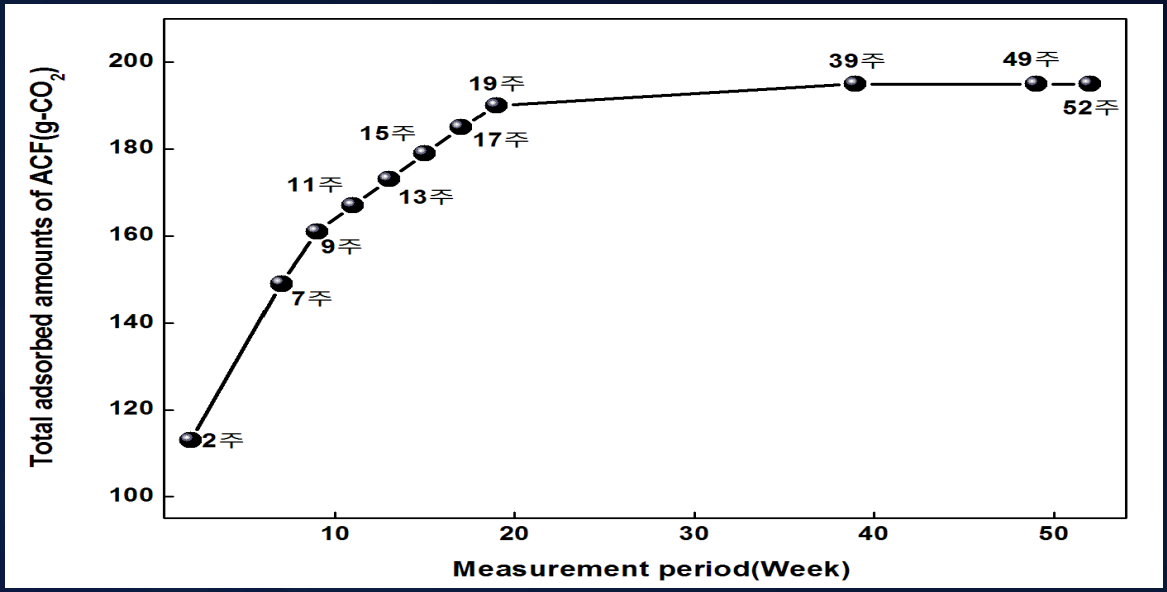
CO_2 concentration in congested area: above average global concentration (400ppm)

CO_2 absorption Soundproof panel application

2. Noise Reduction Facilities

Evaluation of CO_2 adsorption amount





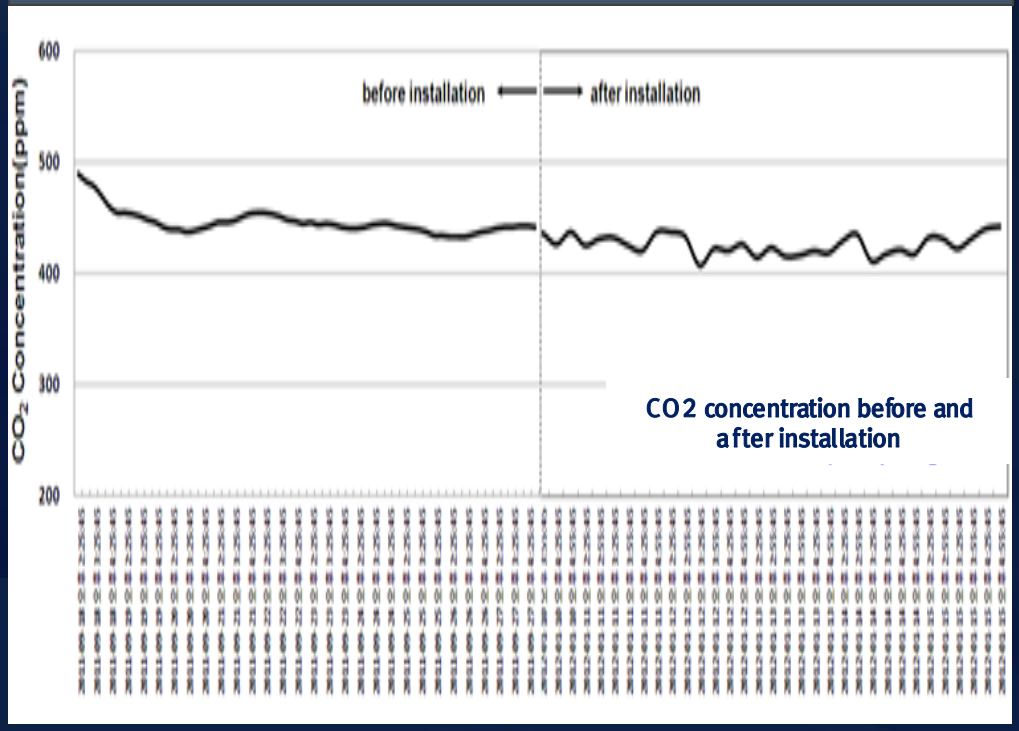
구 분	2week	7week	9week	11week	13week	15week	17week	19week	39week	49week	52week
CO2 per sample Adsorption amount (g-CO2/g-ACF)	0.020	0.029	0.030	0.031	0.032	0.033	0.034	0.035	0.036	0.036	0.036
Total CO2 adsorption amount per 1 panel(g-CO2)	113	149	161	167	173	179	185	190	195	195	195

Between the 2nd and 7th weeks after installation
→ the adsorption amount increases sharply
52 parking after installation (about 12 months)
→ CO_2 adsorption amount is fully included

52 total until 19.5kg Adsorption (installation area) (100 soundproof panels)

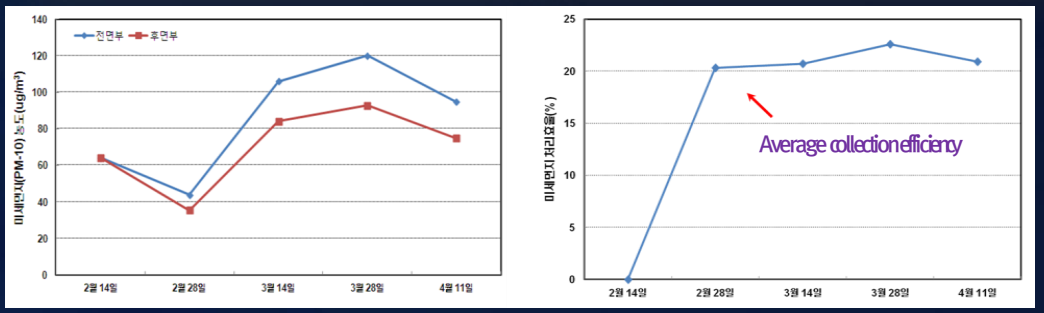
2. Noise Reduction Facilities

CO_2 concentration (before / after comparison)



PM-10 Reduced amount (before / after comparison)

Classification	Before	After	Collection amount	Reduced rates
Figures	250 g	295 g	45 g	18 %



Installation Soundproofing panel Ambient CO_2 concentration: 6.5% reduction (average 444 ppm → 415 ppm)

Installation PM-10 around soundproof panel Reduction: 18% reduction (collection amount and front and rear surface density)

Eco-friendly multifunctional panel reduces CO_2 and fine dust

3. Government Policy (1) – Low Noise Tire System of EU

To introduce during 2019~28 depending on vehicle types & replace types

Class	Year & Date to Apply Tire Noise Standards		
	New Car (OE)	Replacement (RE)	Retails Shop
Passenger Car (C1)	2019.1.1.	2023.1.1	2025.1.1
Small Commercial (C2)	2021.1.1	2025.1.1	2027.1.1
M&L Commercial (C3)	2026.1.1	2027.1.1	2028.1.1

* OE : Original equipment, ** RE : Replacement

4. Government Policy (2) – Noise Map

NOISE AND VIBRATION CONTROL ACT

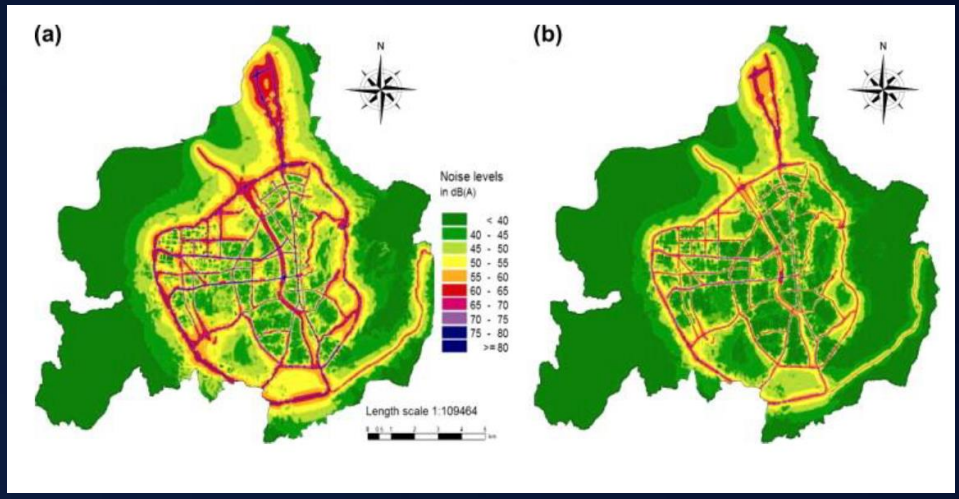
(소음진동관리법)

Article 4-2 (Drawing-Up of Noise Maps)

(1) The Minister of Environment or Mayor/Do Governor may draw up a noise map showing the distribution of noise in a certain area and other relevant matters when deemed necessary for appropriate control of the noise produced by a means of transportation, etc. pursuant to Ordinance of the Ministry of Environment.

(2) The Minister of Environment or Mayor/Do Governor may disclose a noise map through its Internet website, etc. once he/she has drawn up it under paragraph (1).

(3) The Minister of Environment may provide a Mayor/Do Governor who draws up a noise map under paragraph (1) with technical or financial support necessary for the preparation and management thereof. [This Article Newly Inserted by Act No. 9770, Jun. 9, 2009]



*Currently, 38 cities with population of 0.5 million should have noise map by the year of 2016.

관련법령 | 작성절차 | 소음지도 작성대상 도시 현황

인 구 (작성기한)	계	50만명 이상 ('13년까지)	25만~50만명 ('16년까지)	
계	74	17	21	
특별시	1	서울		
광역시	6	부산, 대구, 인천 광주, 대전, 울산	-	
경 기	26	수원, 성남, 부천 안산, 고양, 용인	의정부, 남양주, 안양, 광명, 평택, 시흥, 군포, 화성	구리,
강 원	3	-	춘천, 원주	
충 북	4	청주	-	
충 남	6	천안	-	
전 북	4	전주	군산, 익산	
전 남	4	-	여수, 순천	
경 북	10	-	포항, 경주, 구미	
경 남	9	창원	마산, 진주, 김해	
제 주	1	-	제주	

※ http://www.noiseinfo.or.kr/about/noisemapinfo.jsp?pageNo=1113