

World's first Robot-friendly office building; exploring a new boundary in architectural design - people working together with robots in South Korea's IT valley

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Abstract

As the world awakens from the shock of COVID-19, the deep changes triggered by the seismic shift of technology began to emerge in the world we live-in. Nowhere in Asia will you find a suitable example like this than the brand a new office building in Korea that embraces co-existence of human and robot in a digital environment. A new smart office building for 5,200 staffs and 100 Robots were completed and fully operational in the vicinity of Seoul, Korea. NAVER, which has been Korea's dominant search engine developer, is actively pushing the boundary of technology in a new expansion program of its headquarters. The unique feature of the building program is not just in building physical space, it also explores the hidden dimension to integrate the virtual space by pursuing Digital Twin in its operation.

In the middle of COVID-19, the client and design team developed an idea and test the possibility of having Robot as co-workers in the office space. The design team – architects and researchers – collaborated to make sure Robots are able to move around in the building without barrier. In order to achieve this, each major space is replicated in Digital Twin that makes it possible that a robot can learn the circulation and test its route by Artificial Intelligence. In other words, the whole building is a giant test-bed for continuing experimentation and interaction between humans and robots that is connected to specific cloud servers through 5G networks.

Movement of Robots has been made possible by the collaboration between architects and robot engineers. To avoid human/ robot collision, the design team devised a dedicated vertical core (robot elevator) that robots are able to use for delivery. Wide use of technologies such as facial recognition is used for a robot whether the recipient is the right person to receive the delivery.

A research team even developed an index that evaluates the level of Robot-friendliness in a Smart building as a by-product of building process. Completed building is 29 storey (135 meters high) with 168,156 sq. meters of space. Various spatial features were designed as well like user friendly parking space, big bike storage with 270 bikes that ensures less carbon emission commute.

The building boasts new state-of-the-art sustainable technologies and exploring Digital Twin technology to control the smart features of the building. With full integration of sensors at each space throughout the building, robots help deliveries and AI speakers make meeting notes like stenographers. The building's architect SAMOO architects & engineers of Korea in collaboration with NAVER Labs attempted to integrate architecture with cutting edge technologies.

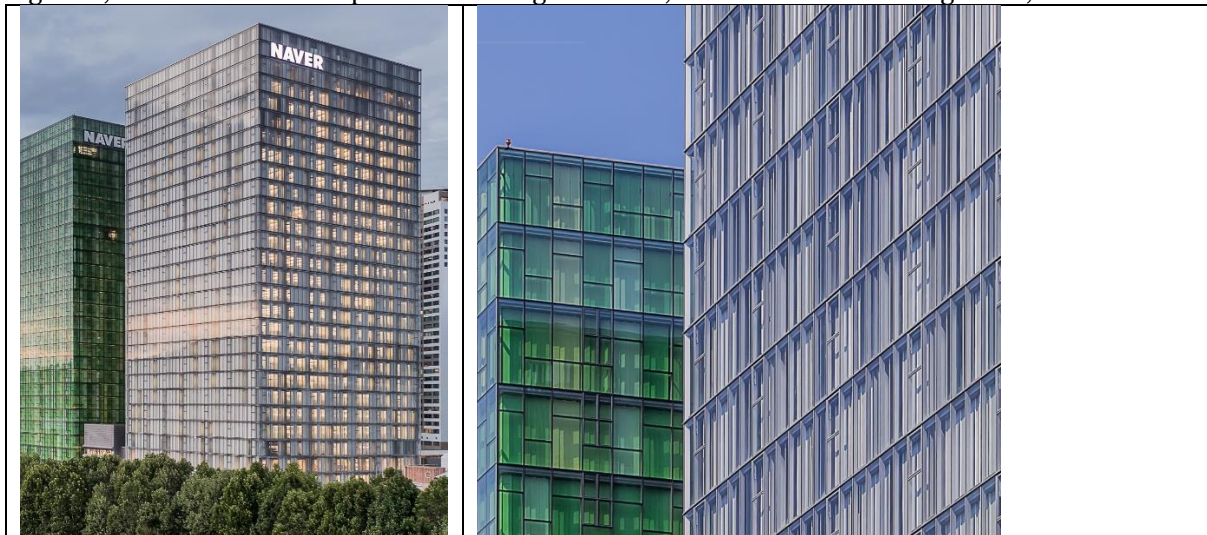
Keywords; Robot-friendly building, Digital Twin, Sustainable design, Façade system

1. Introduction

Naver Corp. has been Korea's most successful search engine developer since its inception in 1999 and the company is actively offering diverse product and services in recent years. The architectural design firm (the authors works at this firm)– Samoo architects & engineers based in Seoul, Korea- designed Naver's 1st headquarters building in 2000 and was asked again in 2015 to design their 2nd headquarters building which was to be built right next to the original headquarter.

The aim of the 1st headquarter building was to achieve maximum human comfort for IT industry workers with natural daylight control and express the new company's Visual identity with a very simple glass box. The 2nd building's design goal reflects the company's already established prestige that it gained for the last 20 years and it wanted to promote new technologies by positioning the new building as a giant lab that allow various experiments of technology and hopes to create new business opportunity such as Robotics rather than just providing typical office space. From early on in the design /planning stages, it was suggested to make a task force that combines “design + technology” development team.

Figure-1; the 1st and 2nd headquarters building for Naver, Samoo architects & engineers, 2022



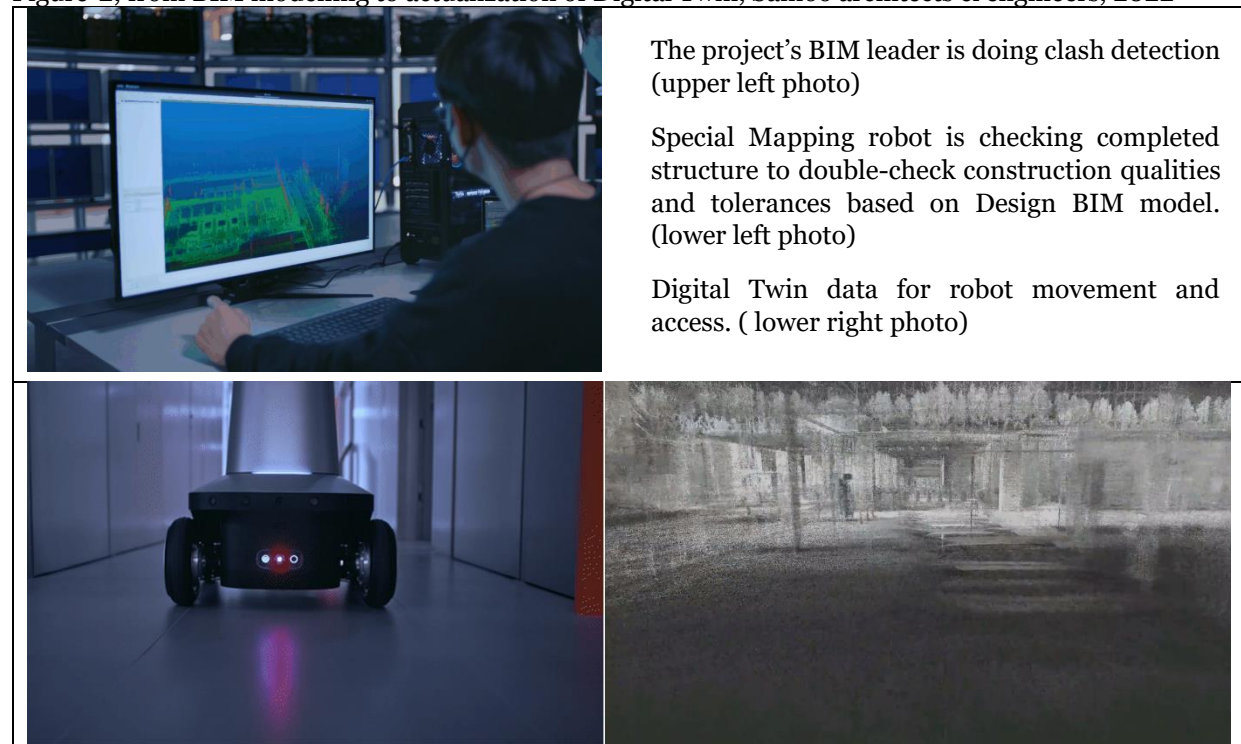
2. Design + Engineering of the project

2-1. Office building as a New Business platform

Designing 168,200 square meters of office space in a compact 29 storey building have many challenges. Especially, the client's requirement was to integrate the entire "design, engineering and construction process" as a way to revolutionize conventional building method with many innovative features.

To ensure the innovation and communication, BIM (Building Information Modelling) was essential for the building project of this magnitude. Instead of typical LOD (Level Of Development) of 200 to 300 for general building trade, LOD 400 was suggested as a target LOD for the Detail Design. This is to ensure the comprehensive quality control and sub-consultants/sub- contractors are also became important part of the project information loop. Since the final BIM model has been developed to LOD 400, the information can be constantly updated and shared to allow productivity and effectiveness during construction and construction administration. Owing to this strategic decision, the whole team is able to integrate the virtual space with physical space and therefore is able to construct "Digital Twin" during construction for its operational purposes.

Figure-2; from BIM modelling to actualization of Digital Twin, Samoo architects & engineers, 2022



In the middle of COVID-19, the client developed an idea and wanted to test the possibility of having Robots as co-workers in the office space. Robots in manufacturing industry are more common but most of the robot in these fields are fixed and not able to move since the expectation is limited to a specific tasks with precision. However, having robots as office co-worker requires developing a new generation of robot that is interacting with humans in every corner of space. The new robot is able to identify each mission's counterparts by recognizing human faces with precision. Also, a new suite of technologies required such as universal movement and access in various types of space. The client is serious in launching a new business line that is called NAVER Labs – a division dedicated for the development of new

generation of robots. The combined design team – architects and researchers – collaborated to make sure Robots are able to move around in the building without barrier. In order to achieve this, each major space is replicated in Digital Twin that makes it possible that a robot can learn the circulation and test its route by Artificial Intelligence. In other words, the whole building is a giant test-bed for continuing experimentation and interaction between humans and robots that is connected to specific cloud servers through 5G networks.

Figure -3 ; Robots line up for delivery in the new Naver building



Movement of Robots has been made possible by the collaboration between architects and robot engineers. To avoid human/ robot collision, the design team devised a dedicated vertical core (robot elevator) that robots are able to use for delivery. Typical floor is about 2,910 square meters, its lease-span is 16.35 meters, and ceiling height of 3.2 meters. By locating peripheral columns in-between its double skin, it provide an efficient work environment without creating an inch of dead space and ensure robot's universal access.

Figure -4 ; Typical floorplan of new Naver building (center robot-core in orange color)



A separate but collaborative research team even developed an index that evaluates the level of Robot-friendliness in a Smart building as a parallel research & development effort of the project.¹

Figure -5 ; physical space evaluation for Robot friendliness criteria (source- prof. Kab-Sung Kim Lab.)

III. Indicator Configure				
01 Indicator Configure				
1 Architecture and Facility Design				
Composition of detailed evaluation items for the physical space and equipment of buildings related to robot movement and task performance				
Evaluation Item	Essential / Additional	Point(s)	Indicator Name	Detailed Evaluation Item(s)
Entrance/ Access	Essential	12	✓ Facilities for supporting the entry and exit of autonomous driving service robots	<ul style="list-style-type: none"> 1.6.1 Effective width 1.6.2 Effective distance of front and rear sides 1.6.3 Exclusive entrance for autonomous mobile robots 1.6.4 Specification for cross-traffic entrance 1.6.5 Infrastructure for robot autonomous driving 1.6.6 Robot charging station
Slope	Essential	7	✓ Adequacy of the passage environment for the movement of mobile service robots	<ul style="list-style-type: none"> 1.7.1 Slope 1.7.2 Step
Sensor Installation	Additional	3	✓ Establishment of the architectural environment for utilizing sensors of mobile service robots within buildings	<ul style="list-style-type: none"> 1.8.1 Sensor Power Compatibility 1.8.2 Ambush Installation 1.8.3 Gap 1.8.4 Power Management 1.8.5 Maintenance Management 1.8.6 Direct Communication
Floor Finish	Essential	5	✓ Flooring suitable for the movement of mobile service robots	<ul style="list-style-type: none"> 1.9.1 Coefficient of Friction 1.9.2 Coefficient of Friction on Slopes 1.9.3 Material 1.9.4 Finishing Material 1.9.5 Sensor Interference 1.9.6 Shock Absorption
			✓ Blocking of obstacles that interfere	<ul style="list-style-type: none"> 1.10.1 Illuminance Range

Completed building is 29 storey (135 meters high) with built up area 168,156_sq. meters. Various spatial features were designed as well like user friendly parking space, big bike storage with 270 bikes that ensures less carbon emission commute.

2-2. Sustainable features in the 2nd Naver building

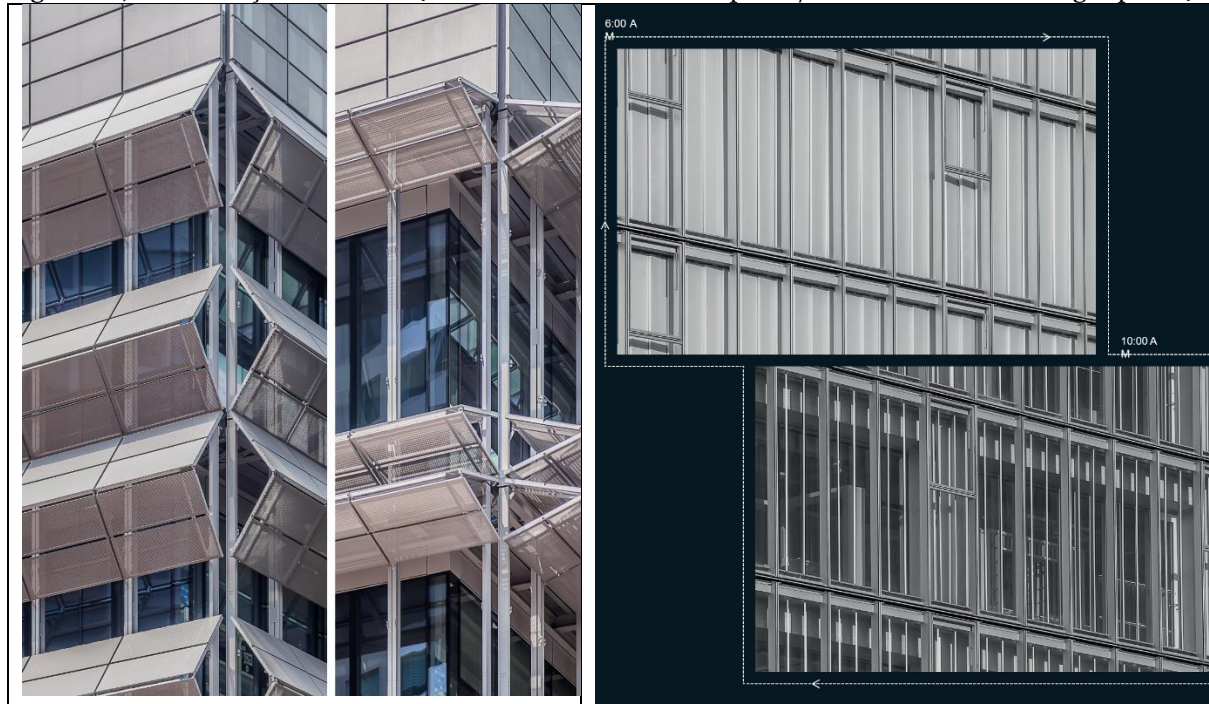
In addition to these new technologies, the building also achieved LEED Platinum of USGBC, to reduce energy use by 34% comparing with conventional office buildings. Hybrid HAVC system consisting of radiant cooling ceiling and floor air conditioning saves 13% of energy use than conventional cooling. To show its good Corporate Citizenship and pledge its Social commitment, the design team's effort focused to achieve this certification. Also, the team was conscious of a specific data that Korea is responsible for 2% of Global Carbon emission in 2020, which emits 0.55 giga tons of Carbon dioxide and eventually ranks the country as the 9th emitter in the world.²

¹ The Robot friendliness index was developed by prof. Kab-Sung Kim's lab, Urban planning Dept., College of Engineering, Yonsei university, Korea

² Data compiled by Union of Concerned Scientists 2023; <https://www.ucsusa.org/resources/each-country-share-co2-emissions>

The design along with engineering resulted in developing sophisticated façade systems. At the podium level, a movable façade system that is connected to a smart daylight control system ensures adequate level of illumination while the façade can transmit visual signs to pedestrians like a mass Card Card Stunt in Sport games.

Figure -6 ; Kinetic façade at Naver (Podium level – below left photo/ Office level – below right photo)



In typical floors, implementing a kinetic façade that responds to solar trajectories of a given day to reduce cooling load in office was adopted as well. New skin system that externally minimizes light reflection, and internally reduces light use to save energy and improving work environment has gone through many simulations and mock-ups. The kinetic skin also contributes to harmonizes the new building with the existing headquarter. Bringing new visual and place identity to the client.

When the Pandemic started in 2019, the client and the architect were fully aware the impact of remote working and reflect the meaning of “the future of Work”. With Korea’s early COVID response began to falter and workplace infection became a negative buzzword, the team went back to scrutinize conventional HVAC systems in offices. The revision of HVAC system spanned several months and finally arrive in finding and adjusting the right mix of re-circulated air therefore reduce the probability of infection at the new workplace by increasing the fresh air from outside air up to 60% and only 40% of air to be re-circulated. This is a balancing act that carefully manages the level of infection safety and remain committed in saving energy.

The building boasts new state-of-the-art sustainable technologies and exploring Digital Twin technology to control the smart features of the building. With full integration of sensors at each space throughout the building, robots help deliveries and AI speakers at meeting rooms offer to make/ distribute meeting notes like stenographers. The building’s architect SAMOO architects & engineers of Korea in

collaboration with NAVER Labs attempted to integrate architecture with cutting edge technologies.

The project's magnitude created a lot more complexity to the building design and construction team. It brought added depth and breadth when compared with the conventional building design scope. Developing Robot itself is a complex task, and the task became even more complicated when designing universal access system for Robots. Since nobody was sure how sophisticated the building requirements are. To set up the robot access criteria with clear target, it was suggested that it needs to develop an experimental "robot friendly building accreditation program" to evaluate and certify the building's Robot- friendliness. The task was implemented by Yonsei university's research team lead by prof. Kab-Sung Kim (the university's smart city research lab.) This test accreditation provided seamless continuity of project intention and benchmark so that the design team can adjust its level of expectation in determining service criteria for current and future projects.

The New Naver building provides space for a humans and robots with offering universal access and comfortable environment for both. With digital twin environment that constantly "update and upgrade", it provides a stage for the next generations of technologies are able to tested and implemented. The use of its space continues to evolve at the 2nd Naver headquarter. It is a platform designed as a framework ready to accommodate boundless possibilities of the coming future.

3. Conclusion

The unprecedented project imposed many challenges, which needs a lot of collaboration that required transparent communication. Most of these tasks were implemented in parallel track that gave additional pressure and deeper dimension to control project's communication flow.

The big lessons learned goes back to somewhat conventional motto -"Integration of all disciplines is the key" to achieve success of the project. Architects needs to tackle these advanced technological challenges with audacity and open mindedness to deliver state-of-the-art building. Architects can be at the leading team if we are determined and make ourselves familiar to these new things. Like this project's case, It is really crucial and helpful to have a guideline set by experts on "Smart buildings" in terms of Robot-friendliness. Together we stand.

Acknowledgement

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