



Preliminary study findings for the “Supporting the policies on green and resilient transport infrastructure along the Asian Highway Network” study project

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1. National Experience from the Republic of Korea

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1-1. Background



[Source: Google Earth]

General information

- Surface Area: 100,032 km²
- Mainly mountainous (70% of the area)
- Short humid summers / long, cold and dry winters

Road networks

- Total length: L=113,405km
- National expressways L=4,866km
- General national highways L=14,175km
- 32 Expressway routes
- **75%** 4 lanes, **13%** 6 lanes, **11%** 8 lanes, **1%** 10 lanes
- Part of the Asian Highway Network (**AH1** and **AH6**)

1-2. Overview

Green and Resilient Highway Initiatives in the Republic of Korea

- Smart construction technology for design, construction, and maintenance
- Introduction of specific design and construction standards for green roads
- Research and design in low-carbon technology and carbon emission management by both public and private sector

Major stakeholders

- Ministry of Land, Infrastructure and Transport
- Korea Expressway Corporation (EX)
- Private companies (Conglomerates)



1-3. Road Standards

“The Road Act”

- The paramount law for roads, developed by the MOLIT
- Contains details on road network planning, route selection, construction, facility standard, operation and maintenance, and cost management
- Under the Road Act, there are 99 road construction regulations
 - 11 Upper technical standards: 4 enforcement rules, 7 design standards
 - 88 Lower standards: 1 explanation, 57 standards, 4 handbooks, 4 standard drawings, and 23 guidelines and manuals
- 7 grades of roads: National Expressway, National Highway, Special Metropolitan City Roads, Metropolitan City Roads, Local Highways, Si Roads, Gun Roads, and Gu Roads
- Korean Design Standard (KDS) 44 00 00
- Korean Construction Specification (KCS) 44 00 00

1-4. Environmentally Friendly Road Design Standard

Elements for Review

There are seven environmental elements that need to be reviewed during the preliminary and detailed design of roads:

- 1) **Topography and geology:** Conservation of topographic features and heritages
- 2) **Wildlife:** Conservation of plant species and wildlife movement
- 3) **Land use:** Consistency with superior policies and relevant plans and minimization of land used
- 4) **Air quality:** Installation of pollution reduction facility when necessary
- 5) **Water quality:** Minimization of impacts to water sources
- 6) **Noise and vibration:** Minimization of impacts on residents
- 7) **Landscape:** Conservation of national parks and conservation areas

1-5. Environmentally Friendly Road Construction Standard

1) Greenhouse Gas Reduction

- To accomplish NDC (Nationally Determined Contributions) of the Republic of Korea
- Management of monthly energy consumption data (Electricity, LNG, diesel, kerosene, gasoline) and site investigation of emission facilities

2) Construction Waste Management

- Mandatory regular reporting of the generation of construction wastes
- Waste treatment by consigned companies (storage of special wastes: combustibles and asphalt-concrete wastes)
- Mandatory use of recycled aggregates: At least 40% of total aggregates in road construction projects

1-5. Environmentally Friendly Road Construction Standard

3) Non-Point Source Pollution Reduction Facility

- Water treatment / pollution mitigation facilities for water source protection areas
- Designation of an inspector to actively monitor facilities
- Systemized operation and maintenance periodically

4) Environmental Impact Assessment during Operation

- Follow-up survey of environment impact during O&M stage
- Introduction of additional follow-up measures necessary to prevent further impacts to the environment

1-6. Policy Initiatives for Environmentally Friendly Roads

As a response to the **Paris Agreement** in the 21st UN Climate Change Conference (COP21), the Republic of Korea announced **‘Framework Act on Green Growth, Carbon Neutrality for Response to Climate Change’** in September 2021, specifying carbon neutrality as a national goal.

Republic of Korea’s 2030 NDC (National Determined Contribution) and 2050 Carbon Neutrality Scenario

- (2030 NDC) 40% Reduction of carbon emissions in relation to 2018
- (2050 Carbon neutrality) ‘Zero’ Domestic carbon emissions by 2050

1-6. Policy Initiatives for Environmentally Friendly Roads

Korea Expressway Corporation's carbon neutrality actions

- KEC formed a carbon neutrality committee and TF to prepare and implement carbon-neutral policies.
- According to their analysis, 80% of emission was generated from the construction of new expressways, 9.1% from service station operation, 7.2% from maintenance, 3.6% from tollgate and 0.1% from waste management.

Korea Expressway Corporation's 2050 Carbon Neutrality Strategy

Mandatory Reduction	Energy Independence	RE 100, carbon sink
	Green Infrastructure Transition	Efficient road management, KEC type EV 100
Social Reduction	People-oriented Carbon Reduction	Smart driving, C-ITS, carbon capture
	Low Carbon Technology	Recyclable materials, replacement of old materials

1-6. Policy Initiatives for Environmentally Friendly Roads

ESG Management of Korea Expressway Corporation

- **E** (Environment), **S** (Social responsibility), and **G** (governance: transparent & ethical management)
- Low carbon conversion scheme in the Life Cycle of Expressways
 - Long-life durable pavement, low carbon advanced material
 - Carbon sink
 - EV-100 (Environmentally friendly vehicles as business vehicles)
- Recharge carefree expressway
 - 60 new hydrogen charging stations and 1,200 electric charging stations
 - Nationwide charging network with a high-speed charging system
- Renewable energy portal
 - To advertise renewable energy projects and provide data to the public
- Issue of ESG Bond and ISO 50001 (EnMS: Energy Management System)

1-6. Policy Initiatives for Environmentally Friendly Roads

GreenRoads Certification System

- In the United States, GreenRoads certification system is adopted in several states including Washington State.
- KAIA's (Korea Agency for Infrastructure Technology Advancement) Carbon Neutral Road R&D Team set up the **Korean GreenRoads Certification System** based on the US example, where different criteria are evaluated such as pavement technology, carbon absorption, ecological relevance, recycling of resources, etc.



Grades	Points %	Points Per Stage	
		Construction (100)	Operation (150)
Certified	30-39.9	30-39.9	45-59.9
Silver	40-49.9	40-49.9	60-74.9
Gold	50-59.9	50-59.9	75-89.9
Evergreen	No less than 60	No less than 60	No less than 90

2. Disability Inclusive Infrastructure

2-1. Background

2-2. Barrier Free Certification System



2-1. Background

- In 2017, Korea Expressway Corporation inspected 186 expressway service stations and 1,488 disability infrastructures.
- As a result, it was decided that a total 498 of disability infrastructures were insufficient and required immediate upgrade.
- This is in line with the central government's national objective of 'Establishing an environment where disabled and non-disabled can live together.'



2-2. Barrier Free Certification System

- Based on the Act on the Guarantee of Convenience Promotion of Persons with Disabilities, Senior Citizens, Pregnant Women and Nursing Mothers, Article 10
- Supervised by the MOHW (Ministry of Health and Welfare and MOLIT)
- **Objective: to promote installation of standardized disability friendly infrastructure in all the Korea Expressway Corporation offices and service stations**
- KODDI (Korea Disabled People's Development Institute) and 7 other institutes are responsible for the certification

2-2. Barrier Free Certification System

Assessment criteria: total 5 sectors, 94 criteria

Category	Evaluation criteria
Access road	<ul style="list-style-type: none"> - Whether the access road separates pedestrians from vehicle traffic - Existence of steep slope and uneven floor - Slipperiness of the floor - Obstacles along the access road
Entrance/door	<ul style="list-style-type: none"> - No difference in floor level in/outside the door - Ratio of automatic doors (60% of doors get 3 points out of 3) - Existence of threshold (Points deducted if exists) - Width and actual range of the door
Toilet/sanitation facilities	<ul style="list-style-type: none"> - Should be placed on the first floor for better accessibility - Should be easily accessible with visible signs - Sufficient space for the pregnant women and nursing mothers
Rest room for pregnant women and nursing mothers	<ul style="list-style-type: none"> - Sufficient width of the entrance, no threshold, provision of electricity and comfortable chairs including space for wheelchairs - Sink with separate diaper deck

- Every criterion (94) should meet the minimum points, and if one or more is unsatisfactory, certification is not given.

Points (100)	Grade
90	Excellent
80-90	Good
70-80	Normal

2-2. Barrier Free Certification System

Expected Benefits of the certification system

- To reduce social costs and problems that may occur from inconveniences experienced by the disabled people
- To make infrastructure more accessible to the disabled and disadvantaged and to give them more opportunity in the society in general
- To generate project opportunity for local and small enterprises by introducing such investment schemes in local expressway service area infrastructure

3. Way Forward Inventories of Best Practices

- 3-1. Development of Green and Resilient Road Technology**
- 3-2. Planning and Design of Green and Resilient Road**
- 3-3. Construction of Green and Resilient Road**
- 3-4. Operation and Management of Green and Resilient Road**



3-1. Development of Green and Resilient Road Technology

Carbon neutral road R&D

- Carbon absorbing road construction materials
 - New materials with higher CO₂ capturing ability by activating industrial byproducts
 - Optimization of road construction materials (durability and efficiency)
- Resource-saving construction technology
 - Increased durability of recycled asphalt-concrete using WMA (warm mix asphalt) manufacturing technology
 - Special additive to restore viscosity of waste asphalt concrete
 - Room temperature recycling asphalt concrete
 - Development of design and construction standards that apply recycling asphalt concrete per each type of road

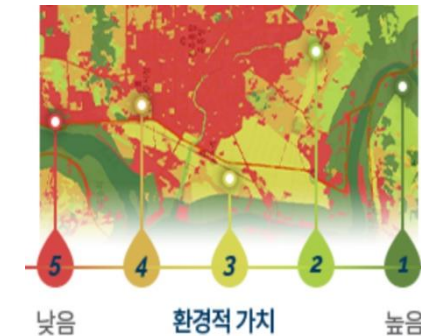
3-1. Development of Green and Resilient Road Technology

- Biopolymer concrete pavement material
 - Biopolymer resin for pavement
 - Development of materials for surface course and base course of biopolymer concrete
 - Quality management and construction technology for biopolymer concrete
- Soil improvement technology for low carbon pavement
 - Pavement base course material and standards for recycled aggregate
 - Carbon reducing bio-soil pavement technology
 - Optimized earthworks (cutting and banking)
- Road CO₂ absorption technology using biotechnology
 - Airborne CO₂ capture technology
 - Development of carbon absorption for bio road materials

3-2. Planning and Design of Green and Resilient Road

Ecological and environmental analysis

- Environmental conservation value assessment map
 - The map classifies the whole land area of the Republic of Korea into 5 grades (1-5) according to each area's environmental value per [Framework Act on Environmental Policy].
 - Areas with grades 1,2,3 and special wildlife protection districts, wildlife protection districts, wetland protection areas, etc. are to be avoided when selecting route alignment of roads.



3-2. Planning and Design of Green and Resilient Road

Minimization of environmental impact by alignment adjustment

- Earthworks such as cutting can significantly damage the natural environment. Adjustment of alignments with various alternatives to avoid such excessive earthworks, or installation of structures such as bridges, tunnels or retaining walls can reduce impacts.

Protection of wild animals and plants

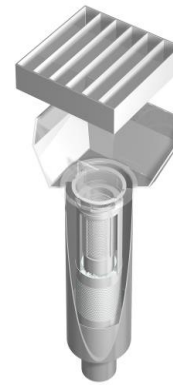
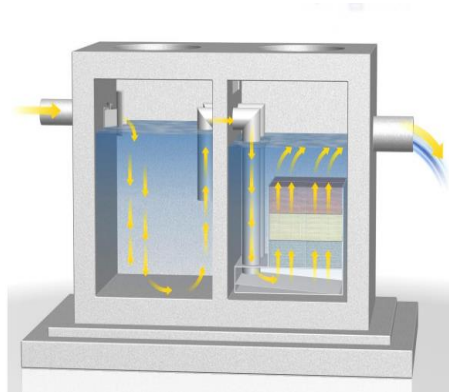
- Various structures such as wildlife fences and wildlife crossings are introduced to minimize impacts caused to flora and fauna.



3-2. Planning and Design of Green and Resilient Road

Prevention of water quality pollution

- Soil erosion at river crossing areas can cause water contamination.
- To protect water quality, settling ponds and non-point source pollution reduction facilities are provided.



3-3. Construction of Green and Resilient Road

Low carbon construction materials

- GBFS(Granulated Blast Furnace Slag) concrete
 - Compliance with mandatory use of recycled asphalt concrete material (from 25% to 50%)
 - Low carbon concrete – 50% cement content replaced by furnace slag powder (crushed powder form of GBFS, manufactured by spraying water onto high-temperature molten slag)

Ground
granulated
blast-furnace
slag for
concrete
(KS F 2563)

1. Reduced bleeding
2. Alkali aggregate reaction
3. Suppression of urea infiltration that accelerates concrete aging
4. Reduction of exothermic chemical reaction
5. Reduction of slump unit quality due to good workability
6. Enhanced durability by increase in long-term strength
7. High resistance to corrosion caused by chemicals such as acid, salt, anti-freezing admixture, etc.

3-3. Construction of Green and Resilient Road

- WMA pavement
 - Warm Mix Asphalt (WMA) pavement is a low energy-consuming pavement method where pavement production temperature is 30°C lower than the HMA, whilst maintaining a quality that is equal to or better than the hot-mix asphalt.
 - Low carbon WMA is for the surface course, intermediate course, and base course of the pavement.
 - Polyethylene wax-based additive is used for the low-carbon WMA production
- GFRP rebar
 - Glass Fiber Reinforced Polymer (GFRP) has a production cost that is 10% cheaper than that of rebar, being free of rust and corrosion. Its weight is also 1/4 of the normal rebar, with carbon emission from production being 40-50 % lower.

3-3. Construction of Green and Resilient Road

Low carbon pavement methods

- Long life composite pavement
 - Long-life composite pavement increases the life cycle of pavement from 20 years to 30 years, with reduced frequency of pavement renewal and carbon emission.
 - High-performance asphalt pavement on top of the highly durable concrete rigid base course
 - Impermeable intermediate layer to prevent deterioration of base course whilst enhancing adhesiveness of layers and continuously reinforced rigid base course to suppress reflective crack



Source: Hyungbae Kim, etc. (2022), Performance and LTPP Analysis of Composite Pavement Based on Long-term Life Cycles, International Journal of Highway Engineering Volume 24 No. 1

3-3. Construction of Green and Resilient Road

- **TiO₂ concrete method**
 - Photocatalytic concrete material (TiO₂) absorbs and removes nitrogen oxide, which is the main component of road transport pollutants.
 - TiO₂ can be applied to various road structures such as concrete median strips, concrete protection walls, and side ditch curbs)

- **Carbon-reducing soil pavement method using polymer concrete**
 - Soil pavement uses widely distributed soil and binder as main materials, and is used for pedestrian paths, cycle lanes, and parking lots
 - For binders, organic compound type polymer, ASP, or similar materials are used, and plaster and stabilizer are used when necessary
 - To overcome soil pavement disadvantages of low strength, high surface abrasion, and drying shrinkage cracks, organic mixtures or surface hardeners are used.

3-3. Construction of Green and Resilient Road

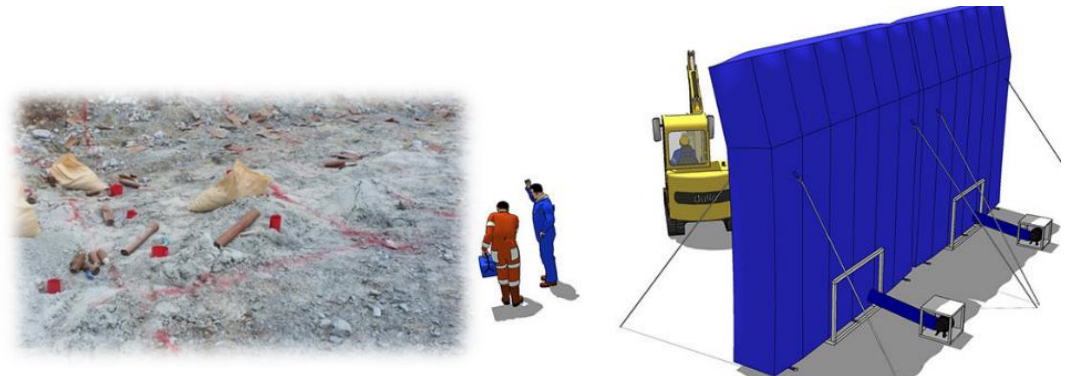
Construction management for green and resilient road

- Environmentally friendly heavy construction equipment
 - Conglomerates such as Hyundai Motors Group and Doosan Bobcat have introduced electric, hydrogen fuel cell, and lithium-ion battery-run construction equipment that can significantly reduce CO2 emission and energy costs.
 - Charging station that can fuel electric loaders and hydrogen vehicles at the same time is also developed.



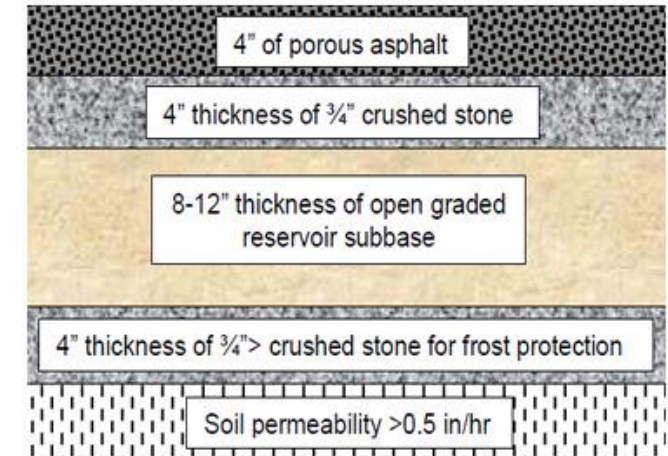
3-3. Construction of Green and Resilient Road

- Surveillance and monitoring system
 - Web cameras at construction sites are used for monitoring blind spots and to provide speedy responses to potential environmental impacts.
- Noise and vibration reduction facility
 - Controlled blasting significantly reduces the impact of blasting such as noise, vibration, and debris, whilst a soundproof mat installed near the site also reduces noise, reducing the chance of civil complaints being raised.
 - A residential environmental expert is deployed at the site to inspect and lead blasting and manage civil complaints



3-3. Construction of Green and Resilient Road

- Low-noise permeable and porous pavement
 - Permeable pavement has approximately five times more porosity than normal asphalt concrete pavement (4% compared to 20%).
 - Noise is reduced by over 3dB and noise generated by vehicle tires is absorbed.
- Diamond grinding
 - Longitudinal micro grooving of the pavement and surface flattening reduces noise and increases pavement life cycle by 14 years.







3-3. Construction of Green and Resilient Road

- Construction waste recovery and recycling of materials
 - Compliance with waste oil treatment by storing them at the designated site for recovery and treatment
 - Tree trunk disposal to reduce tree waste for crushing. Trunks are sold to lumber merchants, whereas roots and branches are crushed and processed as woodchips.
 - Autonomous production (crushing and grinding) of recycled aggregates from construction waste and recycling it as banking material
 - Installation of sludge drying facility (To keep water content below 70%) and mixing sludge with other banking materials



3-3. Construction of Green and Resilient Road

- Air quality impact reducing facility
 - Installation of dust net and dust suppressant to prevent fugitive dust generated from heavy equipment and earthwork to affect the surrounding environment
 - Use of environmentally friendly dust suppressant and biodegradable(water soluble) materials
 - Installation of sprinklers and car and wheel washing facilities
 - Installation of particular matter LED signal and provision of site management plan per different signal levels

Signals		Levels ($\mu\text{g}/\text{m}^3$)		Site management plan
		PM 10	PM 2.5	
Good		0-30	0-15	Sprinkler truck operation (1-2 times/day)
Normal		31-80	16-35	Sprinkler truck operation (1-2 times/day)
Bad		81-150	36-75	Increased sprinkler truck / dust masks
Very bad		151≤	76≤	Speed limits and checking of truck covers

3-4. Operation and Management of Green and Resilient Road

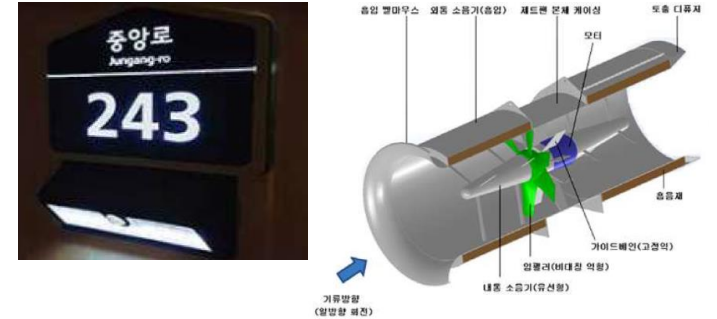
- **Post-Environmental Impact Assessment**
 - Post-Environmental Impact Assessment is carried out quarterly after the construction of the road
 - It inspects and analyses how insufficiencies can be met with countermeasures and training of management staff.
 - 52 environmental components such as air quality, surface water quality, sewage treatment quality, noise and vibration, soil pollution, etc. are assessed.
- **Independent solar power plant**
 - Currently MOLIT uses 319 empty lands to operate a solar power plant (149 MW).
 - Korea Expressway Corporation also generates renewable energy and aims to use it independently from 2030.



3-4. Operation and Management of Green and Resilient Road

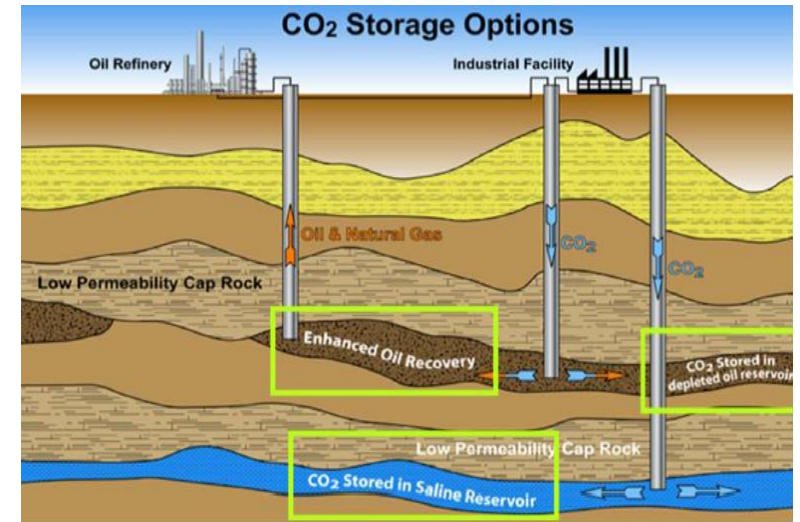
■ Power efficiency

- Replacement of existing road lights with LED smart lighting (power consumption reduced by 50%)
- New efficient road signs (power consumption reduced by 30%)
- Highly efficient jet fan for tunnels (as a small-scale wind power generator)



■ CCUS (Carbon Capture Utilization and Storage)

- CCUS separates and captures carbon from other gases generated by factories.
- Captured carbon is conveyed to depleted oil reservoir a few kilometers below the surface of the earth to enhance oil recovery



3-4. Operation and Management of Green and Resilient Road

- Carbon-neutral toll gate operation
 - Smart tolling system (Hi-Pass)
 - Increase of Hi-pass and smart tolling rate from 85% in 2022 to 92% in 2030
 - Multi-lane Hi-pass provides an increased speed limit with the same road width, to prevent congestion and deceleration, and acceleration of vehicles.
 - Smart tolling system is known to reduce around 43% of GHG emissions.



4. Conclusion



4. Conclusion

1. National Experience from the Republic of Korea

- In response to climate change and relevant policies, green and resilient expressway technologies have been developed and are being developed.

2. Disability Inclusive Infrastructure

- Korea Expressway Corporation is aware of the benefits of disability-inclusive infrastructure and has been working actively to maximize the benefits.

3. Way Forward Inventories of Best Practices

- Various technologies are being developed and adopted throughout the whole life-cycle of Asian Highways in Korea.

Thanks all!

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