
ORACLE

# USE OF UNDERGROUND SPACE IN SEOUL AND ITS FORESEEABLE FUTURE

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ESCO Consultant and Engineers Company
KOREA

WTC2012

# Contents


# Introduction

# Korea, no longer the land of morning calm

- The land of morning calm



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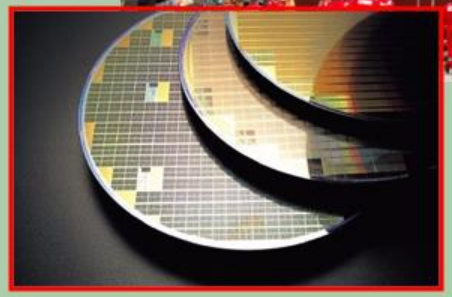
# Korea, no longer the land of morning calm

- The land of morning calm

- Dynamic KOREA

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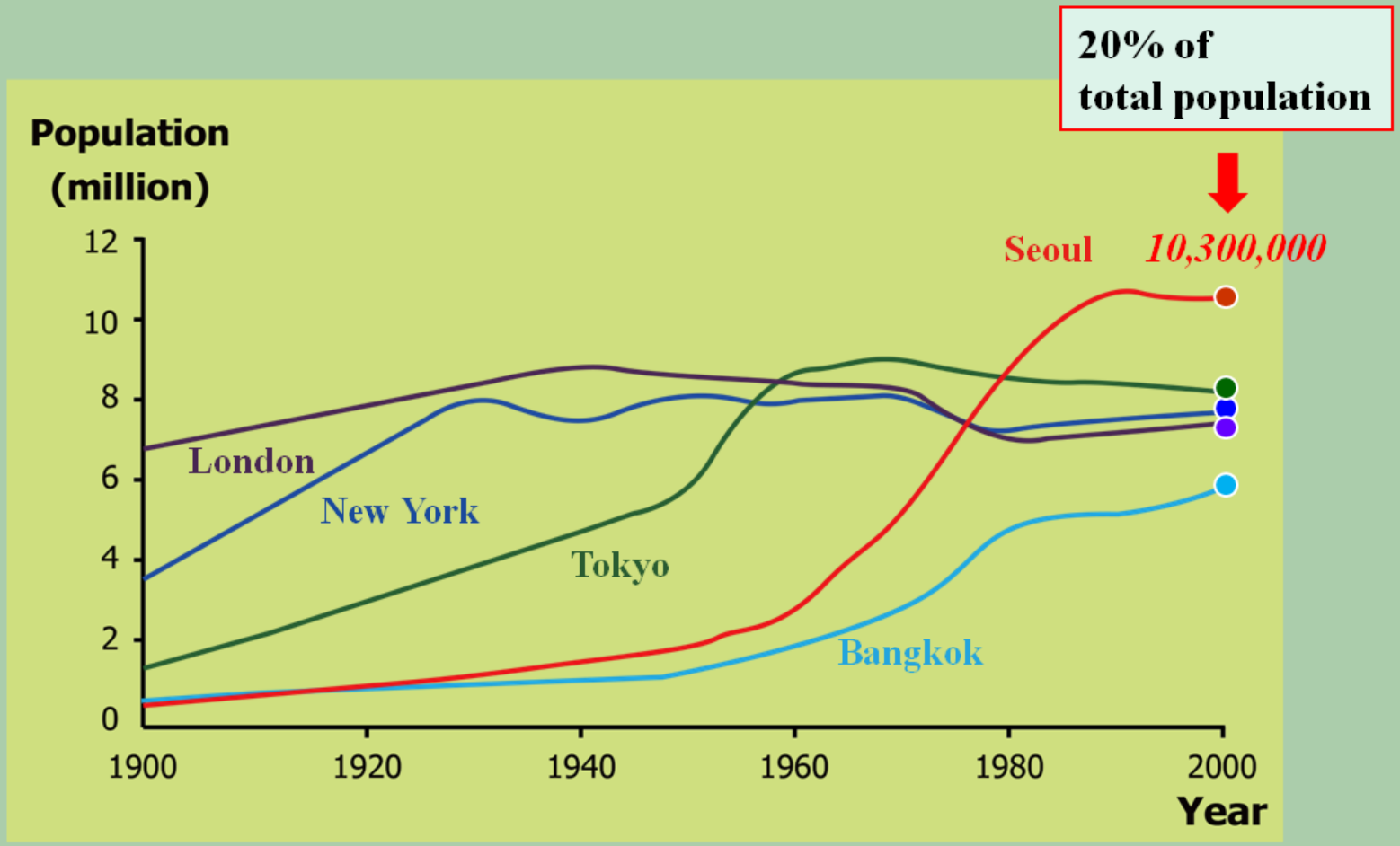
# Population growth in Seoul



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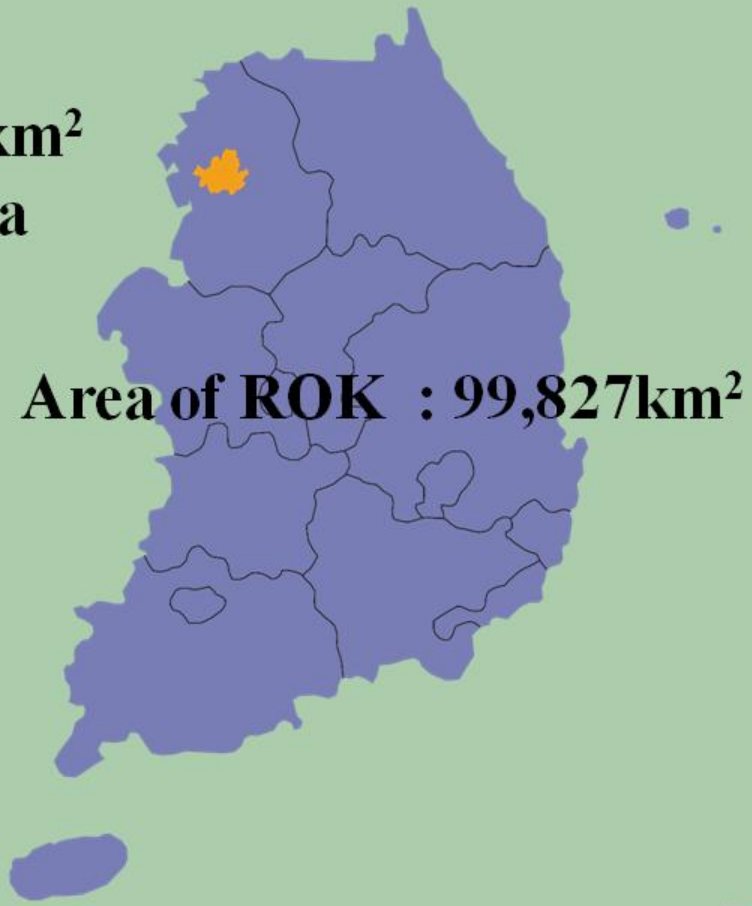
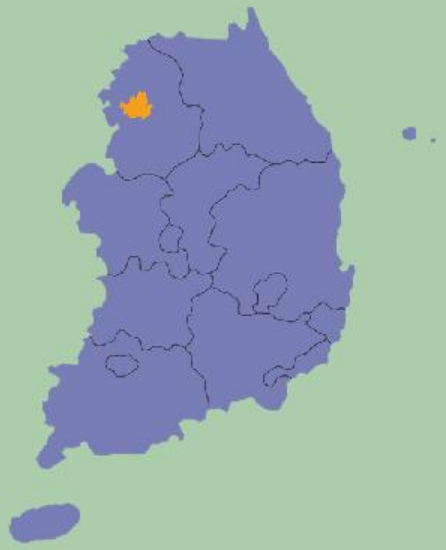
# Population density of Seoul

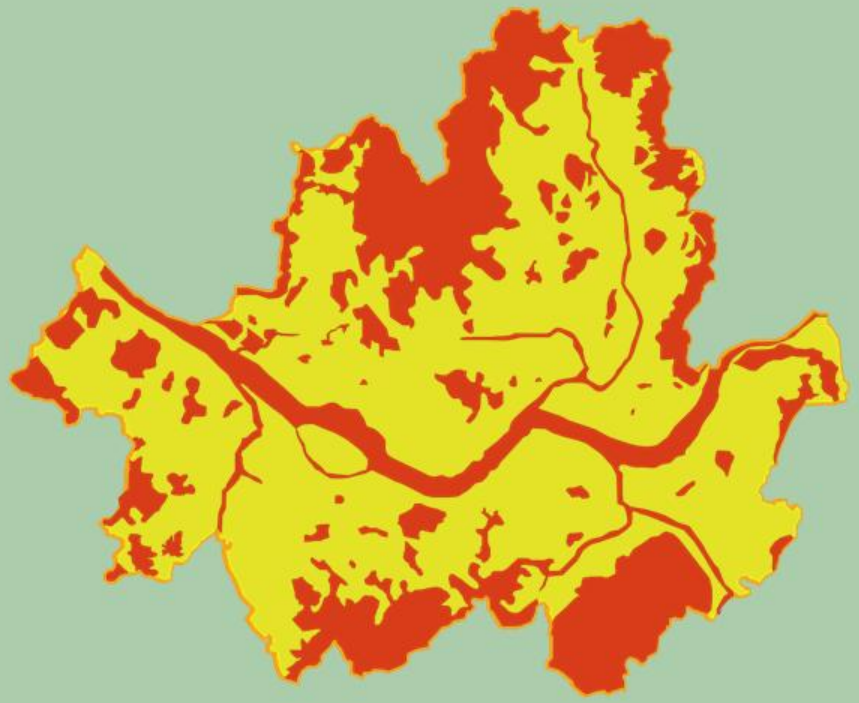
Area of Seoul : 605km²
→ 0.6% of total area



Area of ROK : 99,827km²

# Population density of Seoul



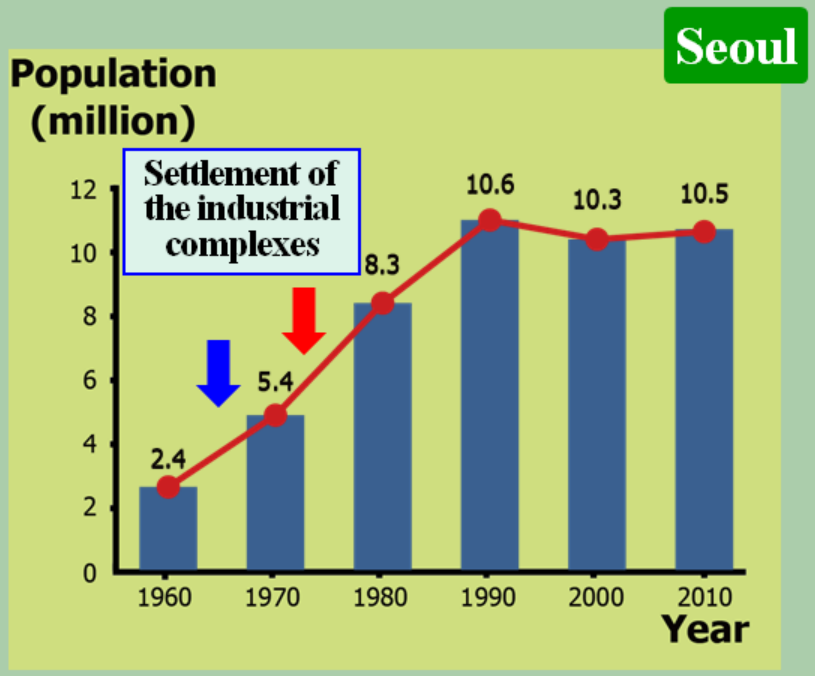


- **Population density : 27,548 persons/km²**

**non-residential areas (224km², 37%)**

**residential areas (381km², 63%)**

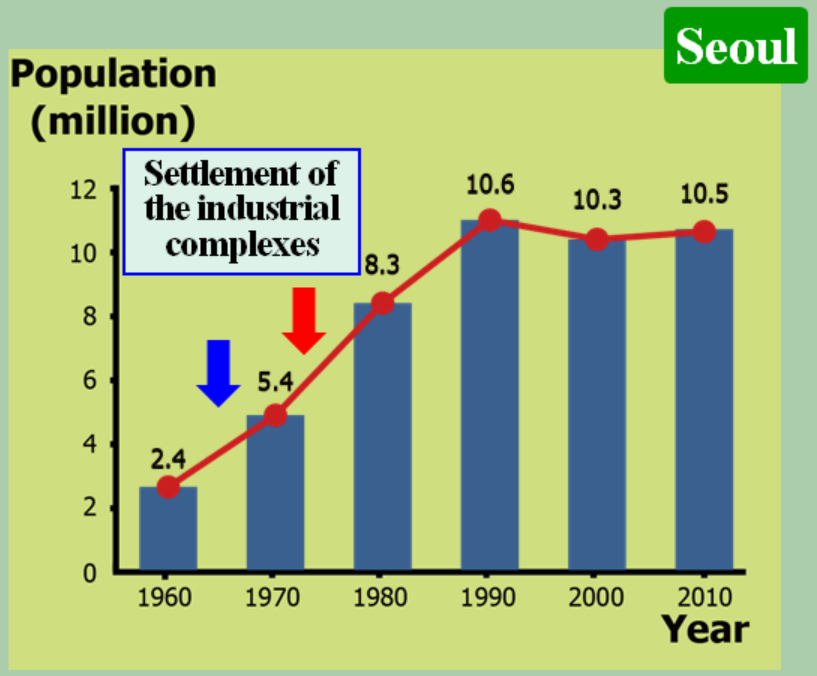
# Growth of population in Seoul and the economic growth of Korea

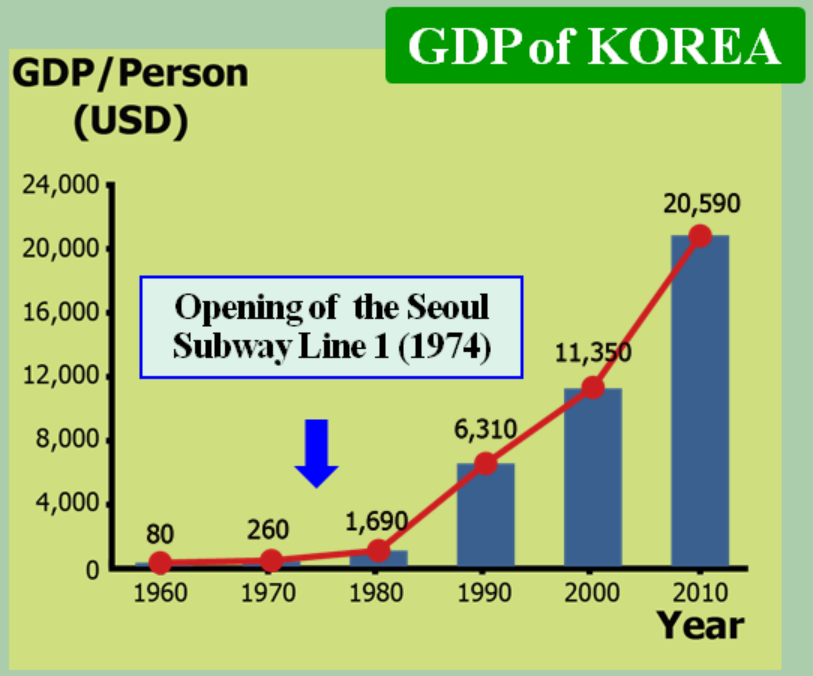



Guro industrial complex(1965)

Yeongdeungpo industrial complex(1973)

# Growth of population in Seoul and the economic growth of Korea



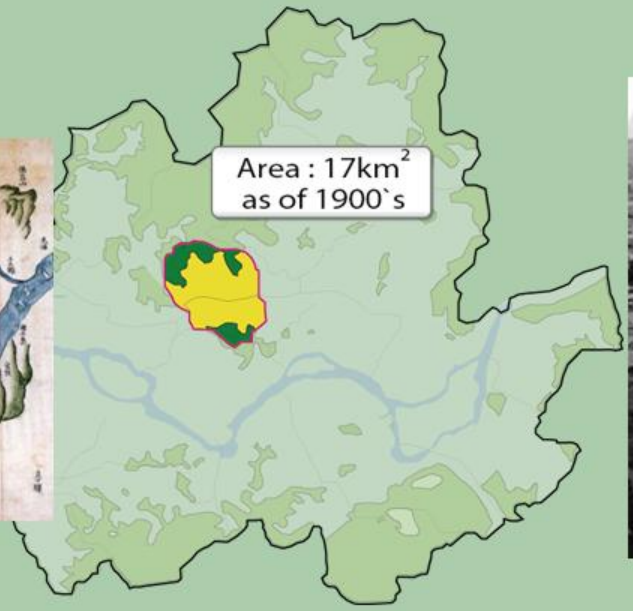

- Guro industrial complex(1965)
- Yeongdeungpo industrial complex(1973)

- GDP in 2011 : USD 23,800

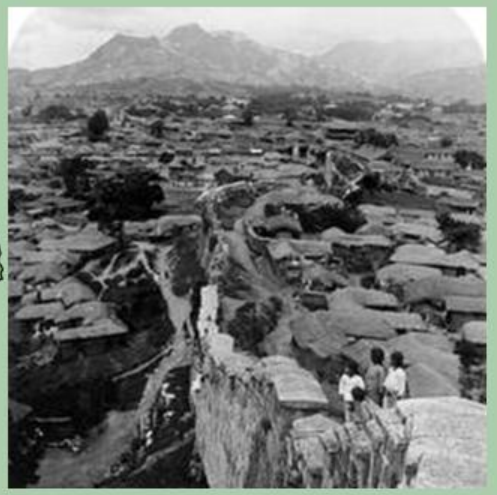
# Area expansion of Seoul(as of 1900s)

• Seoul boundaries, 1777

(Topographic map of Seoul)




• Seoul wall, 1880

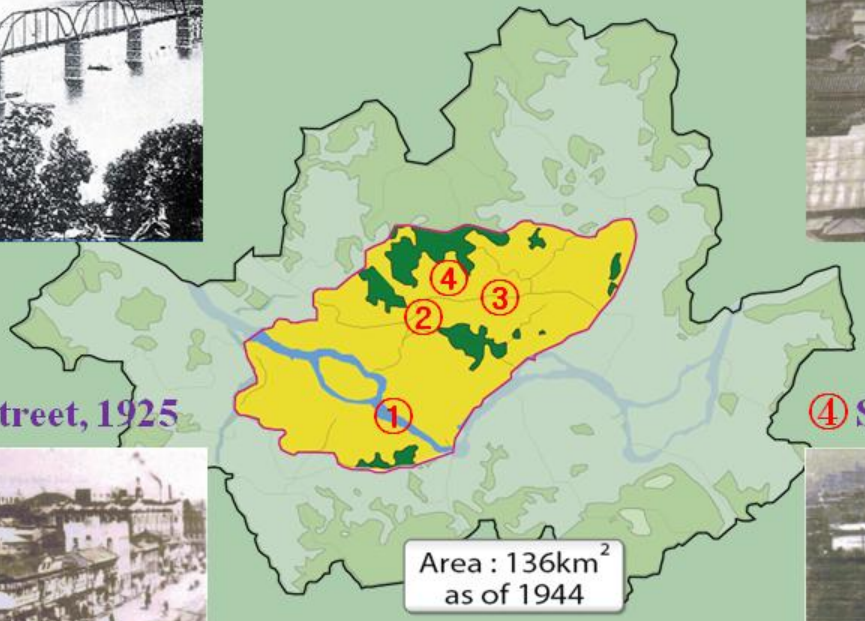


(Thatched roof houses)

# Area expansion of Seoul(as of 1944)

① Han River railway Br, 1920

③ Jong street, 1930




② Namdaemum street, 1925

④ Sejong street, 1935



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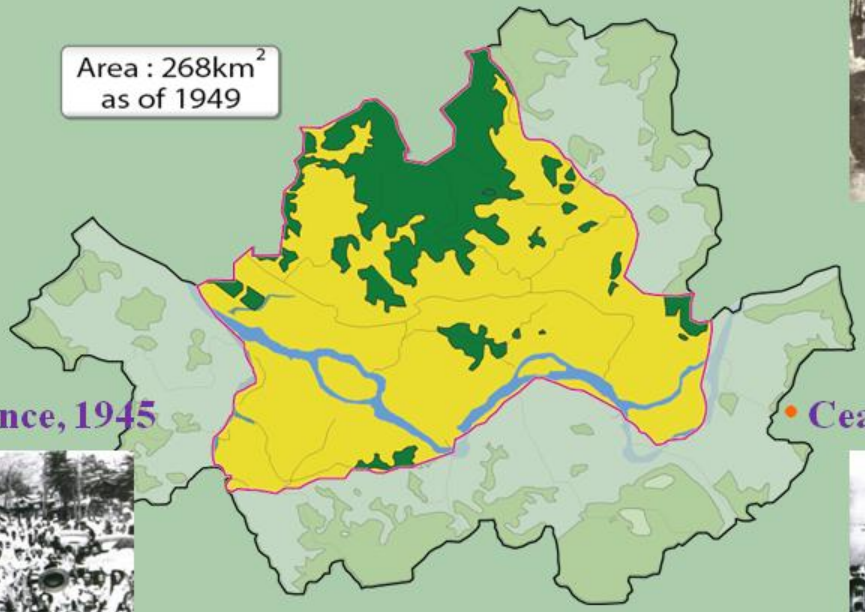
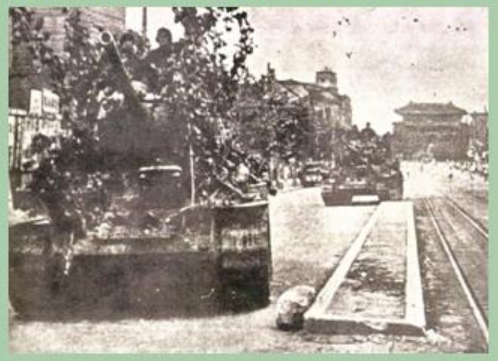
# Area expansion of Seoul(as of 1949)




- Outbreak of the Korean War, 1950



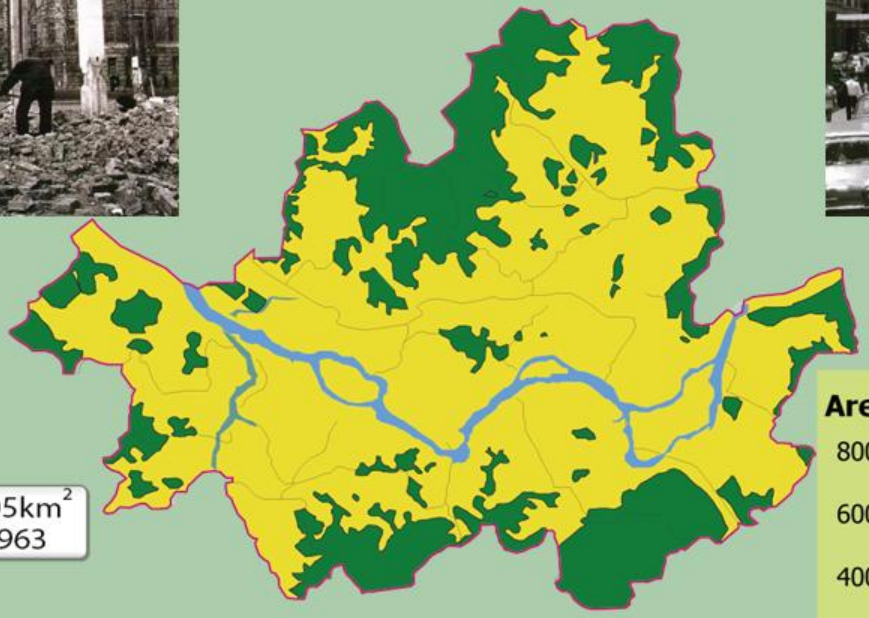
- The joy of independence, 1945

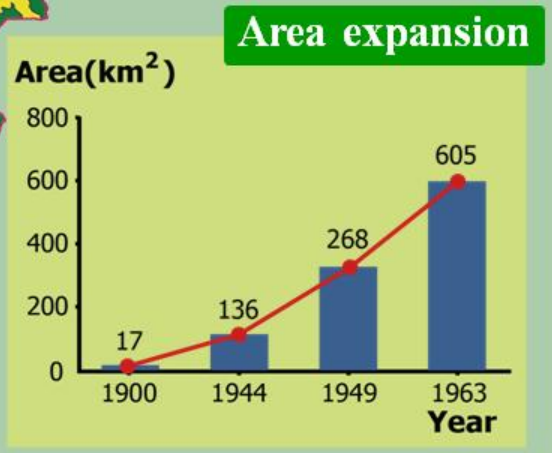
- Ceasefire of the Korean War, 1953

# Area expansion of Seoul(as of 1963)

- City Hall, 1955

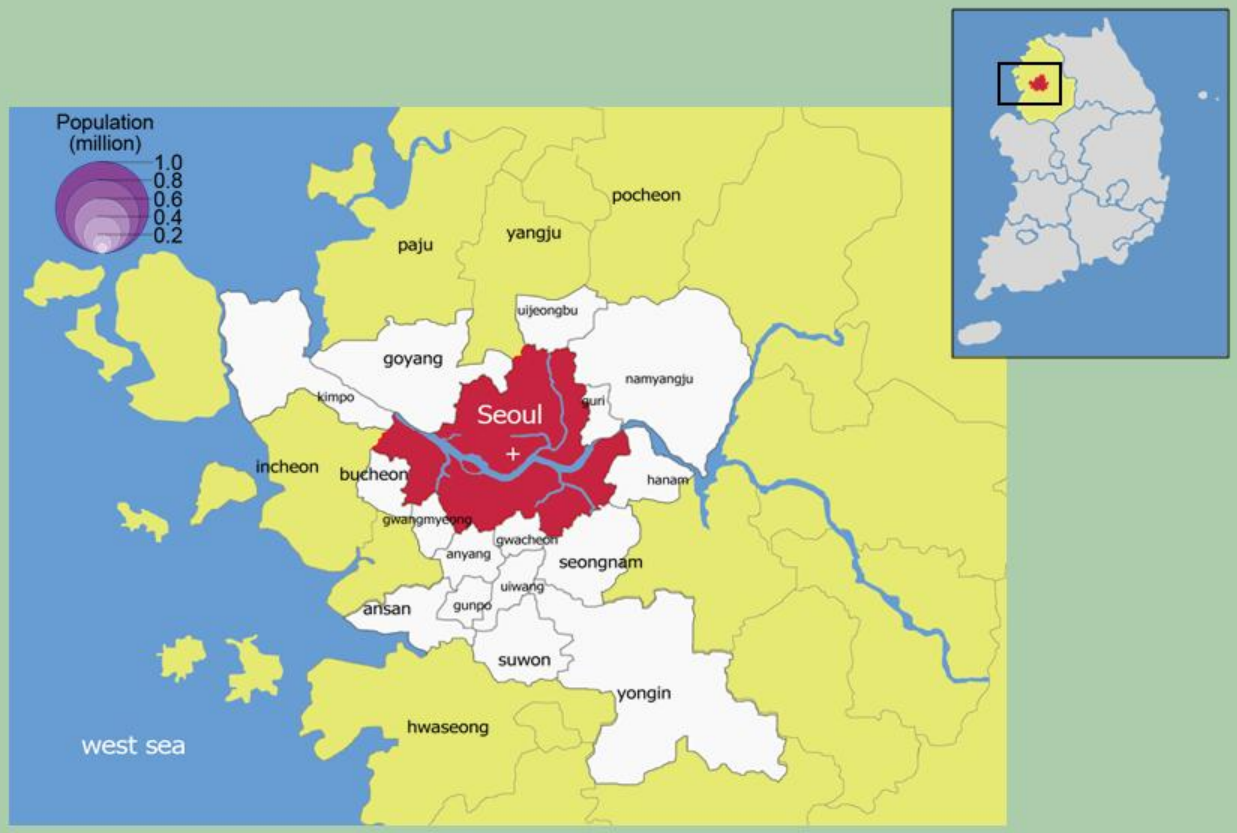
- Jong street, 1960




- 17km² (1900) → 605km²(1963) : 30 times in sixty years
- Population of Seoul in 1963 : 3,254,630 persons

# Number of inhabitants in Seoul conurbation



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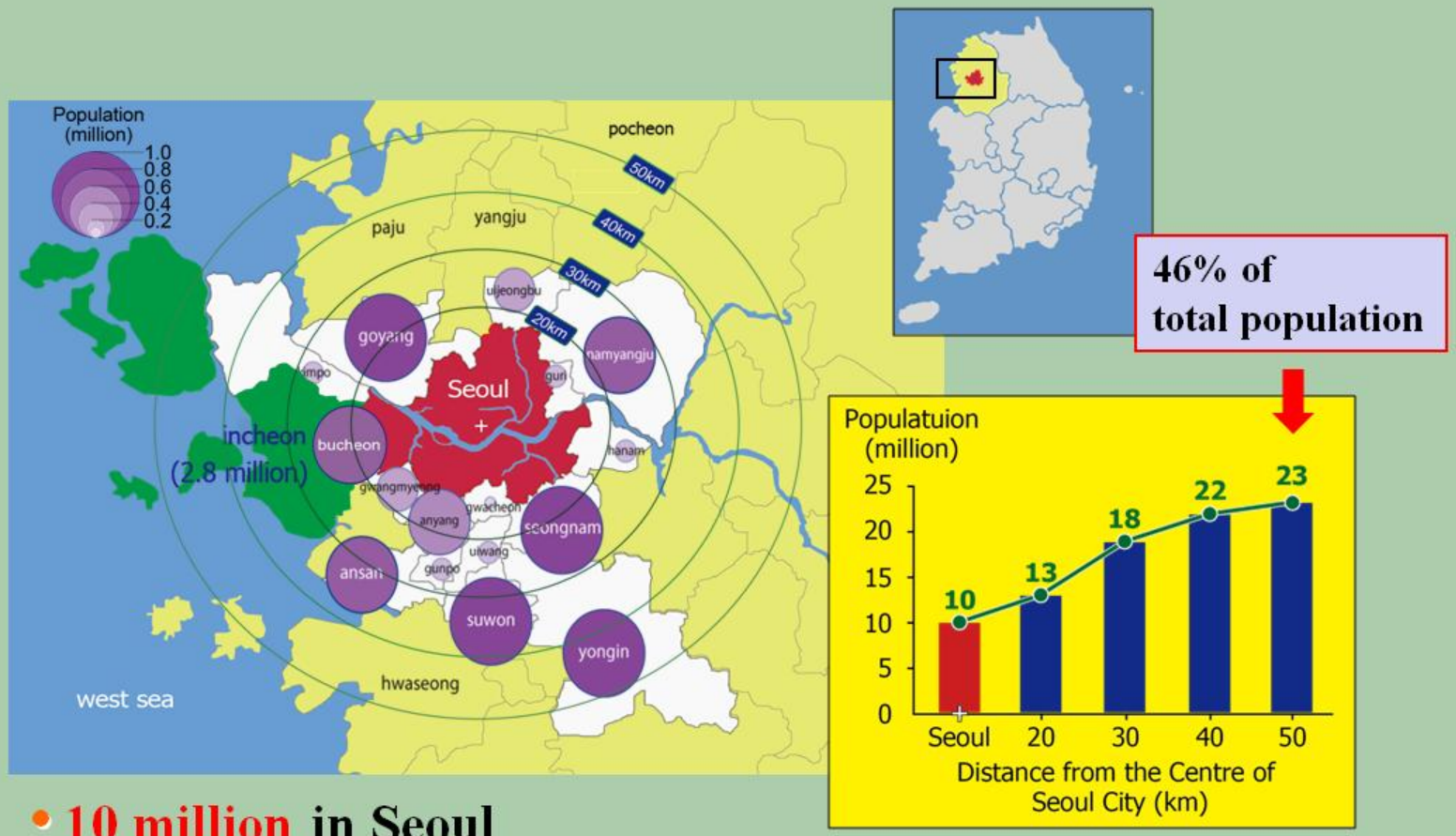
# Number of inhabitants in Seoul conurbation




- **10 million** in Seoul
  **13 million** in 16 satellite cities



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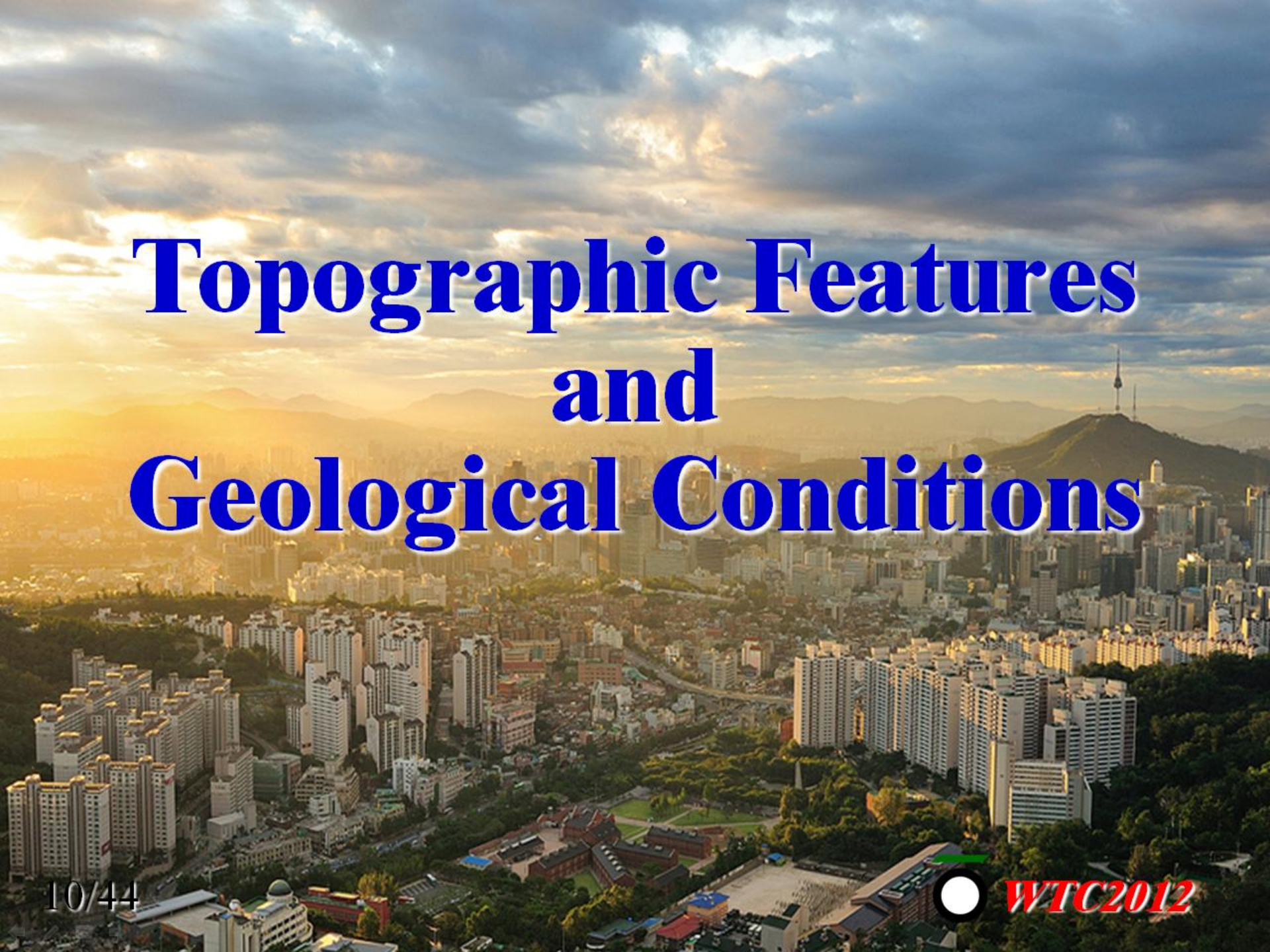
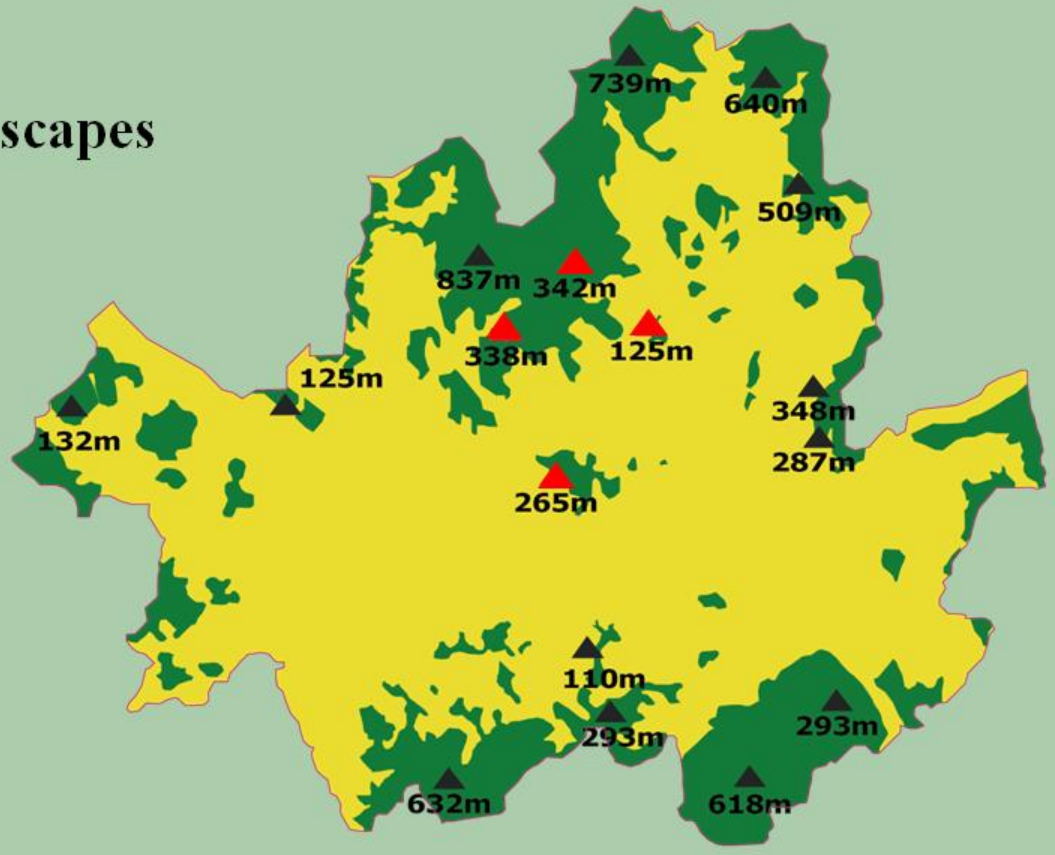

Topographic Features
and
Geological Conditions

# Mountains, hills and rivers within the city boundaries

- Hilly landscapes



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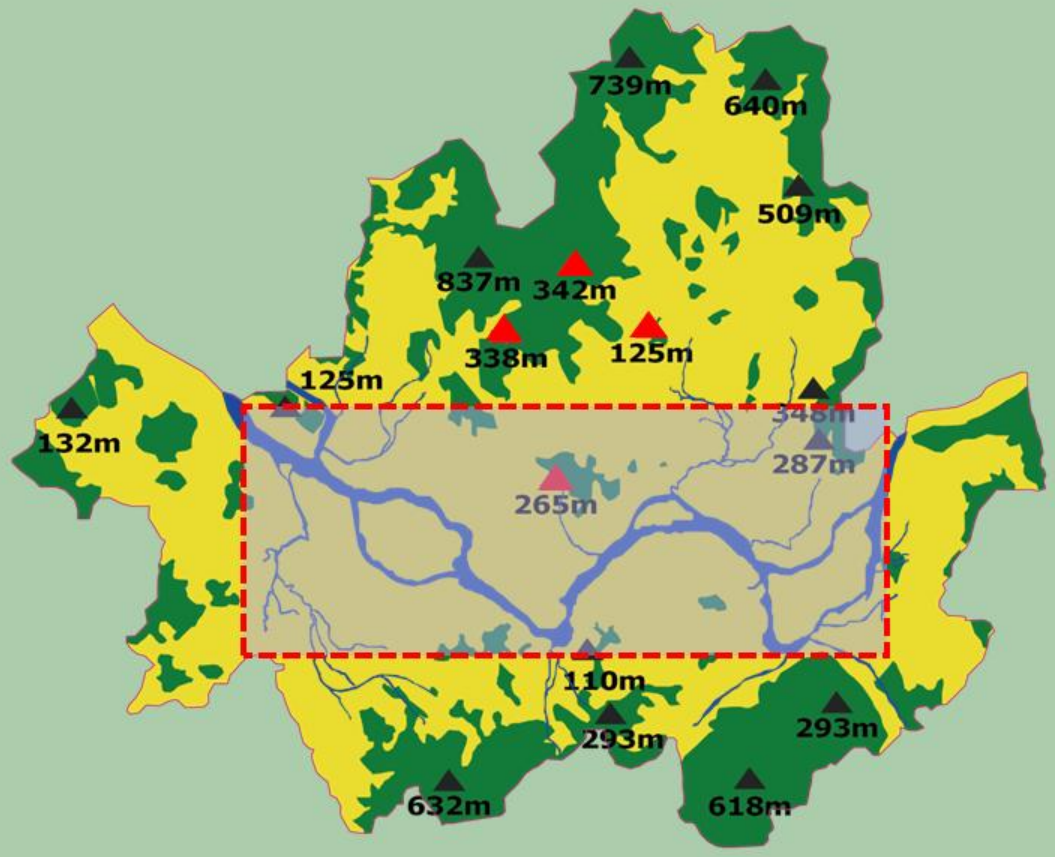
# Mountains, hills and rivers within the city boundaries

- Hilly landscapes


- Seoul area is divided into two parts by the Han River

# Mountains, hills and rivers within the city boundaries



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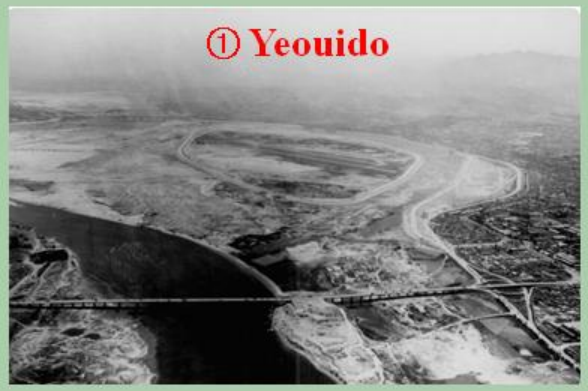
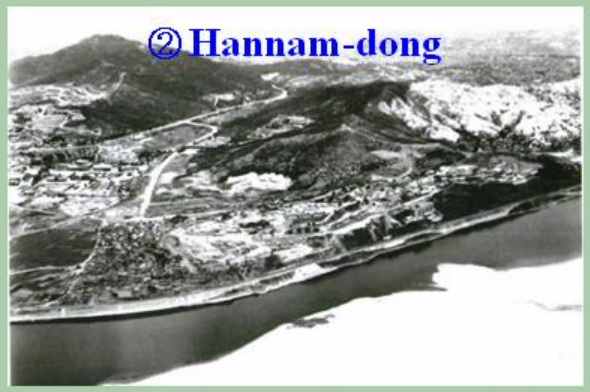
# Close-up view of waterway of Han River

## (1915, before development)

# Close-up view of waterway of Han River

## (1985, after development)

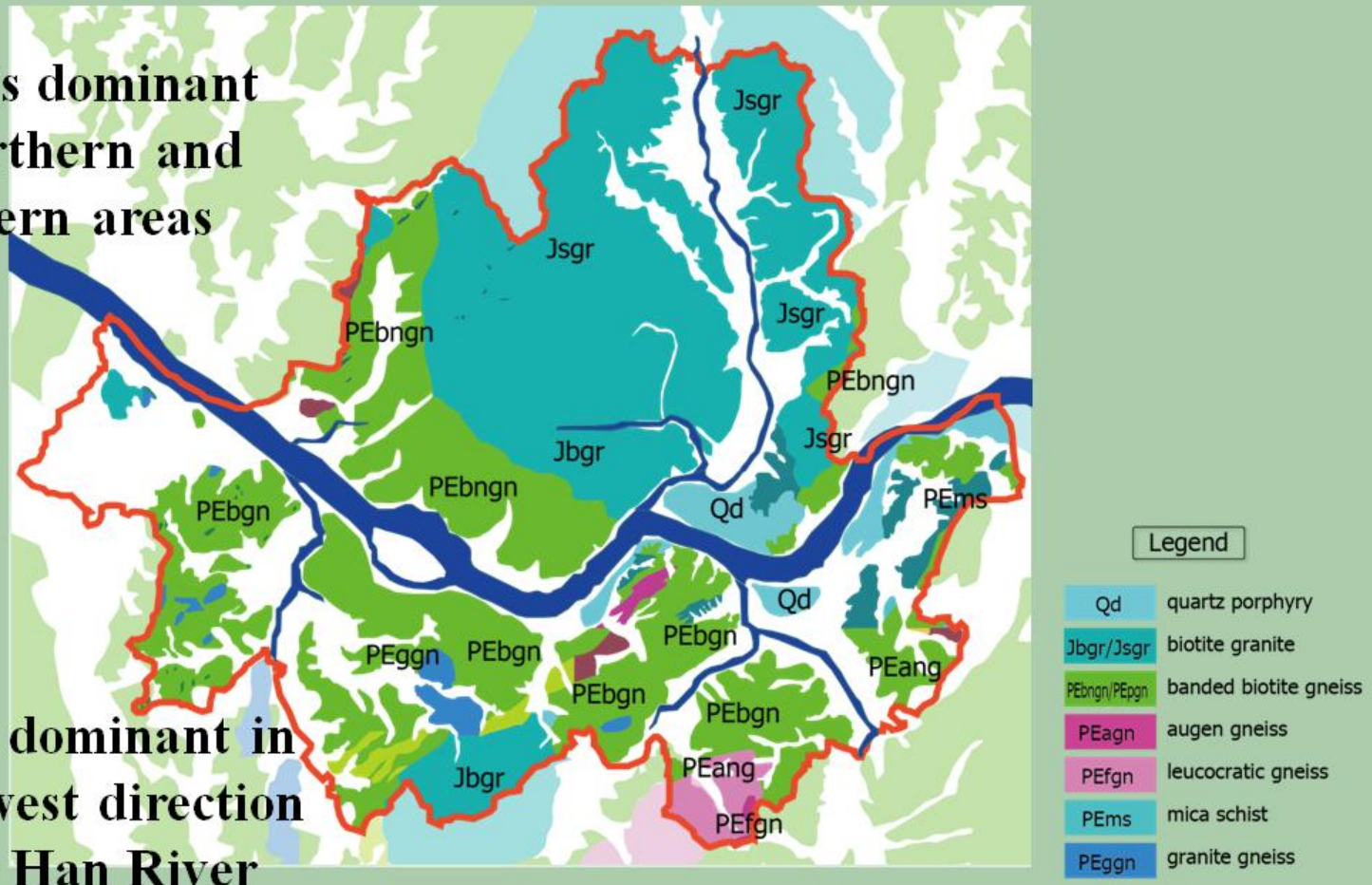


# Landscapes along the Han River

| | Yeouido area | Hannam-dong area |
|---|---|---|
| 1915 |  |  |
| 1985 |  |  |

# Bedrock formations

- Granite is dominant in the northern and the southern areas
- Gneiss is dominant in the east-west direction along the Han River

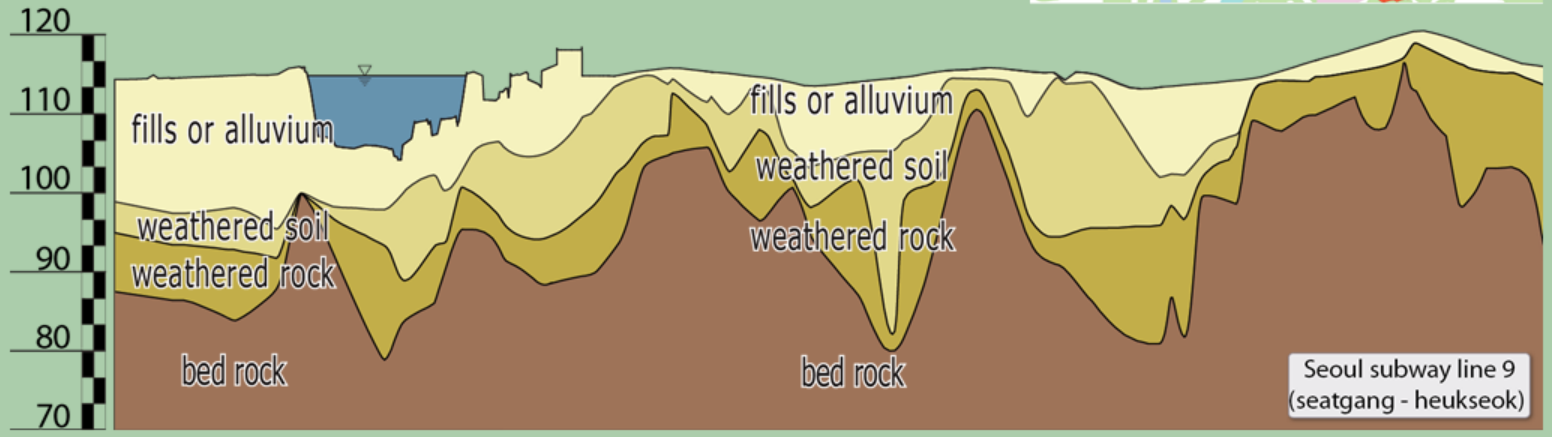


# Formations of sedimentary deposits

- Areas of the Han River and its tributaries are covered with the alluvial deposits

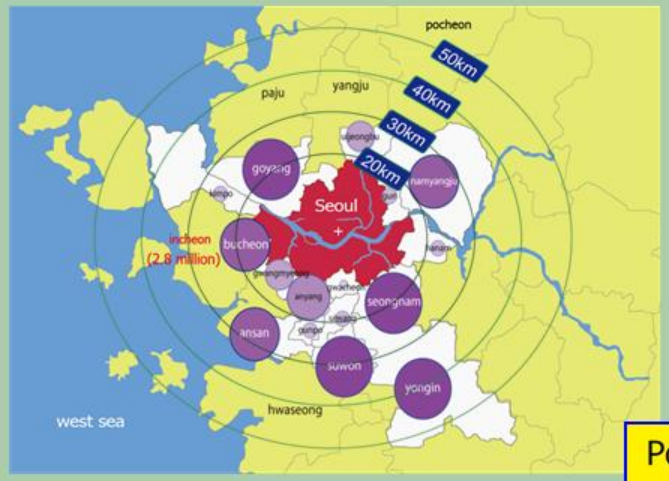
# Typical profiles of the subsurface

- **Bedrock formations are generally covered with weathered zones and fills or alluvium on top of them**



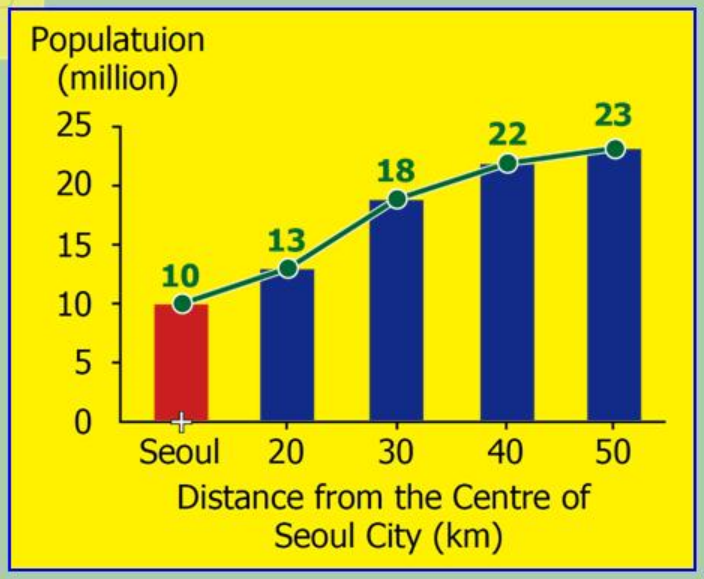

Statistics of
Underground Seoul

# Urban lives and transportation problems

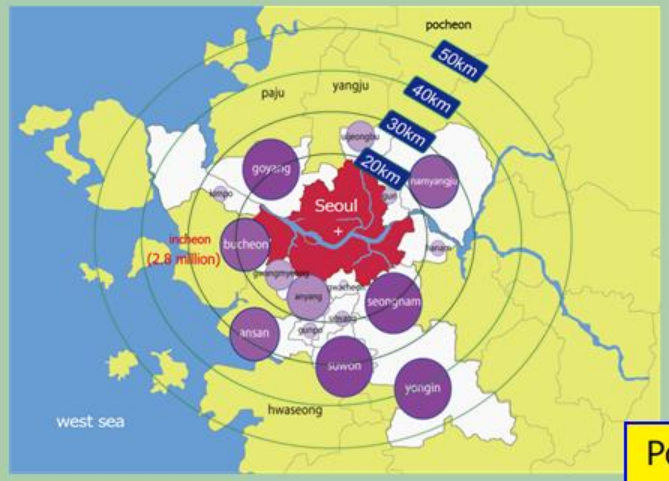



- Heavy concentration of the population in a small area

| Item | Population (million) | Proportion (%) |
|---|---|---|
| Total | 50 | 100 |
| Seoul | 10 | 20 |
| Seoul Conurbation | 23 | 46 |

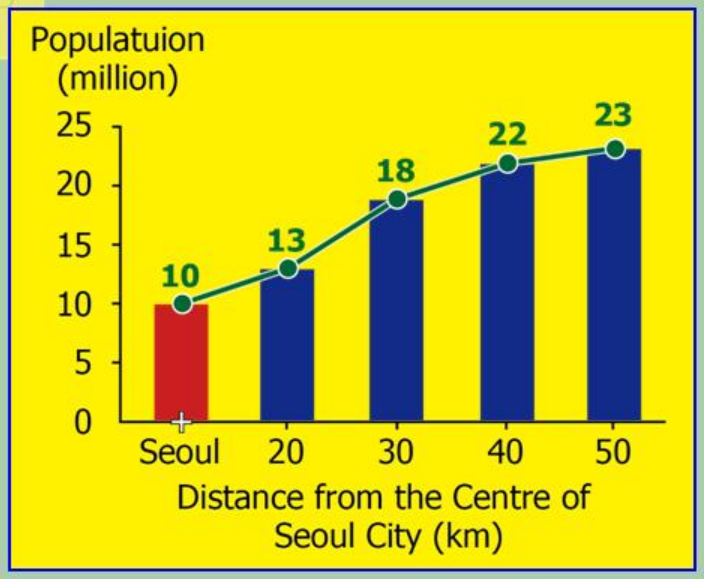


# Urban lives and transportation problems




Crowded people

Traffic congestion



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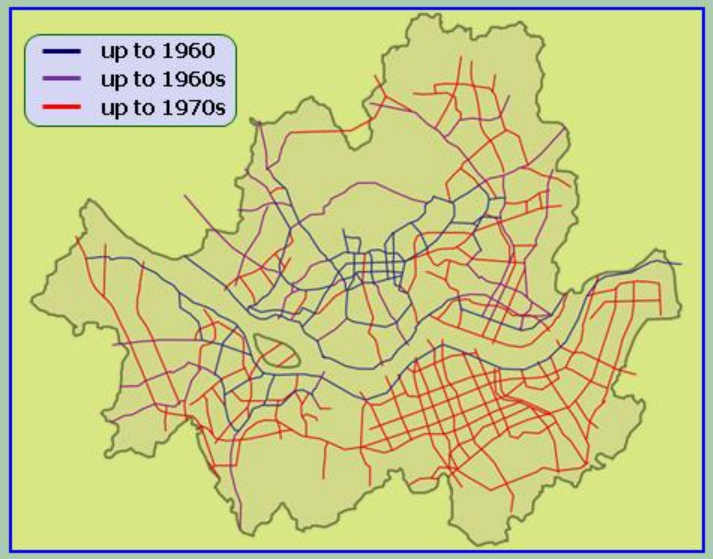
# Surface solutions for urban transportation problems




- Widening of existing roads and extension of road networks

(Covering work)

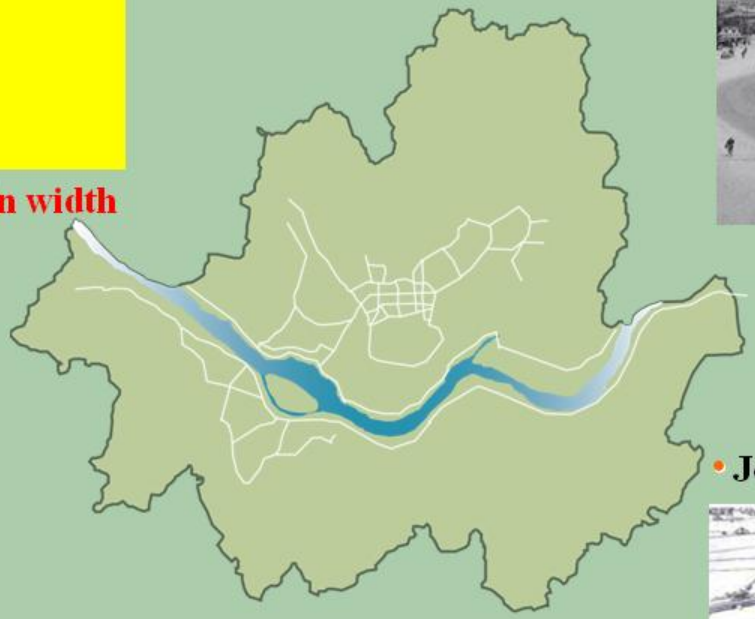
(Elevated road)

- New road construction above the stream

# Road networks(up to 1960)

| Item | Accumulated L(km) |
|---|---|
| up to 1960 | 1,337 |

◆ Roads wider than 4m in width



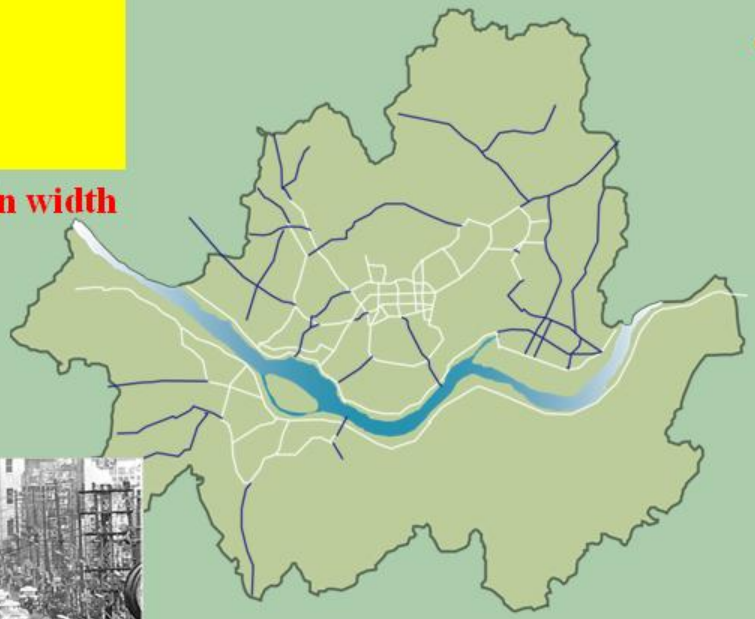
• Namdaemun(1910)

• Jong street(1959)

# Road networks(up to 1970)

| Item | Accumulated L(km) |
|---|---|
| up to 1960 | 1,337 |
| up to 1970 | 3,367 |

◆ Roads wider than 4m in width



• Gwanghwamun street(1965)

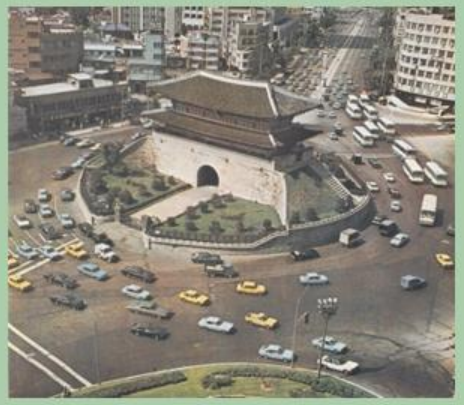
• Jong street(1963)

# Road networks(up to 1980)

| Item | Accumulated L(km) |
|---|---|
| up to 1960 | 1,337 |
| up to 1970 | 3,367 |
| up to 1980 | 6,556 |

◆ Roads wider than 4m in width

• Namdaemun (1974)

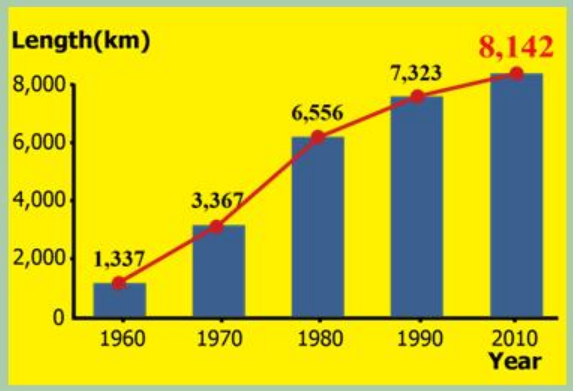


• City Hall(1979)

# Road networks(up to 2010)

| Item | Accumulated L(km) |
|---|---|
| up to 1960 | 1,337 |
| up to 1970 | 3,367 |
| up to 1980 | 6,556 |
| up to 2010 | 8,142 |

◆ Roads wider than 4m in width




• Namdaemun(2008)

• City Hall(2010)



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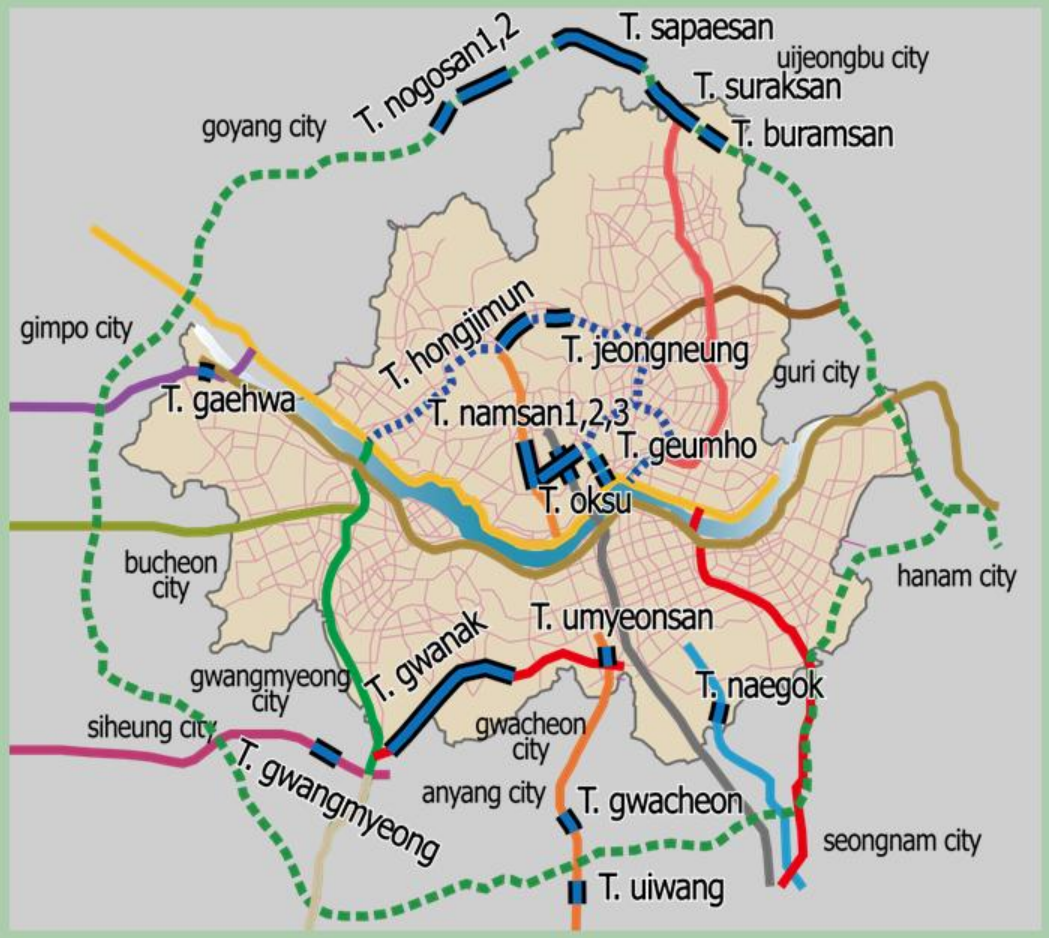
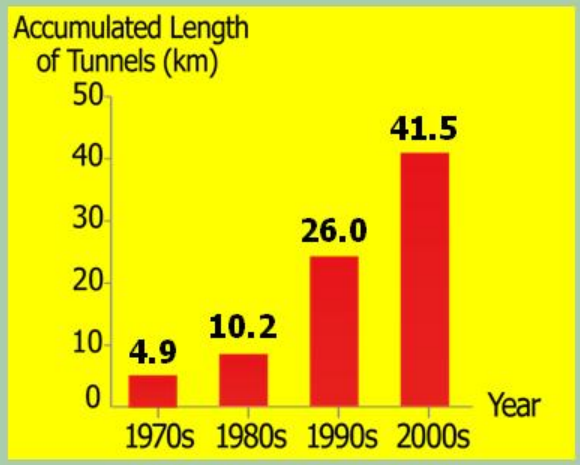
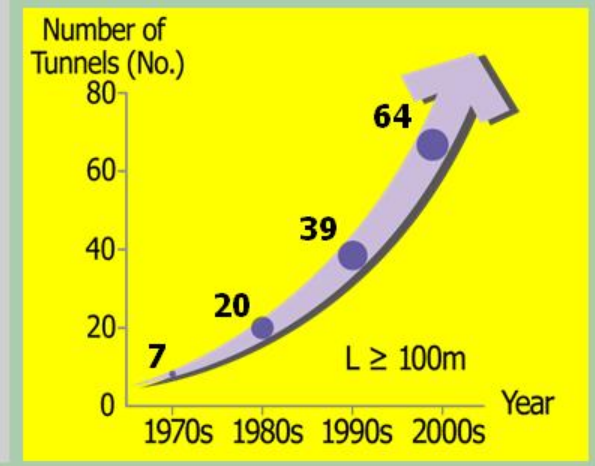
# Road tunnels in Seoul



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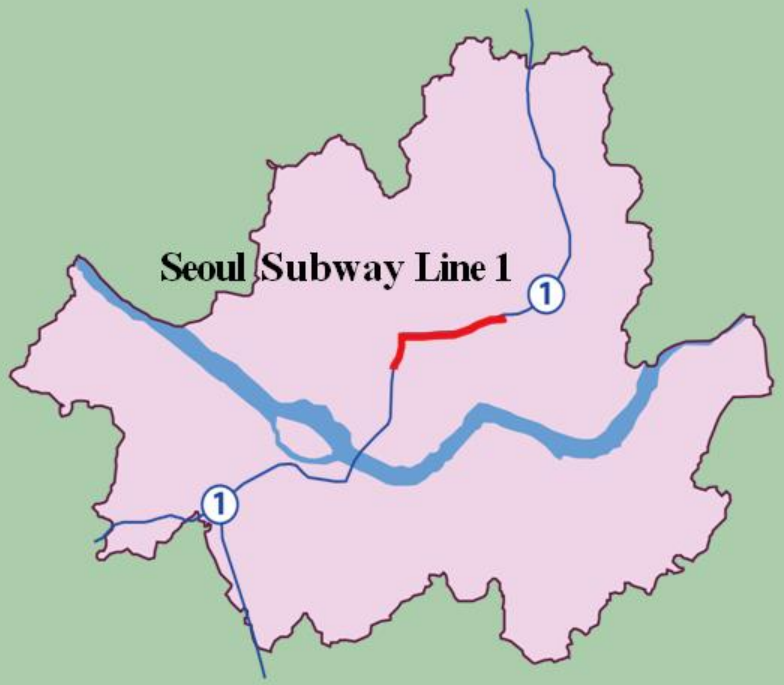
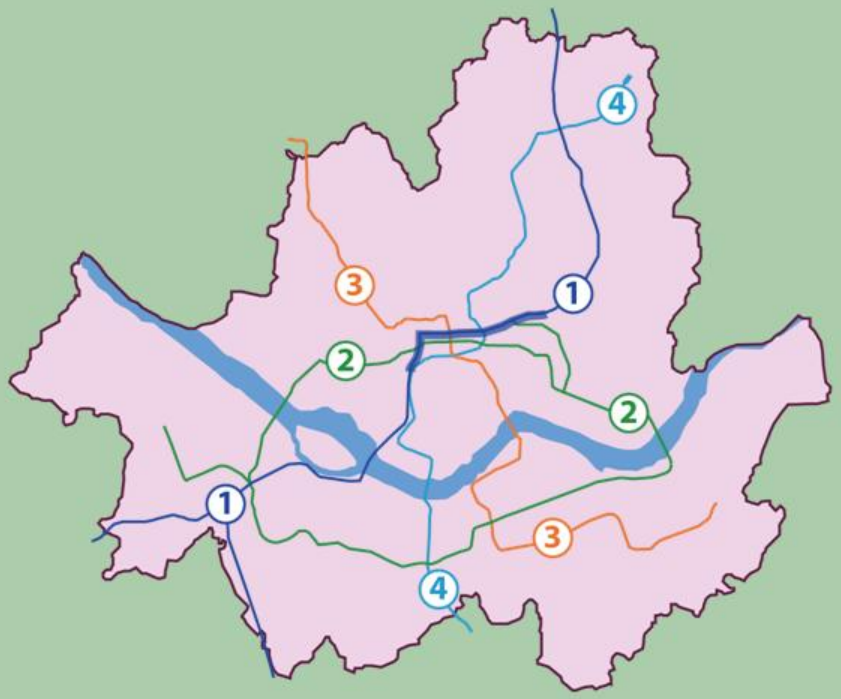
# Underground solutions for urban transportation problems



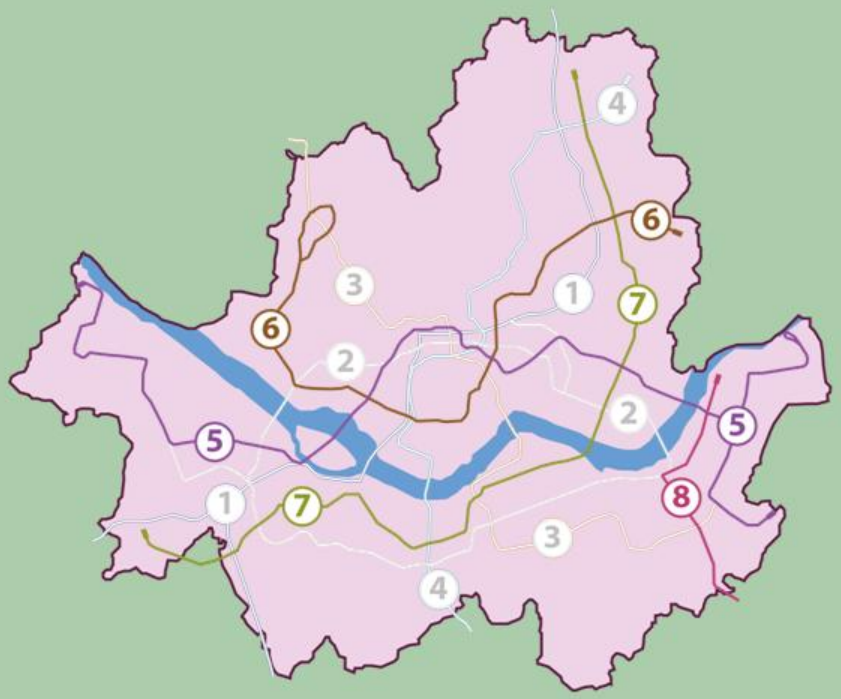

- Opening the era of underground space

# Phase I Seoul subway networks



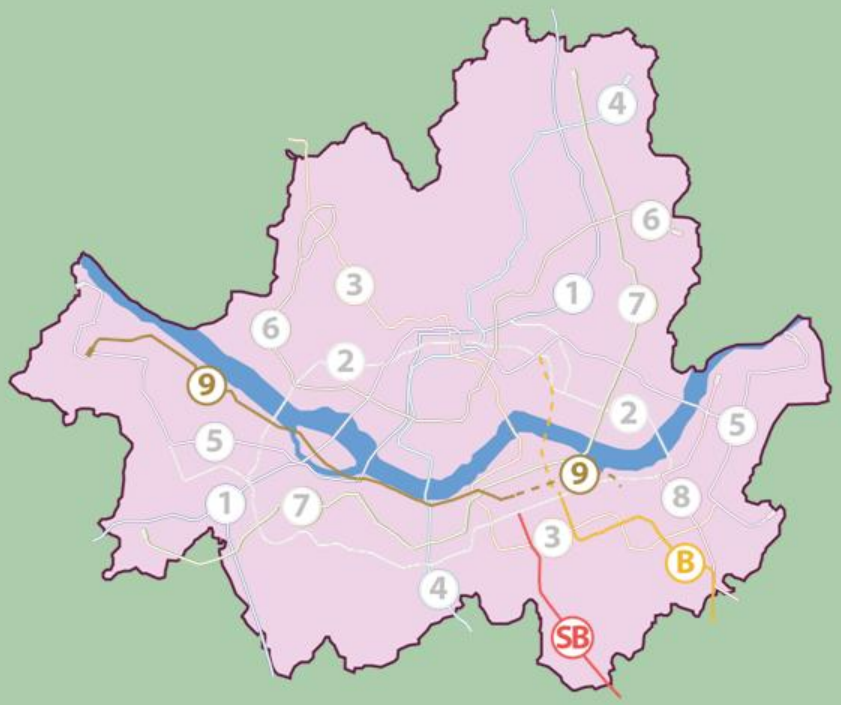

| Line No. | Construction Period (year) | Length (km) Total | Underground |
|---|---|---|---|
| 1 | 1971~1974 | 9.5 | 9.5 |
| 2 | 1978~1984 | 57.3 | 38.1 |
| 3 | 1980~1985 | 41.6 | 36.2 |
| 4 | 1980~1985 | 34.6 | 27.2 |
| | Subtotal | 143.0 | 111.0 |

# Phase II Seoul subway networks



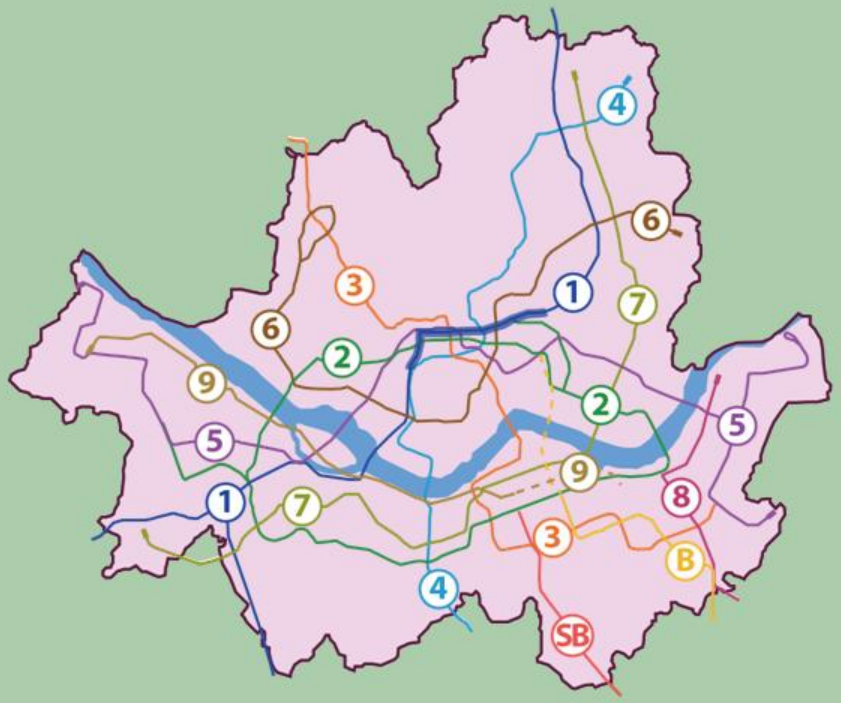

| Line No. | Construction Period (year) | Length (km) Total | Underground |
|---|---|---|---|
| ⑤ | 1990~1996 | 57.9 | 57.3 |
| ⑥ | 1994~2000 | 36.1 | 35.8 |
| ⑦ | 1990~2000 | 45.6 | 43.6 |
| ⑧ | 1990~1999 | 19.7 | 18.2 |
| | Subtotal | 159.3 | 154.9 |

# Phase Ⅲ Seoul subway networks

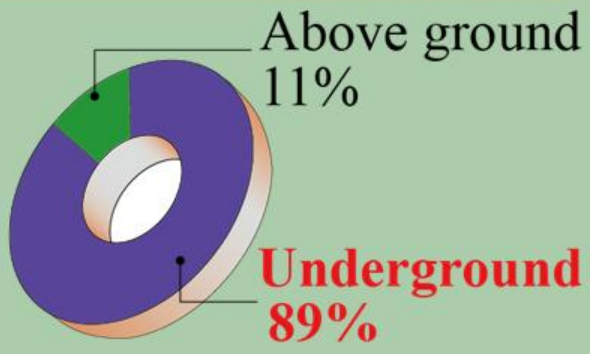



| Line No. | Construction Period (year) | Length (km) Total | Underground |
|---|---|---|---|
| 9 | 2002~2009 | 27.0 | 23.4 |
| | 2008~2013 | 4.5 | 4.5 |
| B | 1990~2010 | 9.8 | 9.8 |
| | 2008~2013 | 6.6 | 6.6 |
| SB | 2005~2011 | 9.1 | 9.1 |
| | Subtotal | 57.0 | 53.4 |

# Present Seoul subway networks

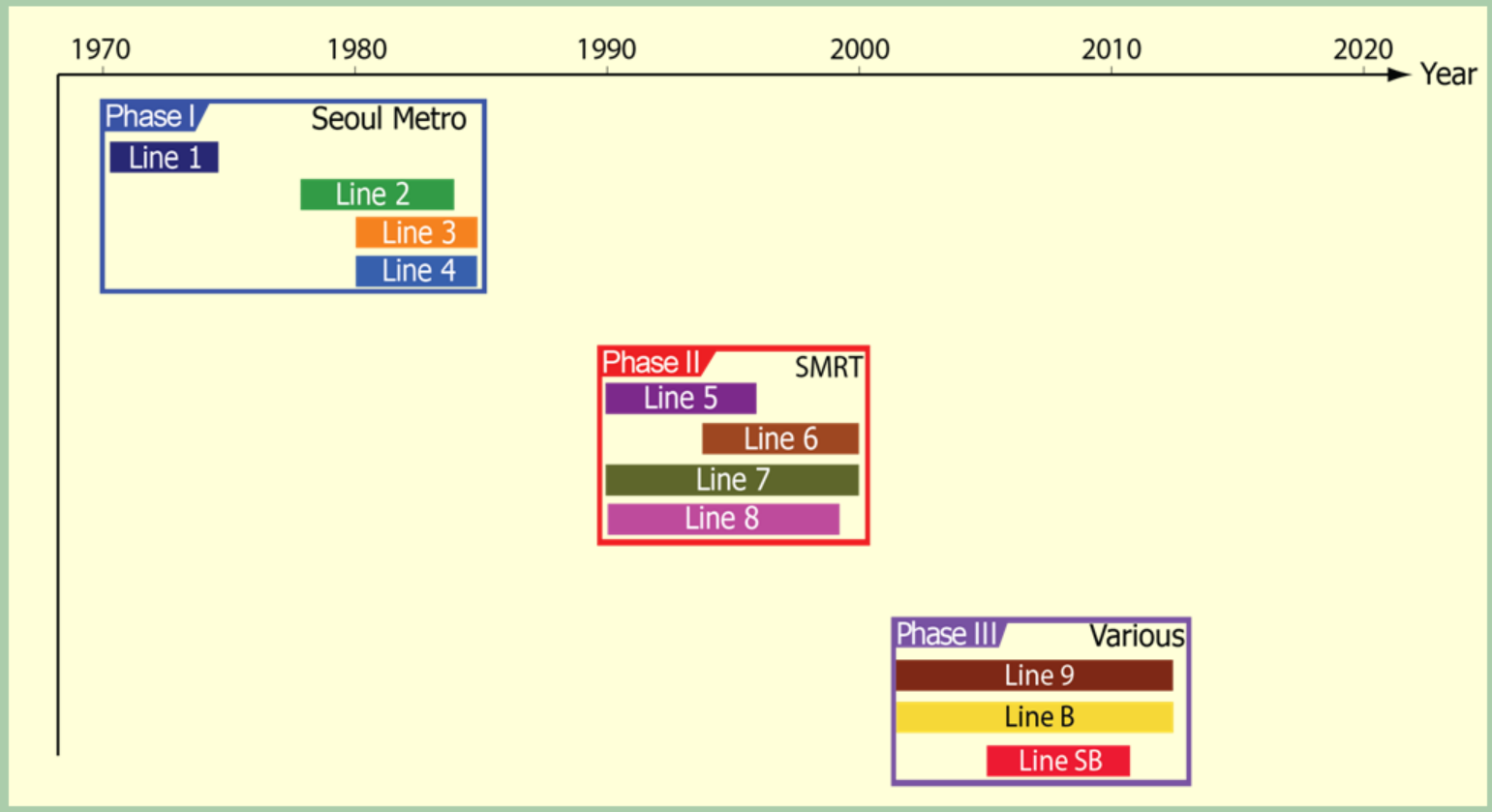



| Item | Length (km) | Percent (%) |
|---|---|---|
| Total | 359.3 | 100 |
| Underground | 319.3 | 89 |
| Above ground | 40.0 | 11 |




- Volume of underground space > 30,000,000 $m^3$

# Construction methods and cover depths of the Seoul subways



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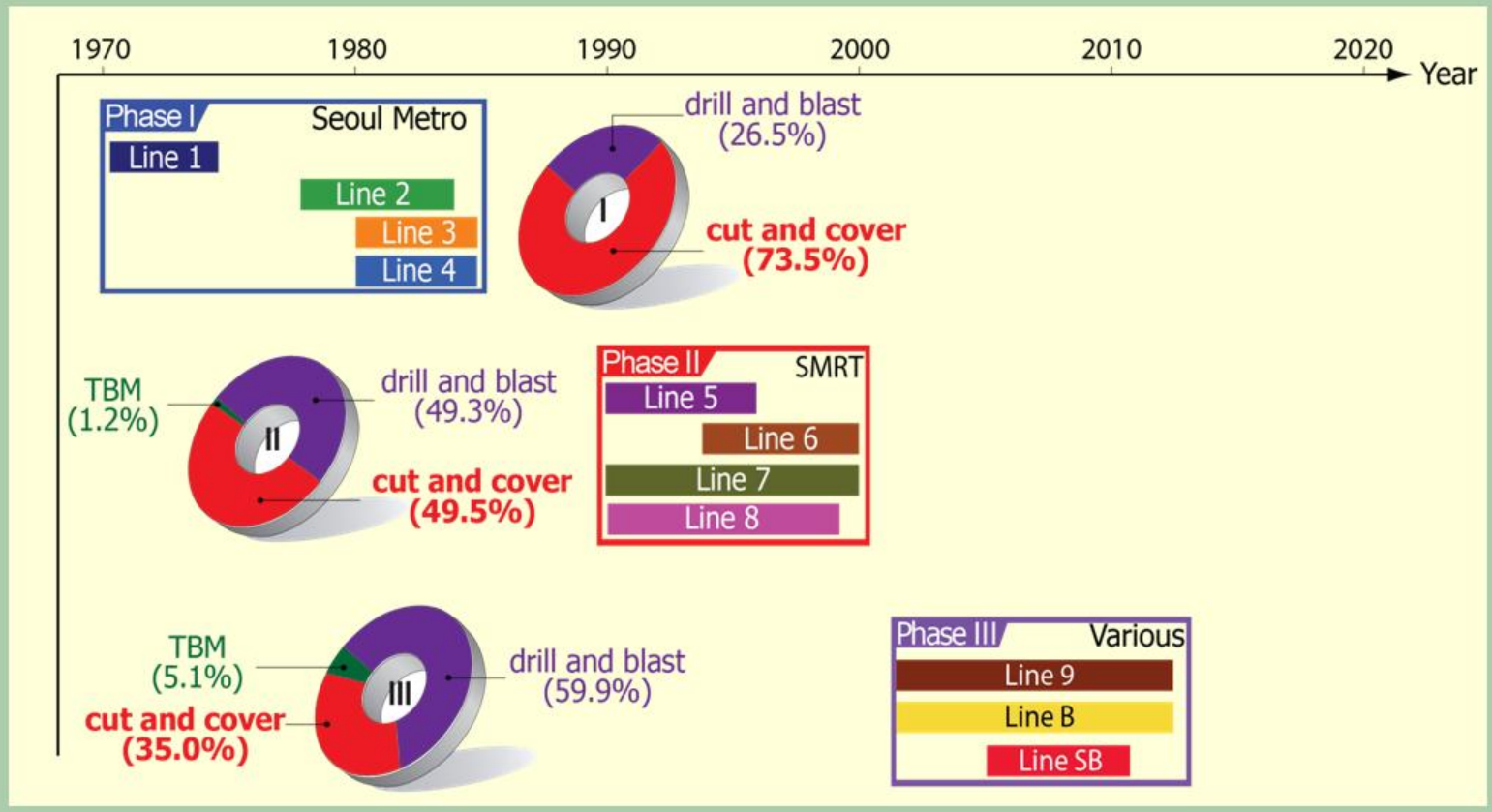
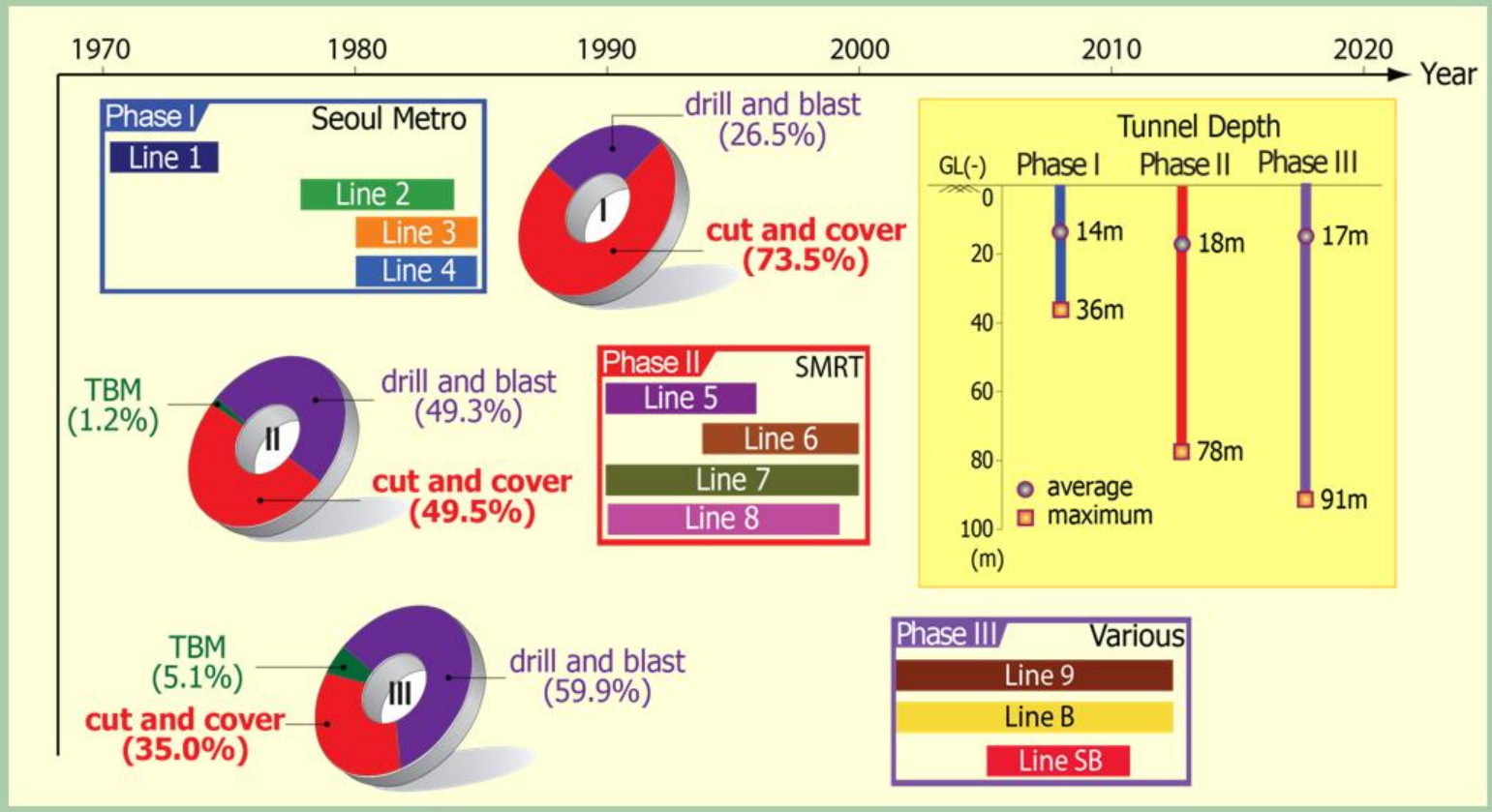
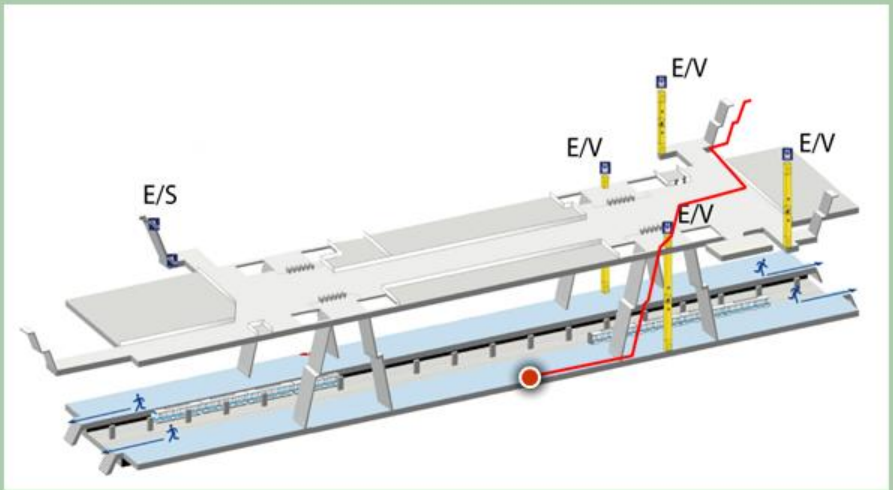


# Construction methods and cover depths of the Seoul subways



# Typical configurations of subway stations (Phase I )

- Major concerns : getting on or off functions
  simple and minimum space




# Typical configurations of subway stations (Phase Ⅱ&Ⅲ)

- Major concerns : multi-functional, comfortable convenient and easy access

# Typical configurations of subway stations (Phase Ⅱ&Ⅲ)

- Major concerns : multi-functional, comfortable convenient and easy access

Concourse

# Typical configurations of subway stations (Phase Ⅱ&Ⅲ)

- Major concerns : multi-functional, comfortable convenient and easy access

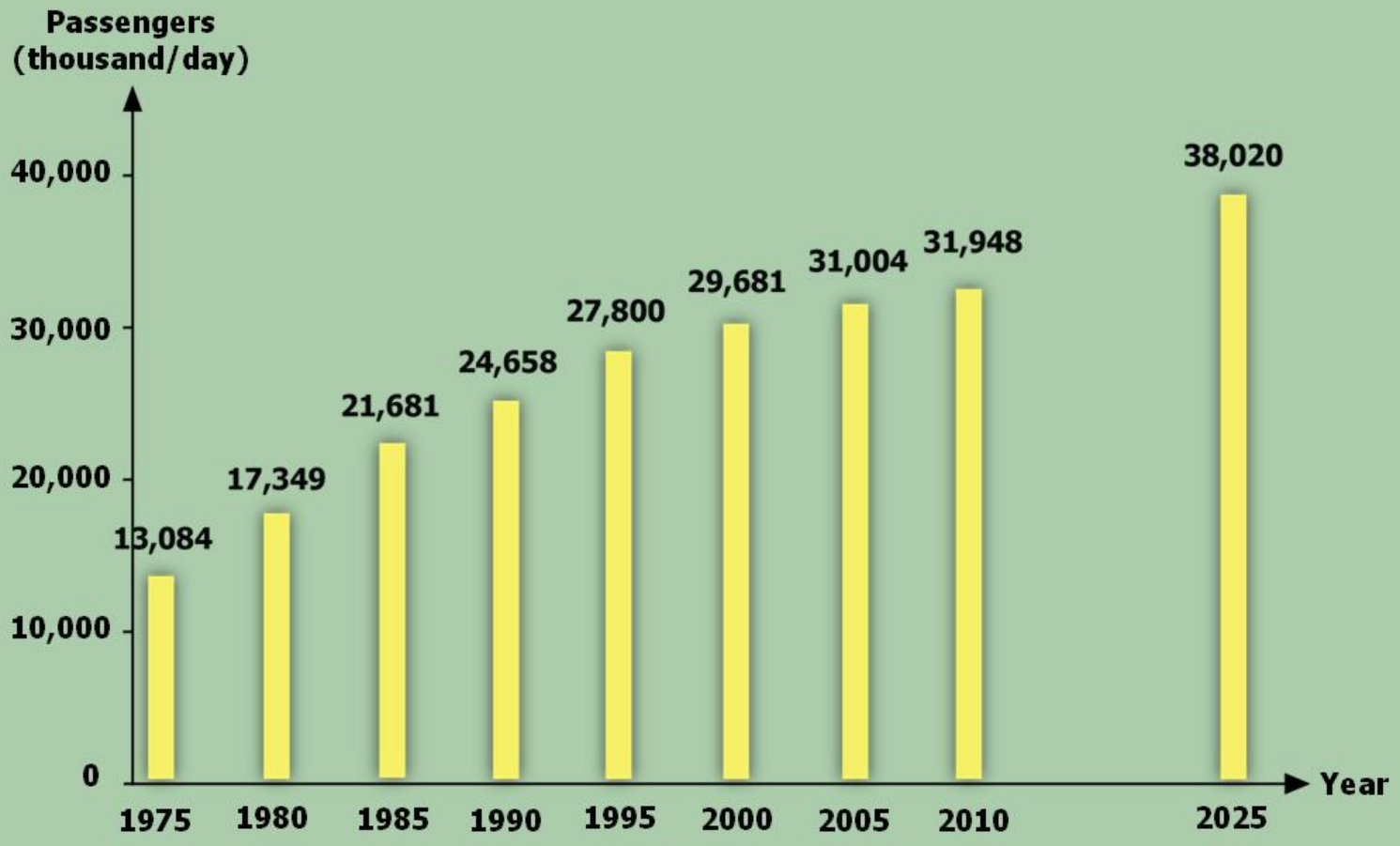
Cultural space

# Typical configurations of subway stations (Phase Ⅱ&Ⅲ)

- Major concerns : multi-functional, comfortable convenient and easy access

Shopping mall

# Transportation modes and the shares of passenger loads



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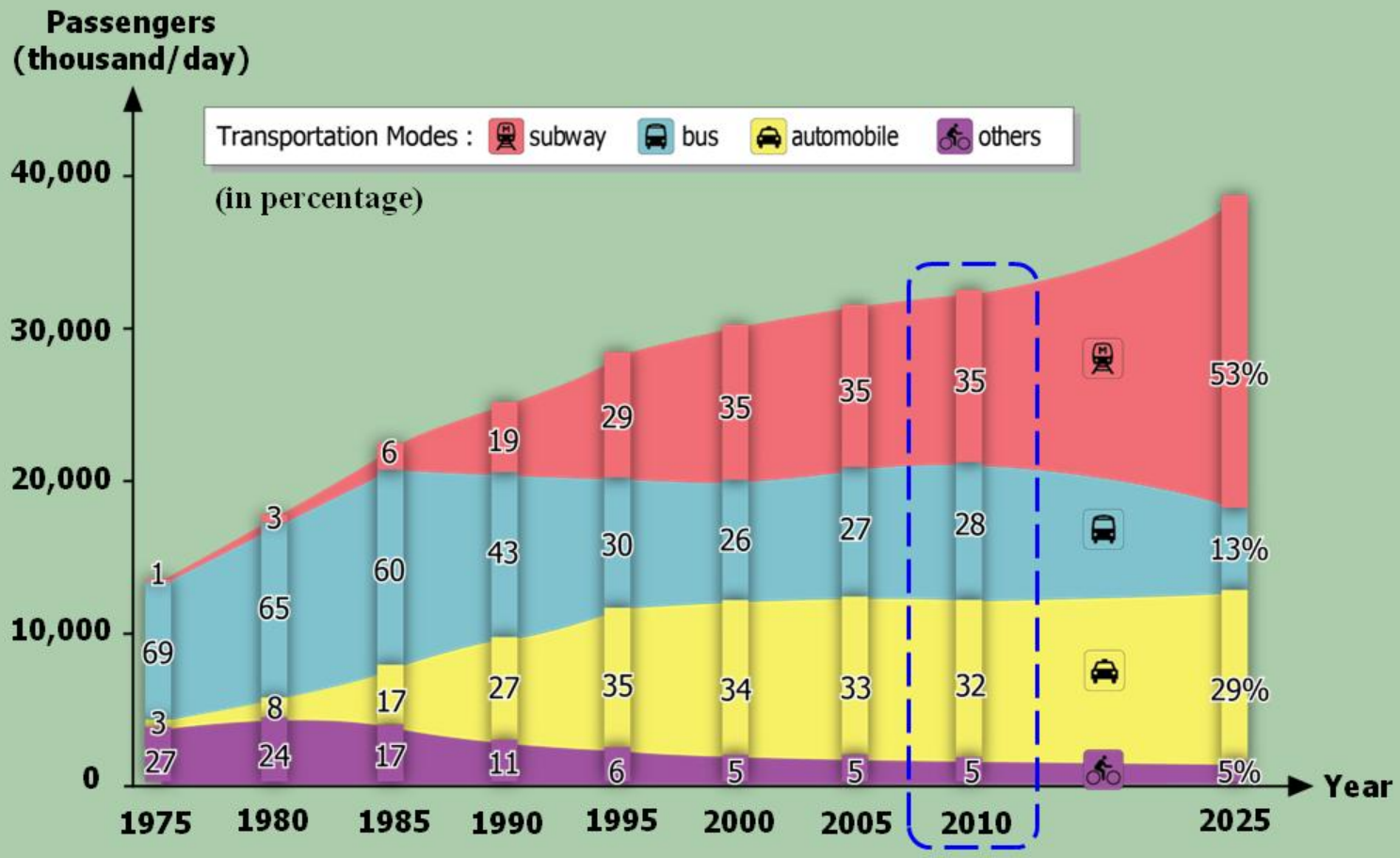
# Transportation modes and the shares of passenger loads



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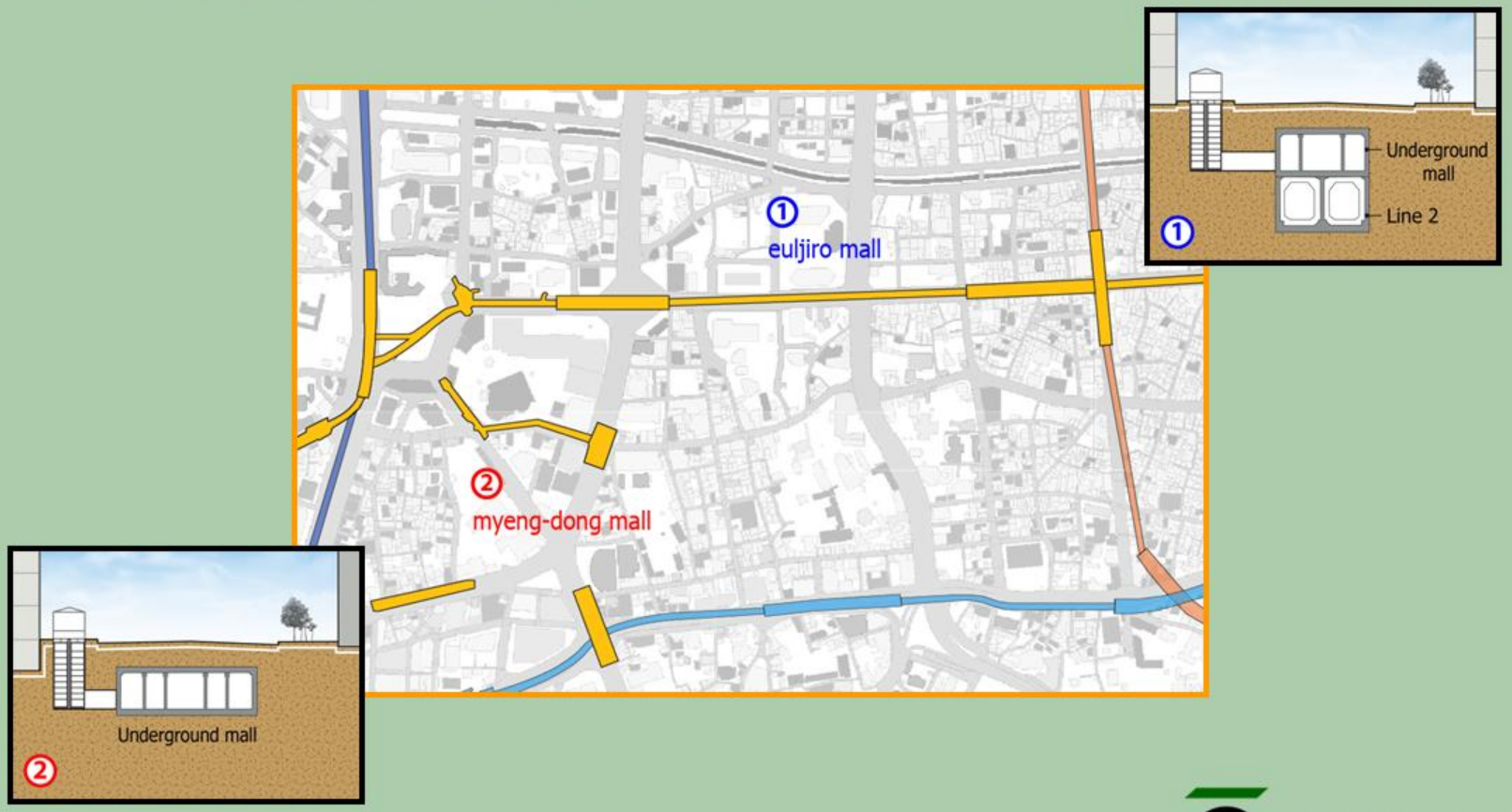
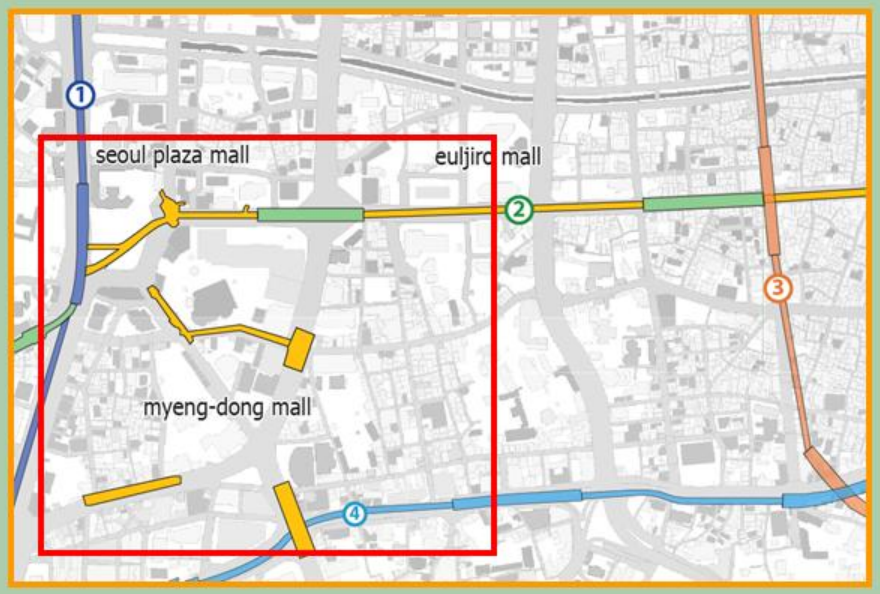
# Layouts of underground malls(1)

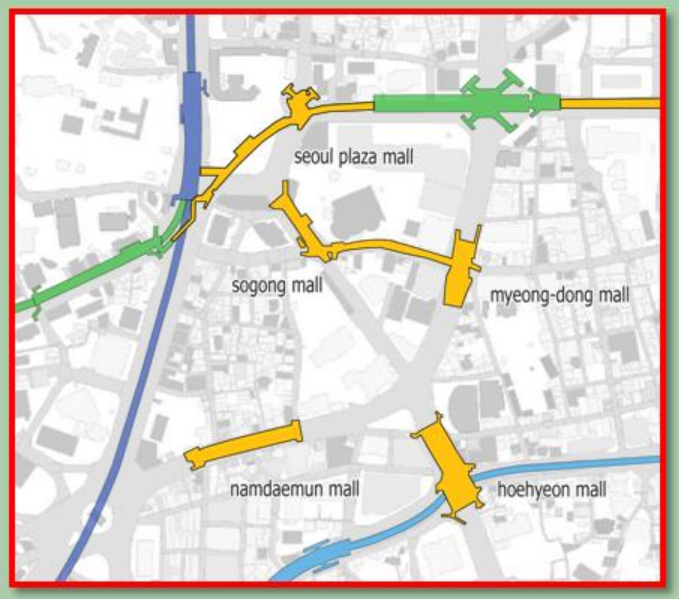
- **Linear configurations** on the subway structure beneath the road



# Layouts of underground malls(2)

- Individual malls are **connected together** to provide more convenient and comfortable underground spaces



# Layouts of underground malls(2)

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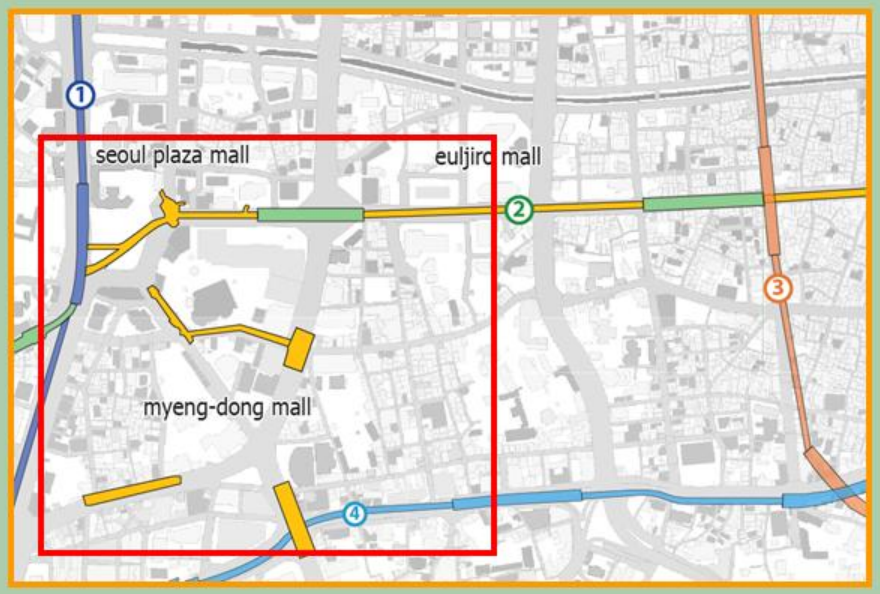
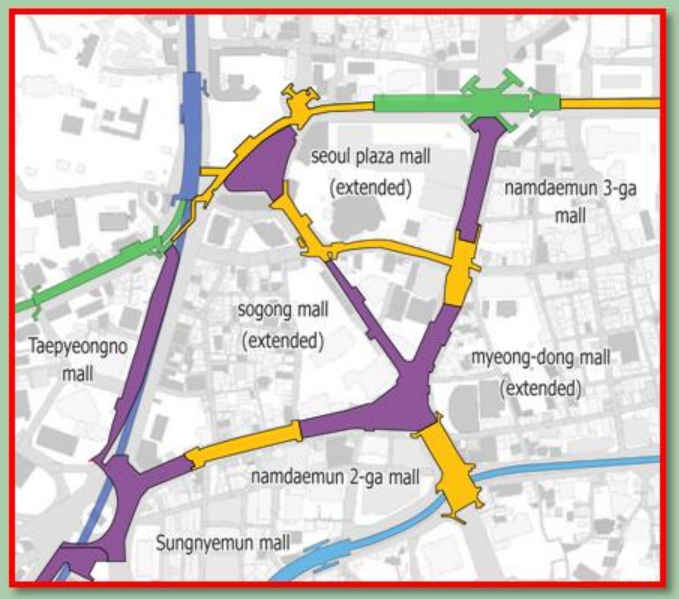
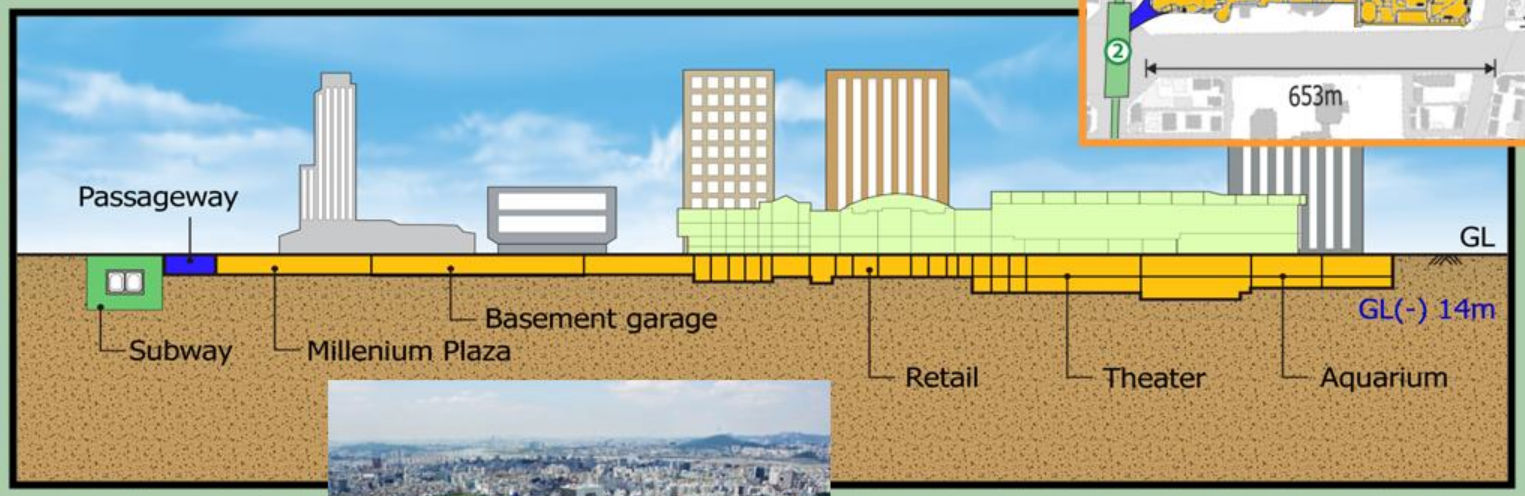


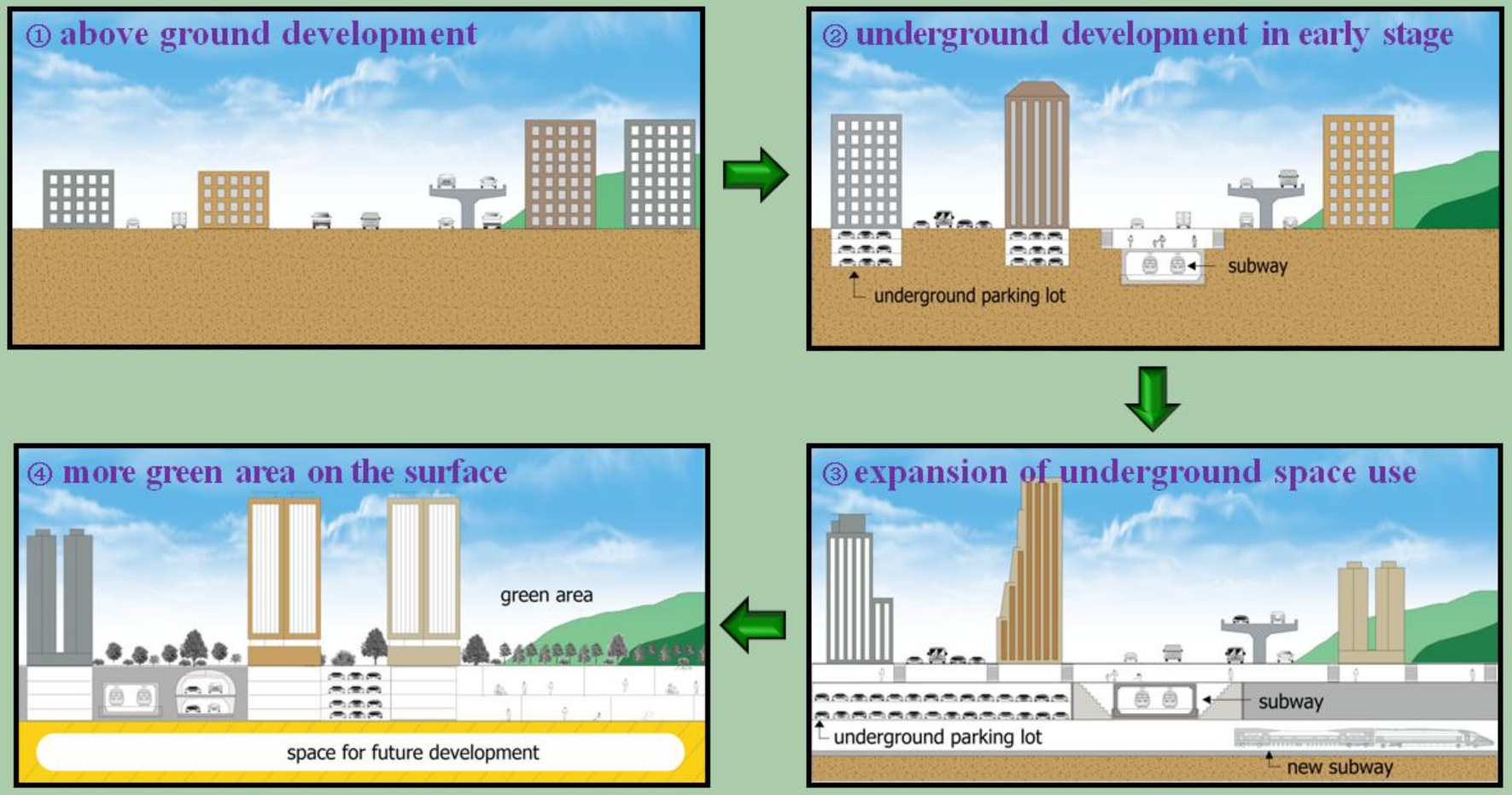
# Layouts of underground malls(3)

- Developments of the underground space increased tremendously in size


Coex mall

# Trends of underground space developments in Seoul



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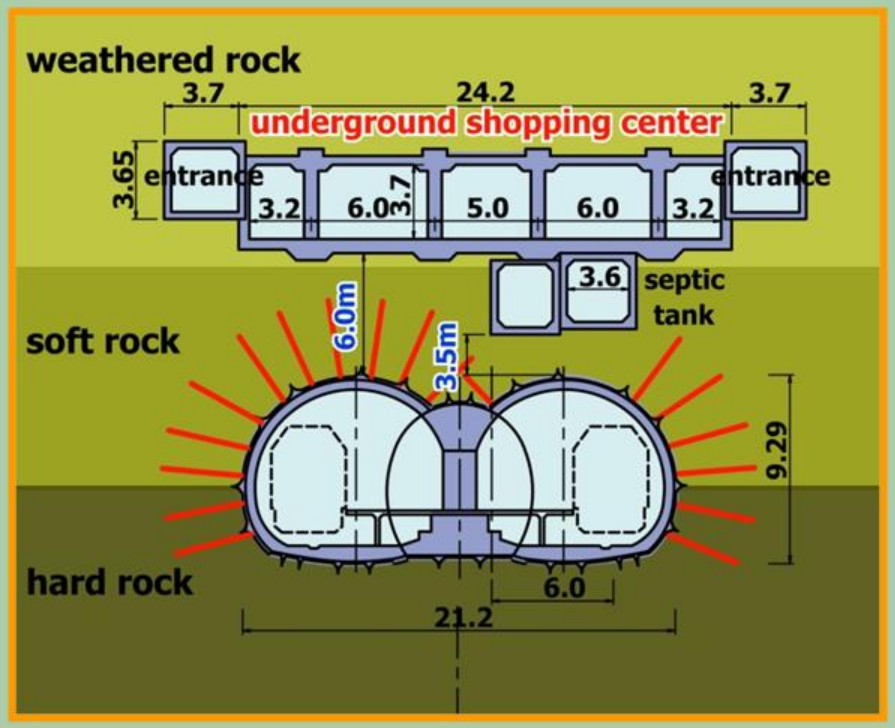
Experience
in Creating
Underground Space

# Two-arch station tunnels

- Constructed beneath the underground shopping center
- Length of two arched tunnel : 167.5m





- *Myeongdong station*
  **Seoul Subway Line 4**



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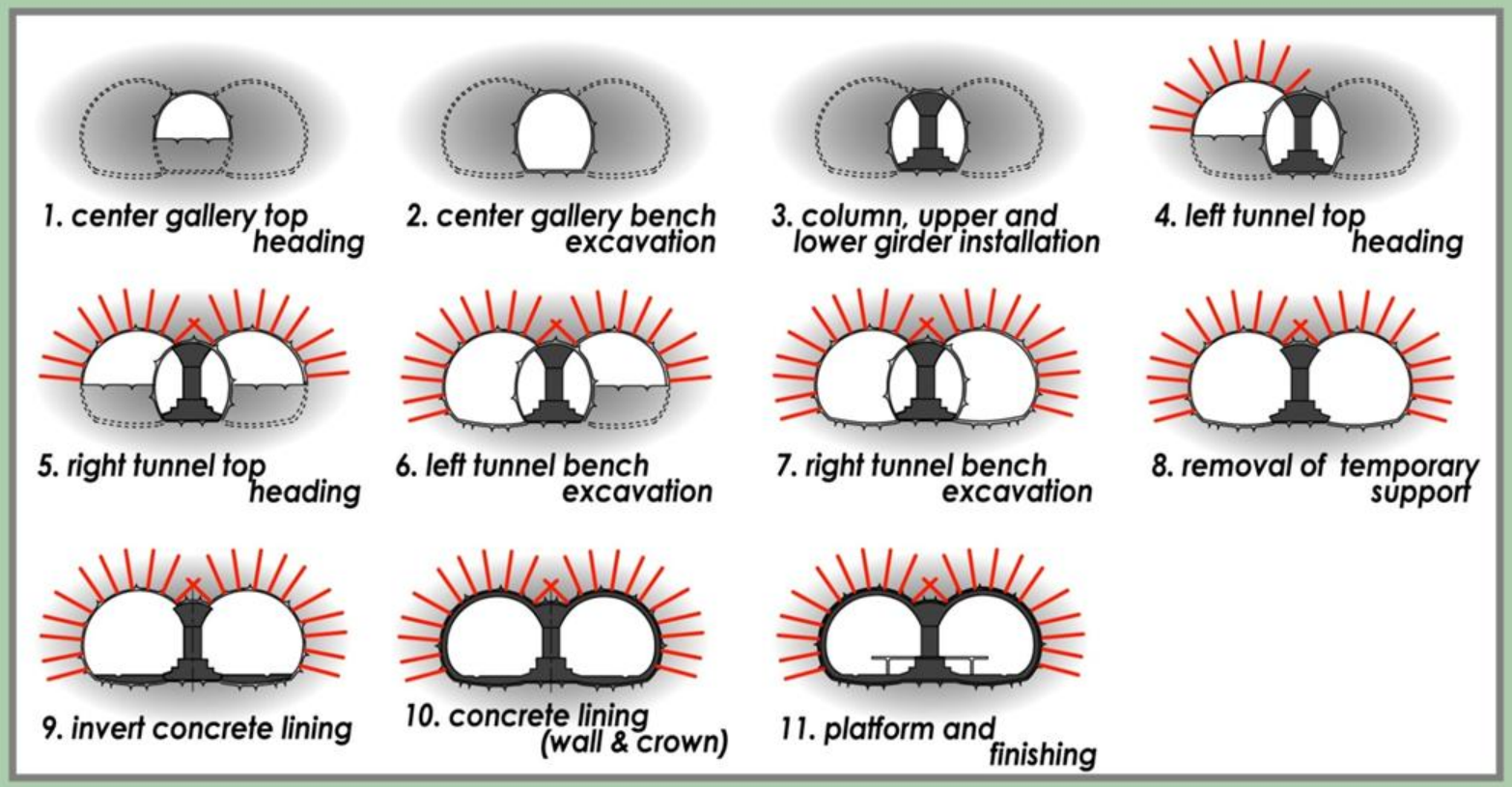
# Technical solutions

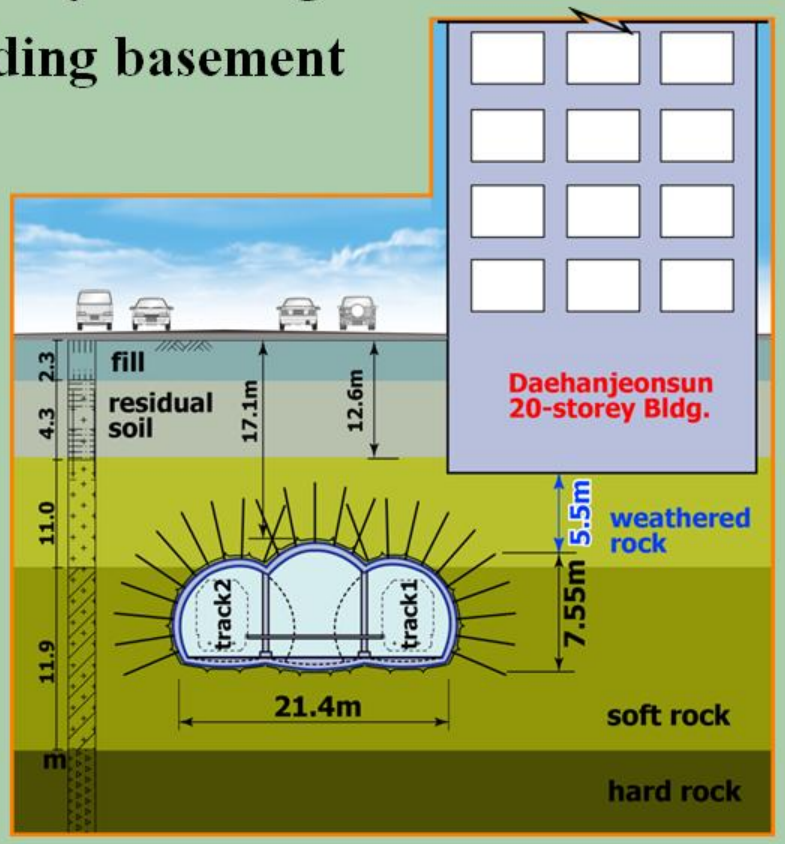
- The central part was excavated first and columns were constructed before the remaining excavation



# Three-arch station tunnels

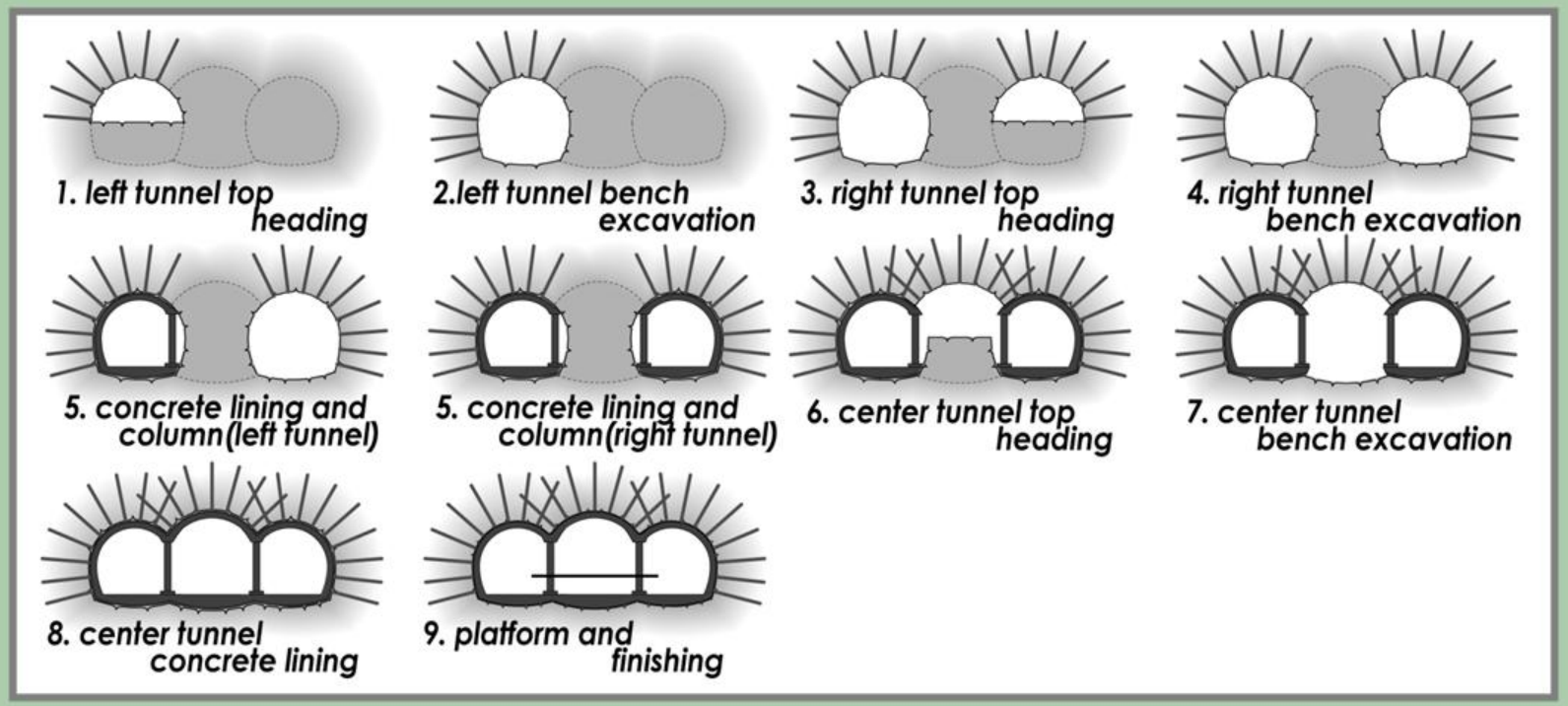
- Constructed beneath the 20-storey building
- Minimum distance from building basement to tunnel : 5.5m
- Length of three-arch tunnel : 128.8m


- *Hoehyeon station*
  Seoul Subway Line 4



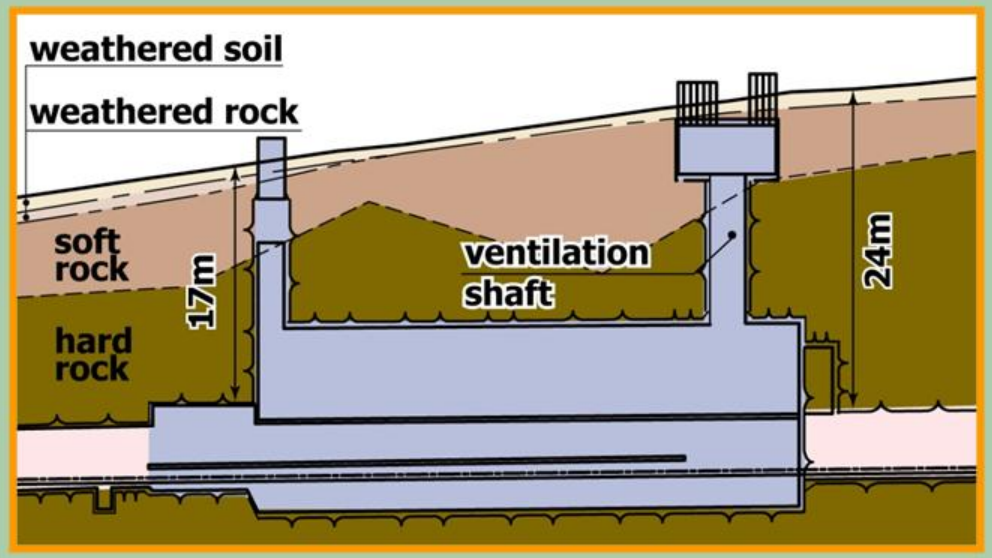
# Technical solutions

- Side tunnelling with sequential excavations and heavy support
- Whole section made by the excavation of the central part
- Bench lengths : 15 ~ 30m



# Single arch station tunnel with a shallow overburden

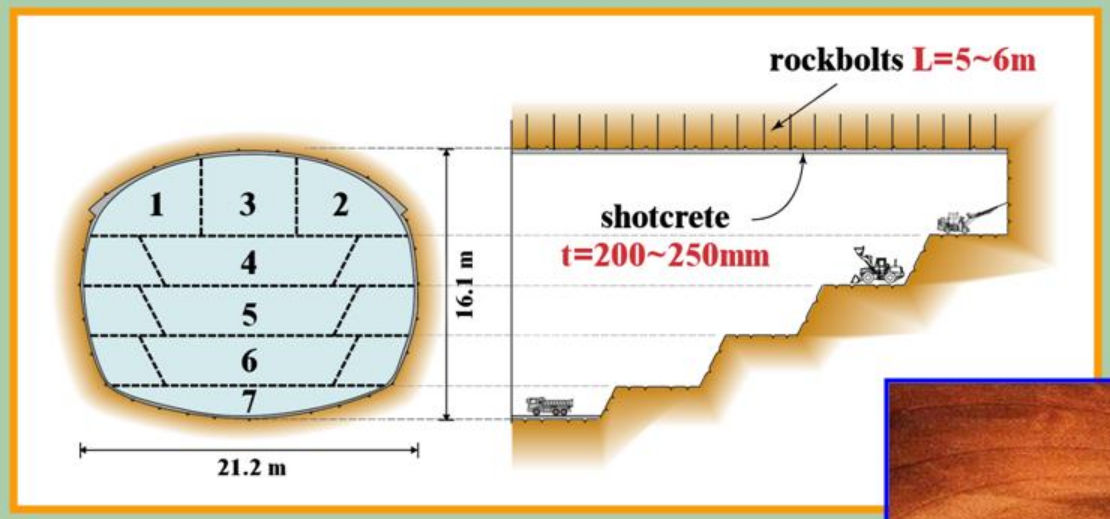
- Safe construction of large-scale station tunnel in urban areas using drill and blast excavation method
- Tunnel was constructed in good to fair rock of gneiss with shallow overburden

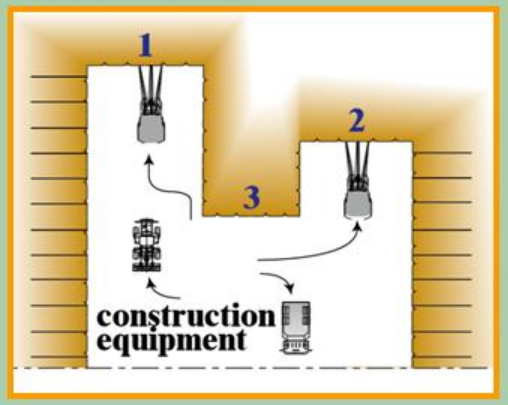



- *Noksapyoung station*
  Seoul Subway Line 6

# Technical solutions

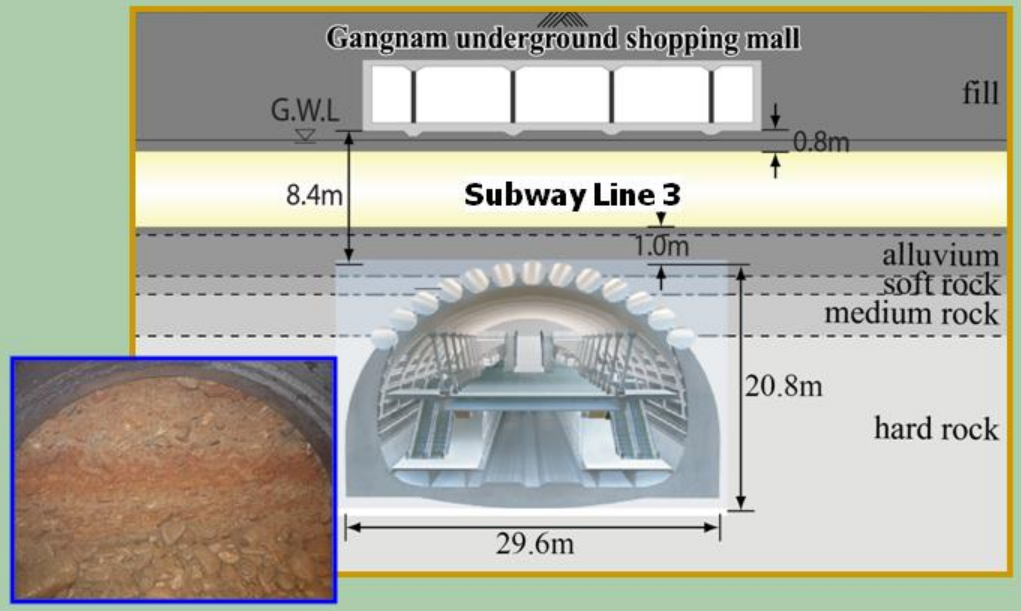
- Sequential excavations : 4-bench, 3-division



# Single arch station under existing structures

- Station tunnel was constructed beneath the old shopping mall and subway Line 3
- Station tunnel face hit the alluvial deposits
- Closest distance between existing subway and new station tunnel is about one meter

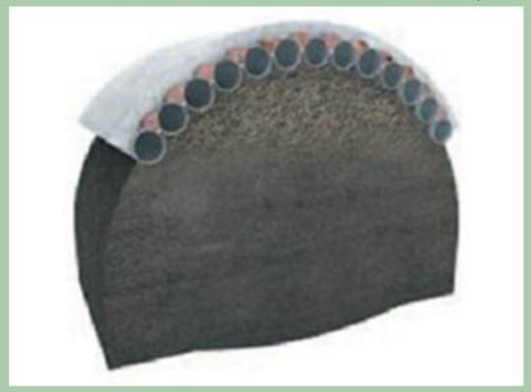




- *Express bus terminal station*
  Seoul Subway Line 9

# Technical solutions

① slab pipes(13 pipes, ℓ=159m, 2m in diameter)



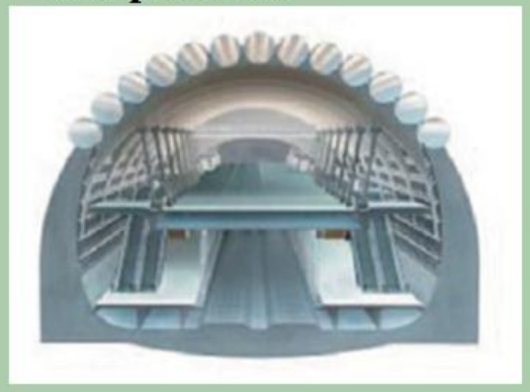
② excavation for lower side walls

③ construction of lower side walls

④ construction of transverse girders

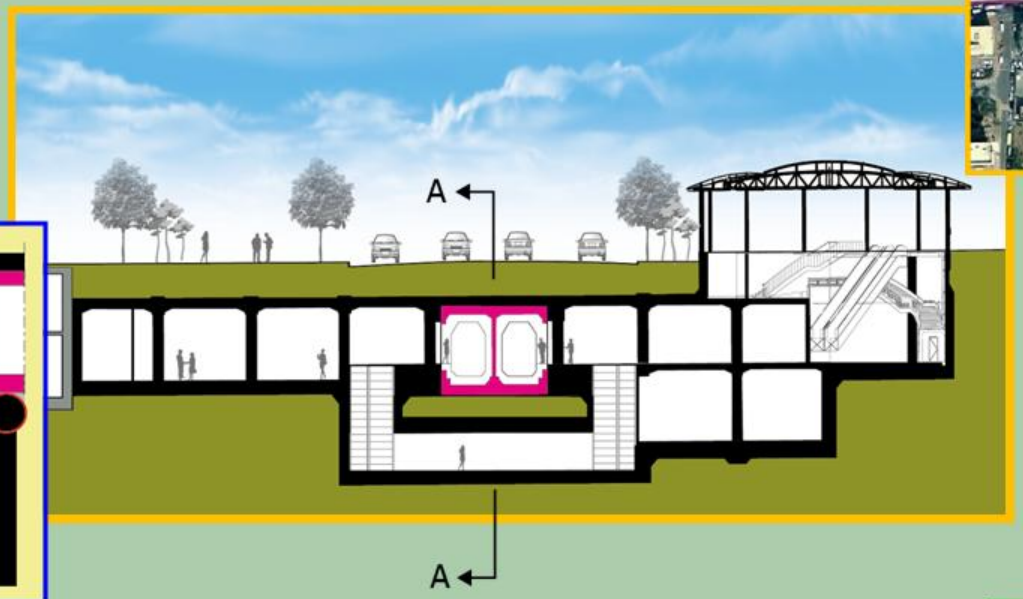
⑤ excavation of remaining parts

⑥ construction of concourse and platform



# Extension of station to existing operating subway line

- New subway station extension to the old subway line
- Technical issue : safe construction without hampering daily services







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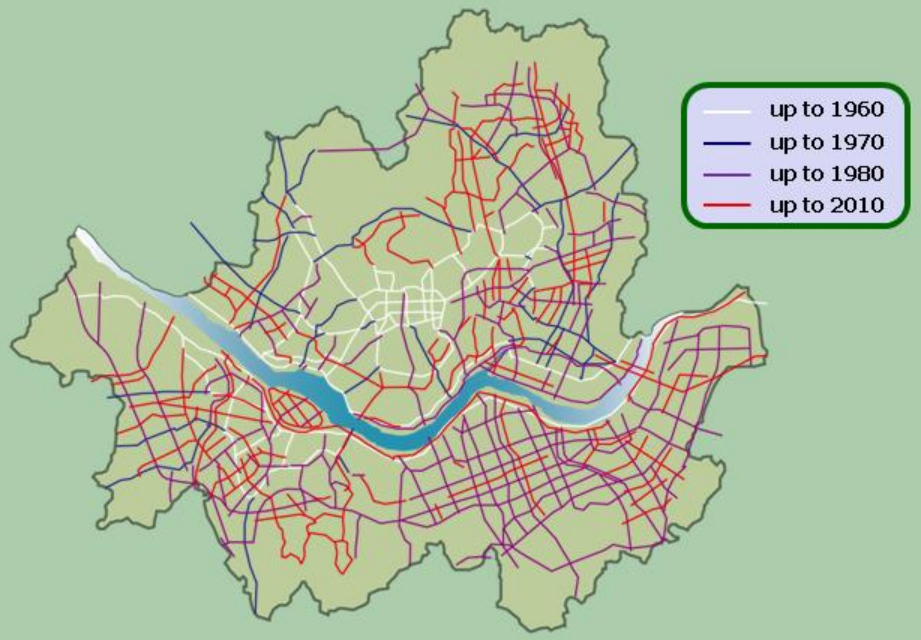
# Surface urban transportation problems



# Surface urban transportation problems

- Overpopulation

- Lack of available road area

- Traffic congestions



- Increase needs for more green space

# Increasing needs in creating more underground spaces(1)

## ✓ New road construction by covering the streams

- Landscapes in 1900s

- Covering work (1958~1961)

- Elevated road(1971)


# Increasing needs in creating more underground spaces(2)

## ✓ Restoration of the original stream

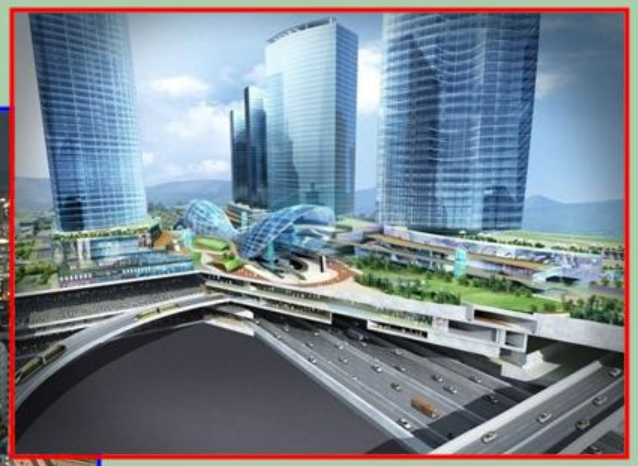
- Demolition of elevated road

- Dismantlement of covering

- Restoration of the stream

# Increasing needs in creating more underground spaces(3)

- ✓ Demand on the underground road construction as a replacement of surface roads



- Developments of the underground roads

- Restored stream

# Proposed underground road networks

| Line | Length (km) | Depth (m) |
|---|---|---|
| SN1 | 24.5 | 40 ~ 60 |
| SN2 | 26.3 | |
| SN3 | 22.8 | |
| EW1 | 22.3 | |
| EW2 | 22.3 | |
| EW3 | 30.5 | |
| Total | 148.7 | |

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# Proposed underground road networks

Underground beltways

Above ground beltways




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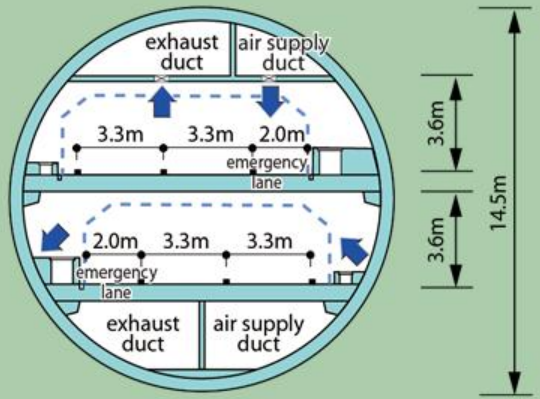
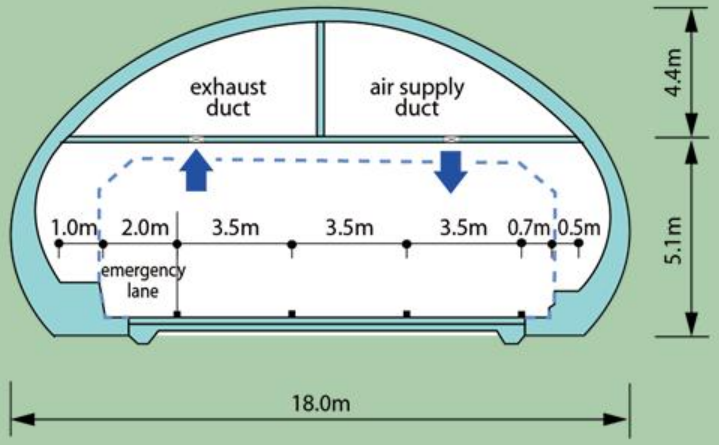
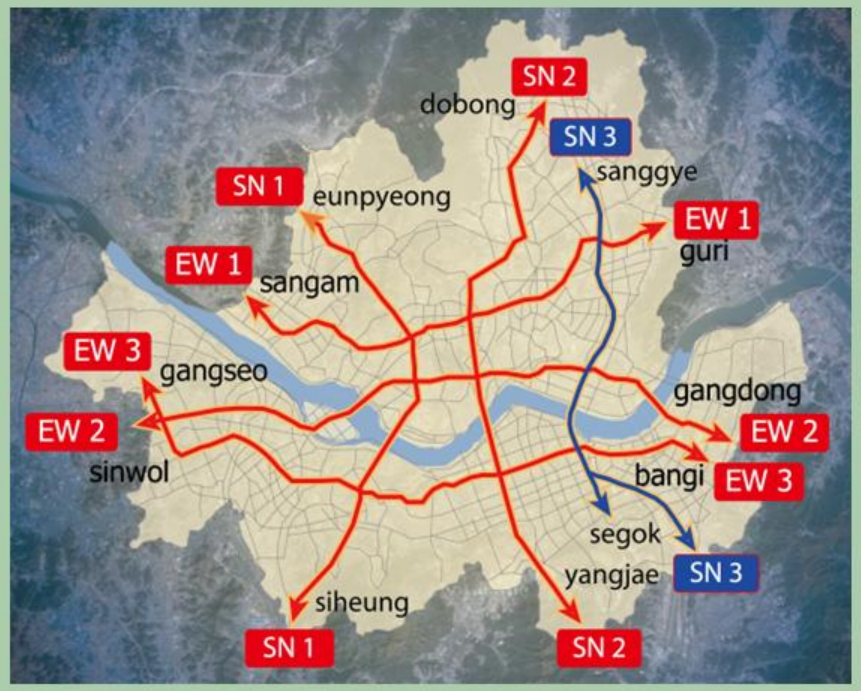
# Proposed underground road networks

# Cross sections of proposed underground road networks(U-smartway)

- Route SN1,2, EW1,2,3

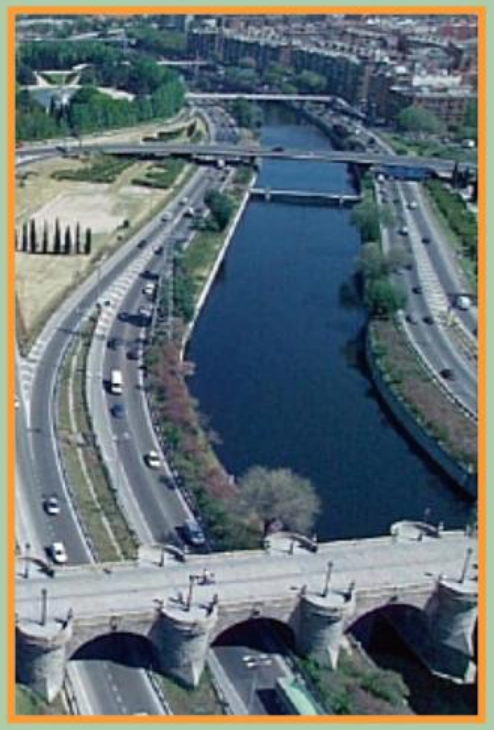


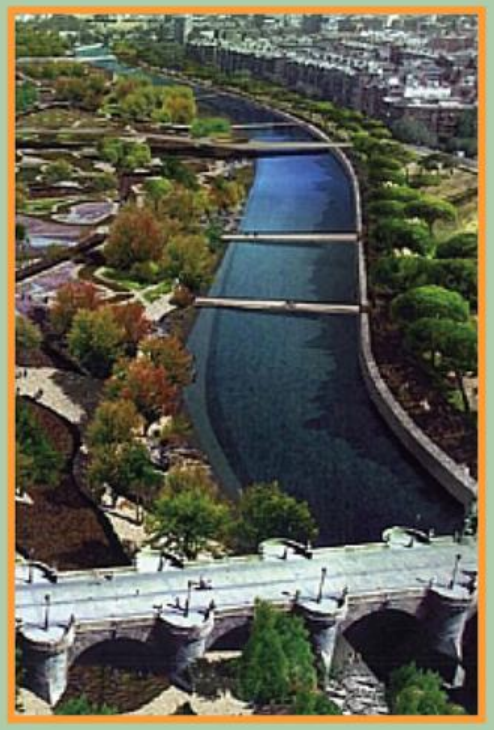

- Route SN3

# Restoration of green space by using underground space



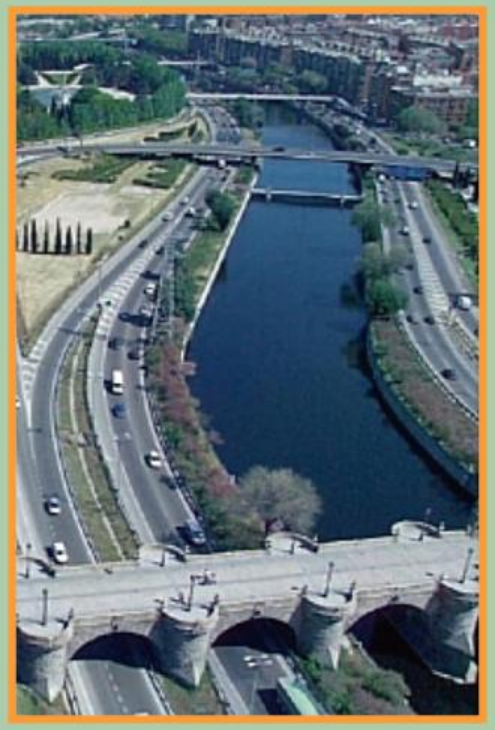
- Present urban highways

# Restoration of green space by using underground space

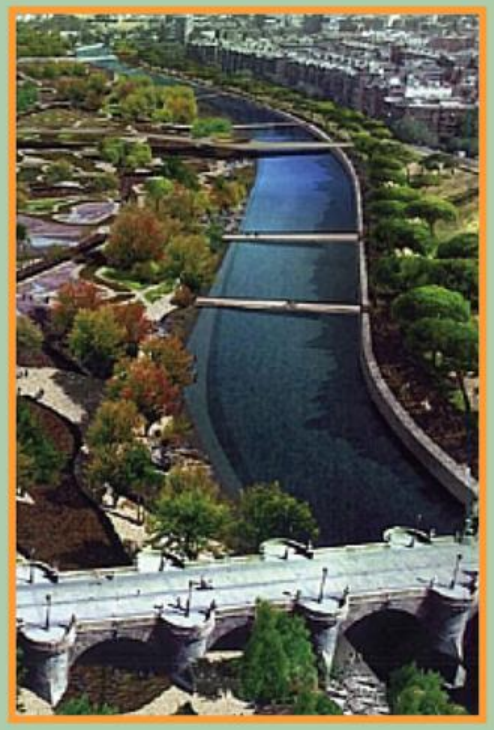


- Parks above the urban highways

# Restoration of green space by using underground space



- Present urban highways



- Parks above the urban highways

# Conclusions

Use of underground space
is a sustainable solution
for the urban transport problems
and providing more surface green areas
in a megacity
like Seoul

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