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A Study on the Actual Major Factors and Perception of Working-level Officials for Change Orders in Public Construction Projects

- Focused on Sejong Administrative City Construction

28 Nov. 2024

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Academic Papers – Room 17: 01:55 PM – 02:25 PM

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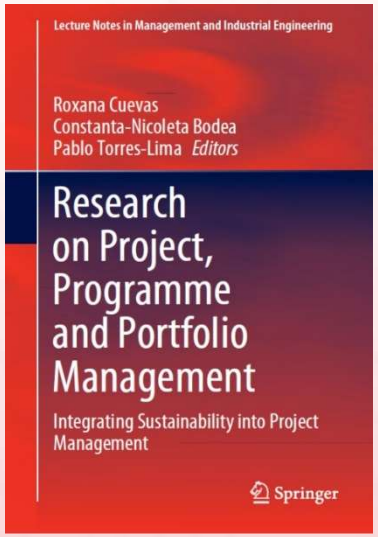

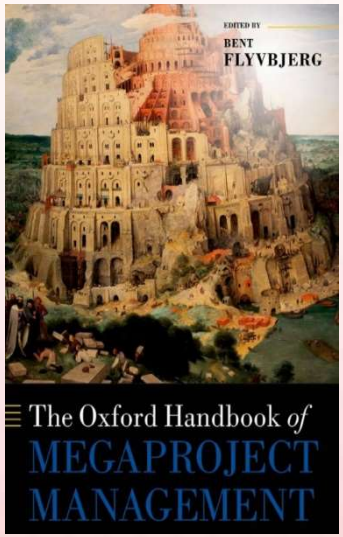

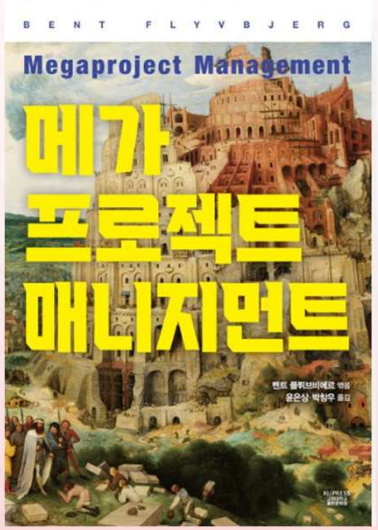

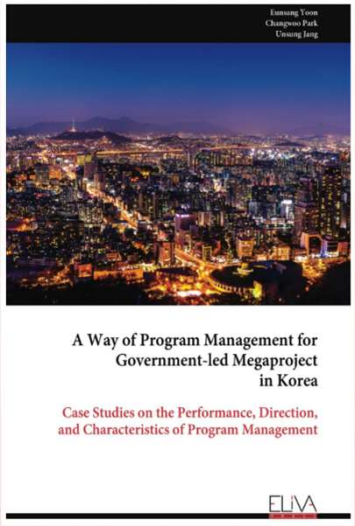

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1. Introduction

1-1. Introduction

- **Aims**: To avert both direct and indirect losses in construction projects stemming from ill-advised change order modifications.

- **Sejong Administrative City(SAC)**: Relocating central government offices to reduce overconcentration in the Seoul metropolitan area to enhance national competitiveness through balanced development. (Total budget : US$ 22.5 billion)

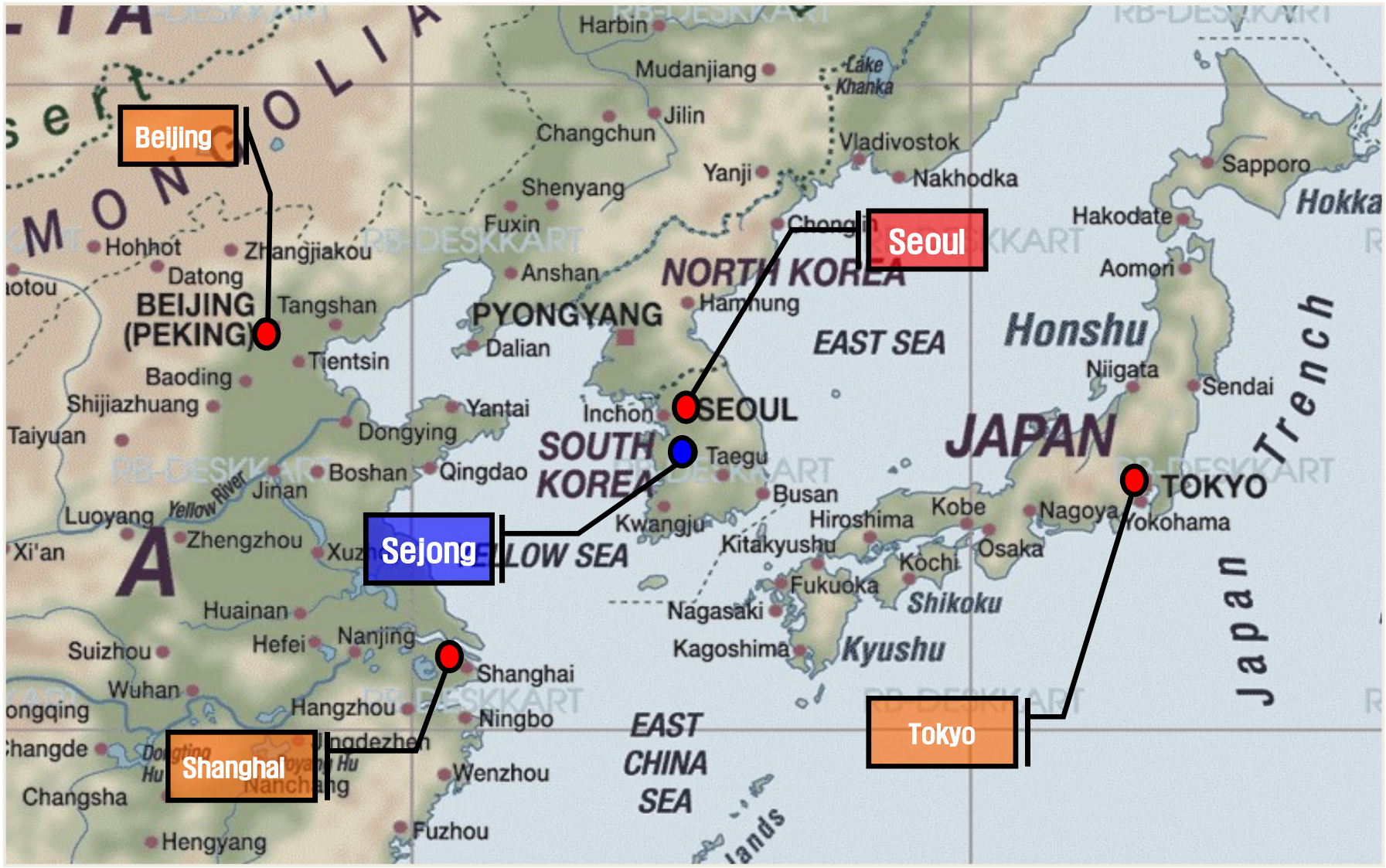
- **Change Order Data**: Building, Site preparation, Road, Urban supply/environmental infrastructure, and Landscape projects.
  - **125** projects, **563** change order contracts, **9 years**('11~'19)
  - **Factors**: Task changes, Site condition adjustments, Plan alterations, Interference with other works, and Construction suspensions

- **Methodology**: ① identifying the limitations of previous studies, ② analyzing change order data, ③ normalizing the derived frequency and result factors, ④ applying the Euclidean distance method to evaluate and identify the main factors, ⑤ analyze AHP results by comparing actual change order factors with the perceptions of construction project professionals.

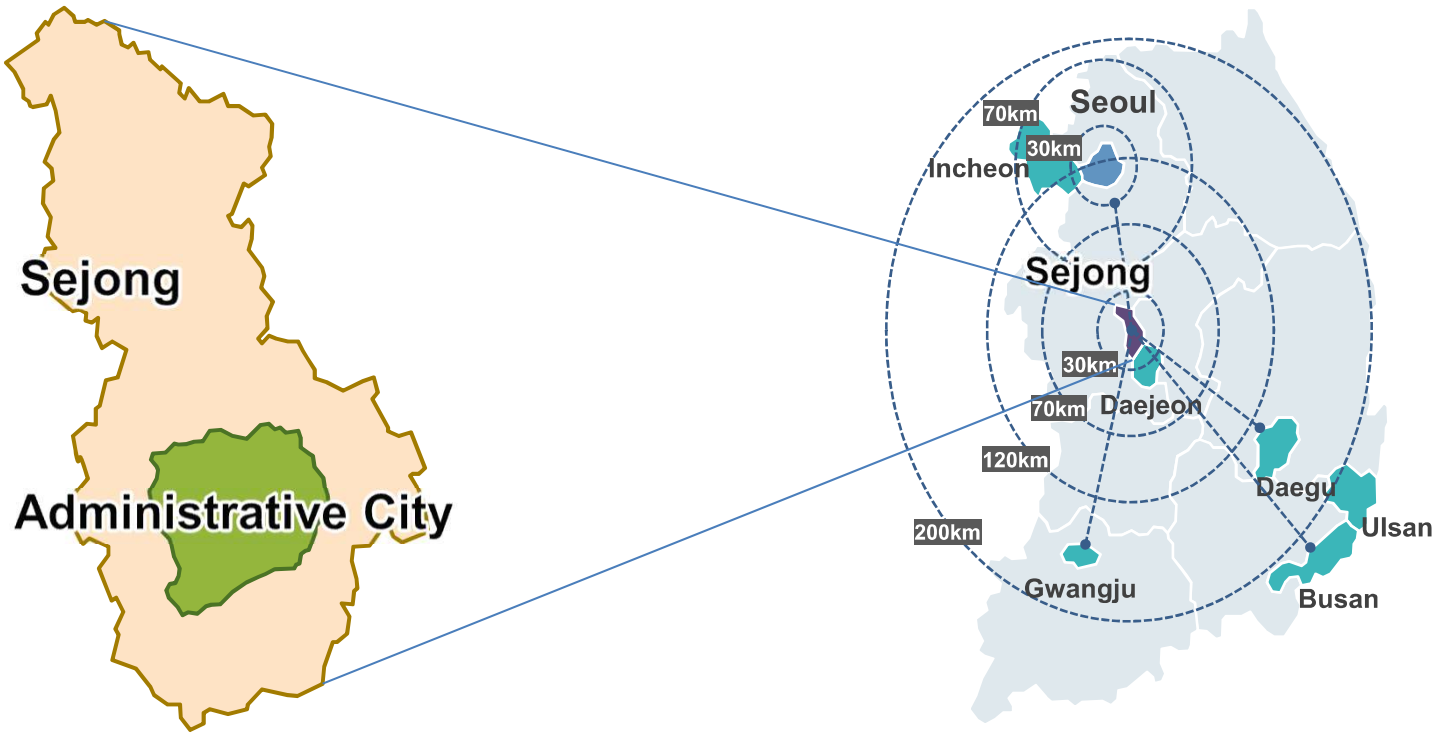
- **Objectives**: To compare the differences between actual change order factors and construction project professionals' perceptions to prevent unnecessary change order.

2. Sejong Administrative City(SAC)

2-1. Location of SAC



2-1. Location of SAC



Category	Administrative City	Sejong
Area	73.0 km² (1/8 of Seoul)	464.84 km² (3/4 of Seoul)
Population (August 2024)	307,927	395,240

2-2. Background

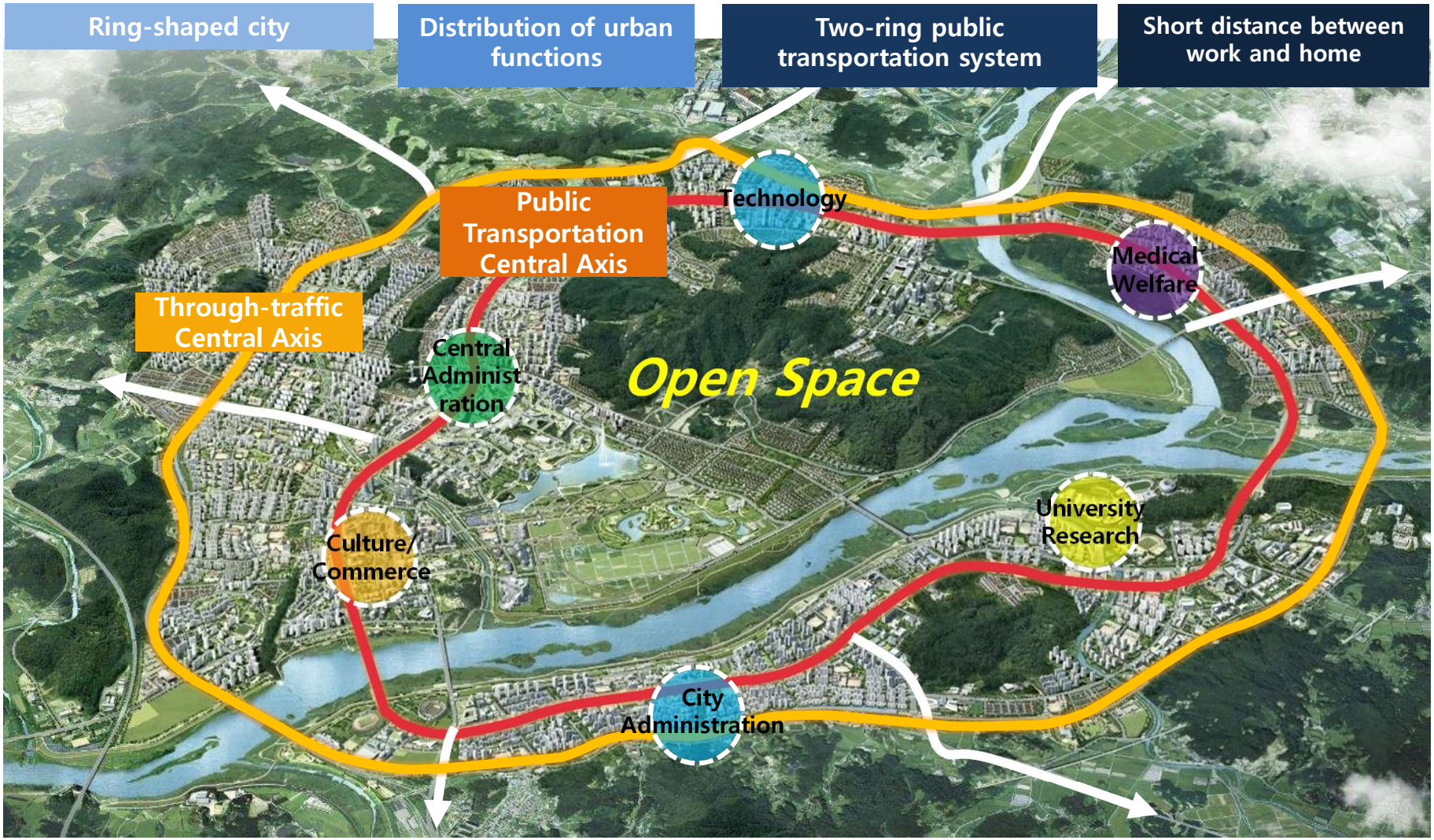
2-3. SAC Project Overview

Objective	Goal	Total Cost
Balanced National development and increased national competitiveness	Creation of a self-sufficient city with a population of 500,000 by 2030	KRW 22.5 tril. (USD 17 bil.) * KRW 8.5tril. from government + KRW 14tril. from LH

Early Stage	Maturing Stage	Completion Stage
Relocation of central government agencies Construction of urban infrastructure	Expansion of self-sufficiency Improvement of urban infrastructure	Completion of self-sufficiency Completion of Administrative City

2007 — 2015 — 2020 — 2030

2-4. Urban Planning



2-5. Main Project : Seat of Government

· Government Sejong Complex (3.5km rooftop garden)

Relocation of 44 government bodies and14,800 employees

2-5. Main Project : Seat of Government

· **Government-funded Research Institutes**

Relocation of 16 national research institutes and 3,900 employees

2-6. Main Project : Culture, Leisure, Welfare

National Museum Complex

Design Museum

Urban and Architecture Museum

Digital Heritage Center

Children's Museum

2-7. Main Project : Culture, Leisure, Welfare

National Library

Arts Center

Multi-purpose Service Center

Urban Plaza

2-8. Main Project : Culture, Leisure, Welfare

National Arboretum

Sejong Lake Park

Sejong Central Park

Pedestrian Bridge

2-9. Main Project : Smart City

Smart Safety

- Crime Prevention Through Environmental Design (CPTED)
- Fire Monitoring Thermal Imaging System
- City-Level Safety Net

Smart Infrastructure

- Safe Urban Environment
- 3D Spatial Information
- Bird's-eye View of Utility Pipe-Conduit

Smart Energy

- Using Geothermal Heat
- Solar-powered Soundproof Tunnel
- Korea's Largest Zero Energy Town (Integrated Energy Management Center)

Smart Transportation

- Hydrogen Fueled Vehicle
- Intelligent Transportation System (Next-Generation ITS, etc.)
- Solar Panel Road

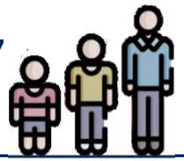
Smart Environment

- Natural Lighting
- Development of Eco-Friendly Rainwater Circulation System

2-10. Sejong Administrative City Now

Demographics

2023
Birth Rate 0.97
Ranked 1st, Avg. 0.72

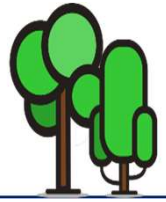


2023
Median age 38.6
Youngest in Korea, Avg. 44.8

2022
Population increase 3.22%
Ranked 1st, Avg. -0.20%

Quality of Life

2023
Satisfaction 53.3%
Ranked 1st, Avg. 42.2%



2022
Size of park 63.300㎡ per 1,000 persons
Ranked 1st, Avg. 12,300㎡

2022
Crime rate 17.1 Per 1,000 persons
Lowest, Avg. 27.9

Young
Child-friendly
Growing
Administrative City
Safe
Great Place to Live
Green Urban Life

2-11. Satellite Images (2007 vs. 2024)

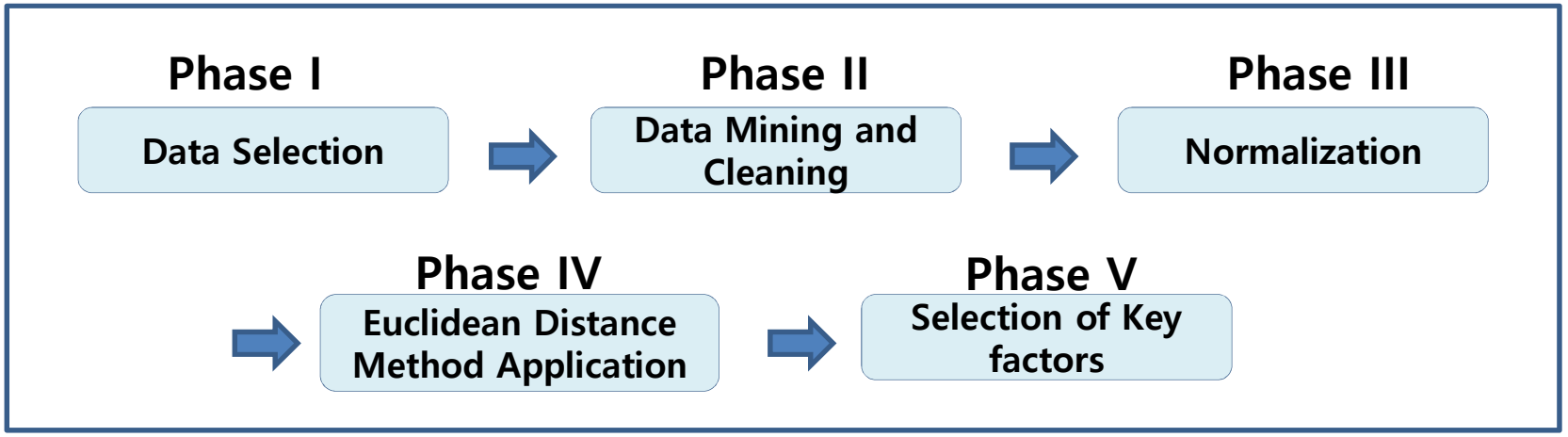
3. Literature Review

3. Literature Review

- One study established **the concepts** of change rate, loss rate, and delay rate to identify change order impacts and estimate losses[4].
- Another **change order risk measurement study** used the loss distribution approach, deriving the average value of loss distribution and presenting a scenario for change order risk management[5].
- **Improvement plans involve clarifying the change order** scope and target, securing an adequate budget, establishing criteria for applying unit prices during contract price adjustments, and enhancing the expertise of project managers[6].
- **A quantitative evaluation study** utilizing the **Euclidean distance scale** is being conducted[7].
- Inundation risks for each drainage division were quantified and verified by **comparing past performance and trace investigations**[8].
- **The risk ranking** of various disasters and accidents involved analyzing five years of overall damage data and large-scale disaster characteristics[9].
- It is used for **making rational and reasonable judgments on matters with numerous factors** to consider, producing quantitative results [10].

4. Methodology

4-1. Euclidian Distance Measurement



The process of using Euclidean distance to analyze change order in public works;

- Step 1: Collect a data on change orders in the SAC construction.
- Step 2: Categorize data according to change order factors.
- Step 3: Analyze the collected and categorized data to derive results such as the frequency of change orders, the average amount of increase, and the average days of construction extension.
- Step 4: Normalize the change order data results to apply the Euclidean distance measurement method.

4-1. Euclidian Distance Measurement

For 563 change order factors, the results revealed the frequency of change orders by project, the average increase, and the average number of extension days.

- **Change order frequency**

  = Total number of change order factors per single project … (1)

- **Average amount increase**

  = Total project cost increase per change order's factor / Number of projects …(2)

- **Average construction extension days**

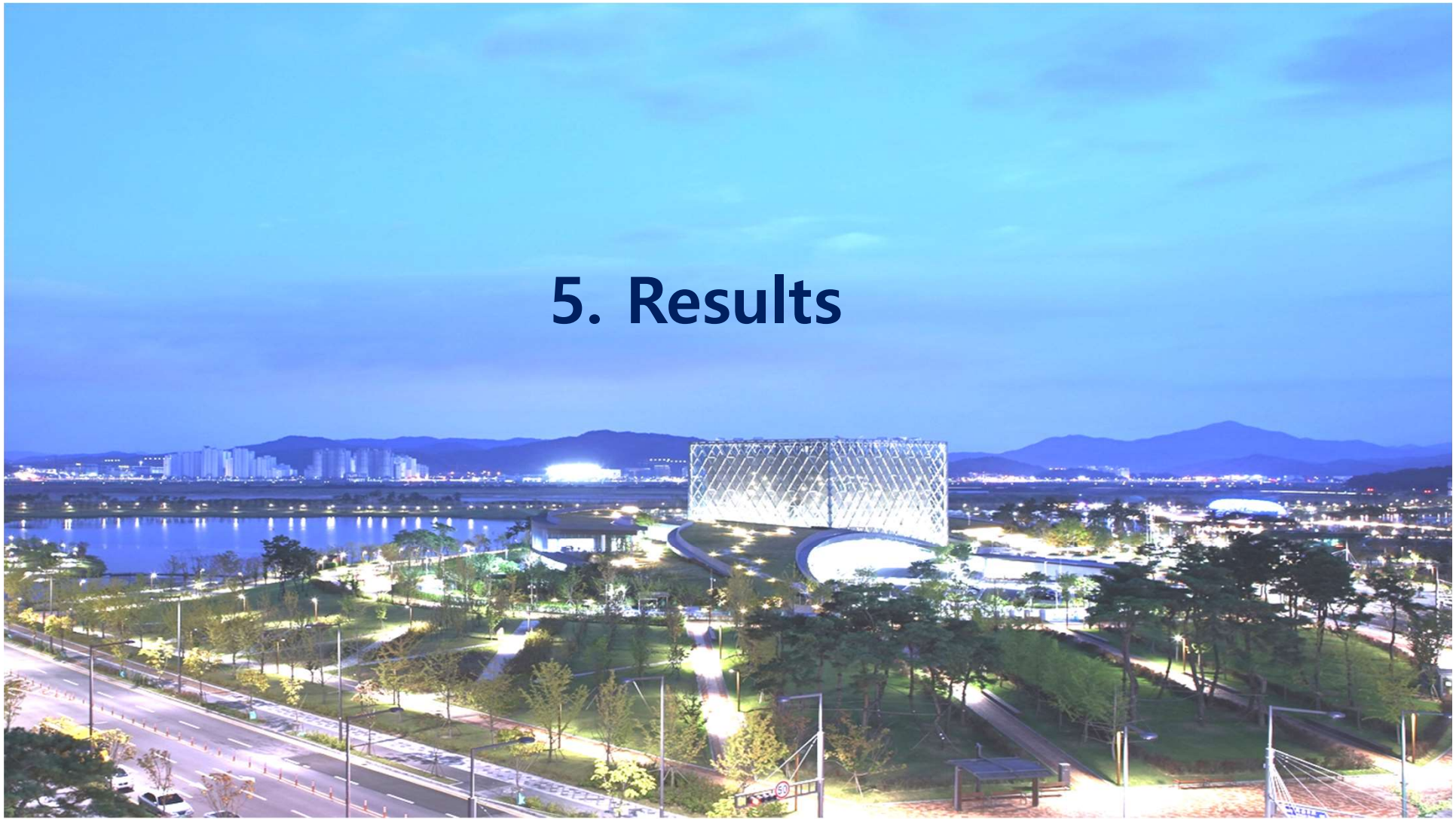
  = Total construction extension days per change order's factor / Number of projects … (3)

4-2. AHP(Analytical Hierarchy Process)

In this study, the AHP method was employed to compare the results of the Euclidean distance scale with practitioners' perceptions.

- A survey was conducted with 60 participants from government agencies, public institutions, private construction, design and supervision, general project management, universities, and research institutions.
- Out of the responses, 51 had a Consistency Index (CI) of 0.2 or less, and the results are presented in Table.

Classification		Gov.	Public Company	Private Company			PM Consulting Company	Researcher
				Construction	Design	Supervision		
Total respondents(n=51)		12	3	8	5	2	10	11
Working experience	Less than 5 years	3	3	1	-	-	1	8
	5~10 years	2	-	-	1	1	2	1
	10~15 years	5	-	2	1	-	3	-
	Over 15 years	2	-	5	1	1	4	2



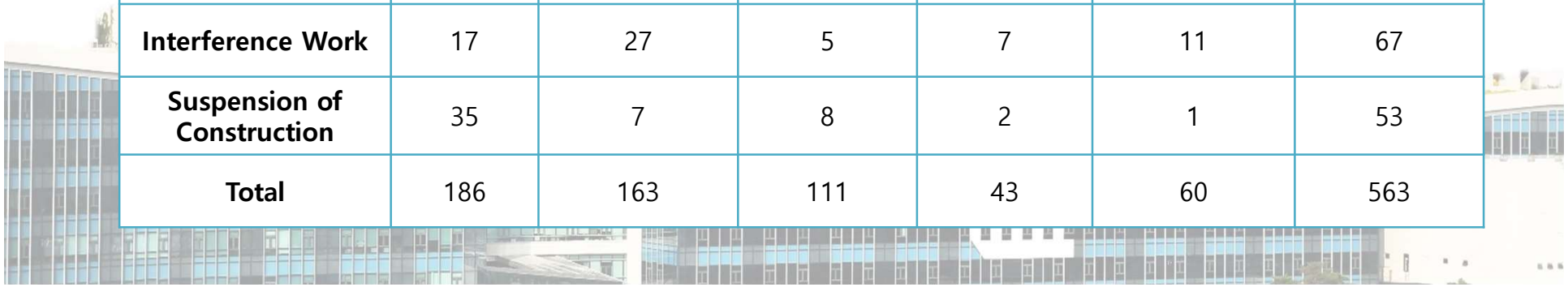
5. Results

5-1. Euclidian Distance Measurement

The total number of change order contracts was 563.

- Data was gathered and preprocessed for various categories, including building construction, site preparation, road construction, infrastructure, and landscape construction.

Type	Building	Earthwork	Urban Road	Public Utility	Landscaping	Total
Additional Scope of Work	51	95	34	19	29	228
Differing Site Conditions	81	6	57	4	7	155
Change of Urban Construction Plan	2	28	7	11	12	60
Interference Work	17	27	5	7	11	67
Suspension of Construction	35	7	8	2	1	53
Total	186	163	111	43	60	563



5-1. Euclidian Distance Measurement

- The Euclidean distance index is calculated by normalizing the results of the change order data using $a_{nor(i)} = \frac{a_i}{a_{max}}$.
- The variables represent the frequency of change order factors, average project cost growth rate, and average extension days.
- The variable signifies the maximum value of change order factors for an individual project.

5-1. Euclidian Distance Measurement

The normalization value ranges between 0 and 1. This value was normalized for individual projects in the Sejong administrative city construction.

- The table summarizes the normalized values for five project categories (construction, site preparation, road, infrastructure, and landscape) and five change order factors (addition of tasks, reflection of site conditions, plan change, interference with other construction, and construction suspension).

Type		Building	Earthwork	Urban Road	Public Utility	Landscaping
Additional Scope of Work	CNT	0.629630	1.000000	0.596491	1.000000	1.000000
	Cost	1.000000	1.000000	0.662570	1.000000	1.000000
	Time	1.000000	1.000000	0.859637	1.000000	0.945763
Differing Site Conditions	CNT	1.000000	0.063158	1.000000	0.210526	0.241379
	Cost	0.855808	0.048708	1.000000	0.884177	0.241111
	Time	0.637640	0.499862	1.000000	0.238854	0.945763
Change of Urban Construction Plan	CNT	0.024691	0.294737	0.122807	0.578947	0.413793
	Cost	0.057855	0.217688	0.106039	0.941632	0.416667
	Time	0.010612	0.607446	0.182118	0.643958	0.661787
Interference Work	CNT	0.209788	0.274211	0.087719	0.368421	0.379310
	Cost	0.051179	0.014600	0.000000	0.046968	0.057778
	Time	0.308052	0.680327	0.250649	0.408854	1.000000
Suspension of Construction	CNT	0.432099	0.073684	0.140351	0.105263	0.034483
	Cost	0.018247	0.022020	0.088132	0.022800	0.060000
	Time	0.751248	0.354890	0.295589	0.019323	0.162096

5-1. Euclidian Distance Measurement

- The results are calculated using the factors applied to **Euclidean distance**: change order frequency, average project cost increase amount, and average construction extension date.

$$d_i = \sqrt{(1 - a_{nor(i)})^2 + (1 - b_{nor(i)})^2 + (1 - c_{nor(i)})^2}$$

$$D_i = D_{max} - d_{(i)}$$

$a_{nor(i)}$ = Project change order frequency normalized value

$b_{nor(i)}$ = Project average cost growth normalized value

$c_{nor(i)}$ = Project average duration growth normalized value

5-1. Euclidian Distance Measurement

As shown in Table, the main factors for construction works were identified as additional work and reflection of site conditions.

- Additional work and urban planning changes emerged as the primary change order factors for site preparation works.
- In road works, a reflection of site conditions and additional work were the main factors.
- Additional work and urban planning changes were the most significant for infrastructure and landscape works.

Type	Building	Earthwork	Urban Road	Public Utility	Landscaping
Additional Scope of Work	**0.786167**	**1.000000**	**0.685686**	**1.000000**	**0.968686**
Differing Site Conditions	**0.774836**	0.176842	**1.000000**	0.363335	0.312989
Change of Urban Construction Plan	0.030850	**0.351025**	0.136371	**0.679866**	**0.484150**
Interference Work	0.182823	0.273007	0.106732	0.048299	0.083865
Suspension of Construction	0.329623	0.137702	0.170001	0.458251	0.043865
Average	0.330560	0.321527	0.389275	0.369246	0.373102

5-2. AHP(Analytical Hierarchy Process)

As depicted in Table, the AHP results from 51 reliable respondents with a CI index of 0.2 or less, including those from government organizations, public institutions, and private companies, reveal that in all five types of projects, interference with other construction and construction suspension were identified as the main change order factors.

Type (Weight / Rank)	**Building**	**Earthwork**	**Urban Road**	**Public Utility**	**Landscaping**
Additional Scope of Work	0.208	0.217	0.204	0.187	0.165
	3	3	3	3	4
Differing Site Conditions	0.171	0.185	0.164	0.175	0.199
	4	4	4	4	3
Change of Urban Construction Plan	0.164	0.135	0.152	0.155	0.164
	5	5	5	5	5
Interference Work	**0.235**	**0.237**	**0.234**	**0.253**	**0.248**
	1	**1**	**2**	**1**	**1**
Suspension of Construction	**0.222**	**0.226**	**0.246**	**0.230**	**0.224**
	2	**2**	**1**	**2**	**2**

Euclidian Distance Measurement

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AHP

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Interference Work	**0.235**	**0.237**	**0.234**	**0.253**	**0.248**
	1	**1**	**2**	**1**	**1**
Suspension of Construction	**0.222**	**0.226**	**0.246**	**0.230**	**0.224**
	2	**2**	**1**	**2**	**2**

6. Discussion

6. Discussion

- **Urban planning change** was selected as a major factor in the **Euclidean distance method** but received **the lowest weight and ranking** among all projects in the **AHP analysis**.
- This indicates that **the expert group does not fully appreciate** the importance of **initial planning and urban plan** compatibility in megaproject urban construction, which involves large-scale, complex organizations and numerous stakeholders.

- These results **emphasize the importance of project management in megaprojects** such as urban construction **to efficiently coordinate** with various stakeholders, **manage** resources effectively, and **respond** to various risks and uncertainties.

7. Conclusion

7. Conclusion

This study aimed to compare the differences in perception between **actual change order factors** and **the perception** of a group of construction professionals to prevent unnecessary change orders in advance.

- The goal was to identify these **perception differences** and develop a plan to **minimize change orders in the early** and management stages of megaprojects, thereby reducing increases in project cost and schedule extensions.

The study's results revealed **a significant gap** between the **actual** main factors for change orders and the perceptions of the expert group, emphasizing the importance of megaproject management and the recognition of individual project characteristics in change orders.

This study has some **limitations**.

- The data range for a change order in Sejong city construction is limited, which may affect the results of the Euclidean distance scale method.
- Despite this limitation, the applicability of the Euclidean distance scale in this study could be extended to other megaprojects, and the findings can serve as a foundation for future research.
- This research helps underline **the importance of aligning expert perceptions with actual factors** influencing change orders to improve project outcomes and minimize unnecessary change orders.

Thank you

Q & A