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Design Guidelines for the Settlement With Industrial Revolution 4.0 Digital Infrastructure-Based Facilities

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ABSTRACT
Amid developments in the era of industrial revolution 4.0, technological change is growing rapidly, and it impacts directly on human life, especially in daily living life. Design guidelines are needed to optimize, integrate, independent, and sustainable spaces to accommodate human activities in settlements with proper infrastructure facilities in this era of digital technology. The writing method is qualitative with plural case studies. Design guidelines come to 5 points in the classification of its application into the architectural design in settlements with digital infrastructure-based facilities of the industrial revolution era 4.0, namely: design concepts, sustainability, efficiency, community, and security.
Keywords: *Digital, Facilities, Design Guideline, Industrial Revolution 4.0, Infrastructure, Settlement*

1. INTRODUCTION

The phenomenon of the industrial revolution 4.0, such as a state address in the annual session of the Republic of Indonesia on Thursday, August 16, 2018, President Joko Widodo said "We must be able to talk about Artificial Intelligence, the Internet of Things (IoT), and various technological advancements that almost every seconds keep updated. Indonesia must adapt quickly". Indonesia is expected to be a superior country is facing various big challenges, one of which is the challenge of industrial revolution 4.0, which is felt to have begun to change the human culture [1].
Changes in technology that are developing very rapidly and impact directly, which can provide a lot of facilities and prosperity for human life, especially in the environment of living [2].
"Supporting facilities that function to organize and develop economic, social and cultural life" [3]. "While infrastructure includes transportation networks such as roads, railways, rivers that are used as means of transportation, and utility networks such as: clean water, waste water, rainwater regulation, telephone networks, gas networks, electricity networks and waste management systems" [2].
The world development of the Industrial Revolution between 1750-1850 where there was a massive change and continues to this day in the agriculture, mining, manufacturing, transportation, technology, and architectural development sectors and has a great influence on social, economic, and cultural conditions in this world [4]. What highlights the current development is the rapid development of the world of information and communication technology that has had a tremendous impact on the advancement of human culture today. The industrial revolution can change the way we live, work, and relate to one and another [5]. Revolution as a development process that provides an opportunity to make guidelines for the design of settlements with digital infrastructure [6].
The impact of digital now is in everyday life, as well as the world of architecture in its design is also not immune from the influence of digital technology. Digital technology affects the development of the architectural world that can help produce the architectural design in the process of creating a technological design in the industrial revolution era 4.0. This simplifies the process of creating design results for the architecture world to be more efficient [7]. Utilization of technology in the work of architects can be found such as the introduction of the use of technology in architectural development now with issues of technological design concepts that can be implemented to the needs of residential development so that designers and architects have begun to think of developing technology [8].
The development of the digital technology era industrial revolution 4.0 provides opportunities and challenges for housing needs. The role of humans will slowly be taken over by automated machines and software to answer the problems that exist in the world of architecture today [8].
As a result of the impact of technological developments that increasingly dominate human life is settling, it is necessary to study guidelines in designing integrated settlements, as well as the implementation of digital technology as the main facility in it [8].

2. RESEARCH METHOD

Using qualitative research methods with a case study approach to analyze the needs of existing settlements in big cities [9]. With a plural case study approach (collective or multiple case study) [10]. Case studies use more than one location [11]; Sidewalk Toronto-Ontario, Canada, and Amsterdam, Netherlands.
In this case, research begins by paying attention and examining the phenomenon of industrial revolution 4.0, which is currently being intensively discussed [12]. The presence of the industrial revolution 4.0 produced a dominant technological role in everyday activities and human needs in settlements [13].

3. INDUSTRIAL REVOLUTION 4.0

The industrial revolution is defined as a radical and rapid change in human development in making work equipment to increase production or industrial output. Industry 4.0 is transforming of all aspects of the industry through the incorporation of digital and internet technology [14]. The structure of the industrial revolution 4.0 theory in the opinion of experts;

1) Realization of industrial concepts 4.0. Robotics and human-robot collaboration; safety and security, namely everything related to the security of the "data processing system" is guaranteed with no leakage of information data and security and safety of the use of technology for its users [15].
2) Modernization of buildings and cities is one of the consequences of technological change. The following can be highlighted for its application, including advances in computing power and Big Data [16].
3) Application of new industry 4.0 generation technology for management, integrated industrialization, informatization, modernization, planning, construction, and sustainable city development with the implementation of the internet, cloud computing, physics-cyber systems, big data, and other technologies [17].

4. SETTLEMENT

The settlement is a system consisting of five elements, namely; society, people, protection, nature, and networks. Part of the settlement called the container is a combination of three elements: nature (land, water, and air), protection (shell), and networks (networks), while the contents are humans and society. Nature is a basic element and, in that nature, creates protection (houses, buildings, and others) as a place for humans to live and carry out other functions in inhabiting [18].

Control of waste and wastewater and pollution generated by the drainage of toilets, kitchens, bathrooms, homes, and facilities as well as the consequences of the use of some electrical equipment, fossil fuels, and so on. The waste must be managed properly and uses the principle of clean production. The housing environment has human principles (humans as individuals), which includes all their personal needs, such as biological, emotional, moral, feelings, and perceptions. Society, as a human group. Shellfish (place), carrying out activities or running life, where humans as individuals or groups. Nature (natural elements), natural resources such as hydrology, topography, soil, and climate. The network is a natural or man-made system that supports the functions of the housing environment, such as roads, electricity, clean water, and so on. [19].

5. SMART CITY

Smart city in question is an integration of urban information systems, matters relating to the internet and cloud computing will be used in every field of business and integrated into the application system.

The application of smart city which is used in calculating the 70 (seventy) cities of smart city index, namely: smart governance (participation), smart mobility (transportation and ICT), smart environment (natural resources), smart people (social and human capital), smart economy (competitiveness), and intelligent life (quality of life) [20].

Smart cities are seen as a more global and systematic approach to initiatives for smart, smart city movements can potentially improve the lives of people who live in urban environments, independent, and sustainable settlements. The following structure of the theory of smart city in the opinion of experts;

1) Application layer, One of the main goals in the internet and cloud computing layer is the creation of intelligent environments such as smart buildings, smart homes, smart health, and smart industries; Network layer, consisting of a set of devices that are interconnected with various sources, resources, information, and services; The perception layer, considered as one of the environment-based layers, uses IoT as the sensor layer [21].
2) Efficient operation of a city, improve the quality of life of its inhabitants, and grow the economy of the region; smart governance that uses information and communication technology by providing web, mobile-based information, and communication systems for public services [22].
3) Smart city planners make use of new intelligent technology applications such as smart energy networks [23].
4) Sensible is the ability of software that can sense or sensor the surrounding environment [24].
5) Smart mobility is a part or dimension of a smart city specializing in the use of public transportation or community mobility [25].

6. RESULTS AND DISCUSSION

Based on the above theories, the research indicators obtained as guidelines for the design of settlements with industrial revolution 4.0 digital infrastructure-based facilities, namely;

1) Design Concept

a) It is efficient and effective, as seen from the module and configuration of the use of information and communication technology for public services in settlements.
b) Integrated, the application of new generation technology between the provision of digital infrastructure is interrelated and synergized with one another.

2) Sustainability

a) Water treatment, settlement drainage systems.
b) Waste treatment, optimization of STP (Sewage Treatment Plant), and the consequences of using some electrical equipment, fossil fuels, and so on with the latest technology.

3) Efficiency

a) Sensor optimization, how to implement sensors that use IoT for the creation of an intelligent environment.
b) Mobility is prioritizing the mobilization of activities in settlements and transportation using ICT (information and communication technology).
c) Robotic, as a collaboration between humans and robots, tries to replace human positions in completing patterned, systematic and dangerous work.
d) Big Data, the application of technological advances in computing power as a large data storage system.

4) Community

a) As an urban information system, cloud computing integrates into an application system that helps reduce the need for large data storage space.

b) Network with third parties, devices that are interconnected with various sources, resources, information, and services.

5) Security

Cybersafety and security, user security, and safety are guaranteed with no leakage of information data to irresponsible parties.

The research indicators will be further analyzed through plural case studies, so that they become guidelines for the design of settlements with industrial revolution 4.0 digital infrastructure-based facilities, namely;

1) Sidewalk Toronto-Ontario, Canada

The site is in a city on the seashore of Toronto-Ontario, Canada (see Figure 1). Waterfront Toronto first initiated this project in 2017. Sidewalk Labs, a subsidiary of Alphabet Inc. issuing requests for proposals/RFPs) regarding developing the Quayside area, aims to be an innovative discovery from the seafront of downtown neglected East Toronto [26].

Figure 1 Map of Toronto's seaside locations
Source: Map of Waterfront Toronto [27], downloaded February 23, 2020

Toronto has an East coast waterfront business center now developed by Toronto's waterfront, an organization that manages revitalization projects along the Toronto waterfront in Canada (see Figure 1). This project's main objective is to utilize technology and use it as a testing ground for urban design and technology in the future, as well as creating smart urban areas that can improve the quality of life of its inhabitants. [28].

The city of Toronto as a "smart city," which will develop 800 hectares of land by the sea into new urban space driven by technology. A sensor-enabled metropolis that is sensor-activated can automate itself on tools and equipment that utilize information and communication technology. This project aims to create a dynamic, modern, and sustainable design environment in East Toronto Waterfront. Sidewalk Toronto presented a number of proposed design features to the public, having five concepts as the most interesting and inventive design methods, namely;

a) Buildings with raincoats

Weather protection along the front of the building (see Figure 2). In this way, the objects underneath will be protected from the wind and rain. The concept is done to encourage people more comfortable outside the house to socialize, walk without having to worry about bad weather. "Raincoats" will be made from a translucent material that will appear or disappear based on weather detection. The use of building facades that use weather monitoring devices is used to measure and detect climate changes from wind speed, humidity, and air temperature. The use of climate detection devices is an embodiment of the concept of sustainability in buildings.

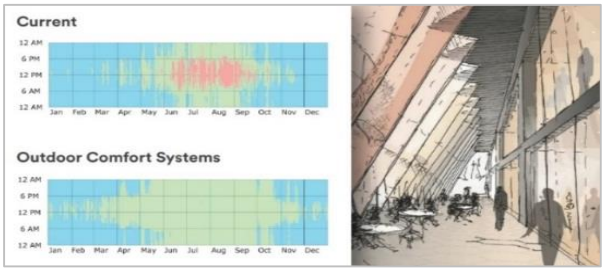

Figure 2 Climate detection façade
Source: Sketch of Facade Ideas [29], downloaded February 23, 2020

b) Underground delivery system

Sidewalk Toronto developed the idea of an underground shipping system (see Figure 3). Then Toronto also wants to create a system of package delivery of goods up and down the building (vertical) using a robot system. The use of robotics is a manifestation of efficiency. Doing a lot of work done by humans can be replaced by machines, even with better results.

Figure 3 Concept of an underground delivery system
Source: Toronto Sidewalk Schematic Pieces [30], downloaded February 23, 2020

c) Dynamic Module Pavement

Development of prototypes for reconfigurable dynamic modular pavement systems. The concept was developed by design firm Carlo Ratti Associati (CRA) (see Figure 4). All the sidewalks will have the same shape (hexagonal), and the sidewalks will be at the same level. The modular sidewalk system can help the city handle snow or ice in winter so that it absorbs quickly, making pedestrians or bicycles easier. Pavement modularity also benefits the city in terms of improvement. The system is part of realizing the efficiency of the mobility of the lane that was made specifically.

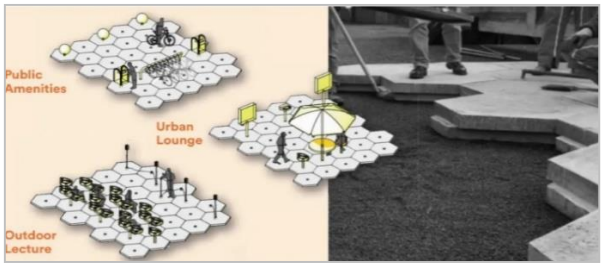

Figure 4 Dynamic Pavement
Source: Toronto Sidewalk Pedestrian Module [29], downloaded February 23, 2020

d) Parking is centralized
Prediction as innovation shows that people will rely more on autonomous vehicles that can be driven automatically to travel in the future. Then, to prevent the accumulation of private car parking on the road, developing a centralized parking system in a step to improve existing parking governance is carried out to help minimize the congestion rate of vehicle build-up caused by irregular parking. This system is a manifestation of mobility efficiency.

e) Buildings that can adapt
This adaptable building will include a green roof and sustainable systems, glass facades to control solar heat and energy efficiency, and smart sprinkler systems to make fire management more efficient.
Conceptually, the City of Toronto's design as a smart city driven by technology will be even better if the information technology used using holograms acts as optical information that displays visually 3-dimensions. Optical information is an additional feature of technology to facilitate the mass media in the delivery of information throughout the Toronto area. 3-dimensional visualization is an embodiment of the design concept, which is an additional feature of technology.

2) Amsterdam, the Netherlands
Amsterdam is the capital and most populous city in the Netherlands (see Figure 5), with a population of 866,737 in the right city, 1,380,872 in the urban area, and 2,410,960 in the metropolitan area. As the commercial capital of Amsterdam is considered a world-alpha city by globalization study groups and World cities. Therefore, the Netherlands is famous as one of the top financial centers in Europe.

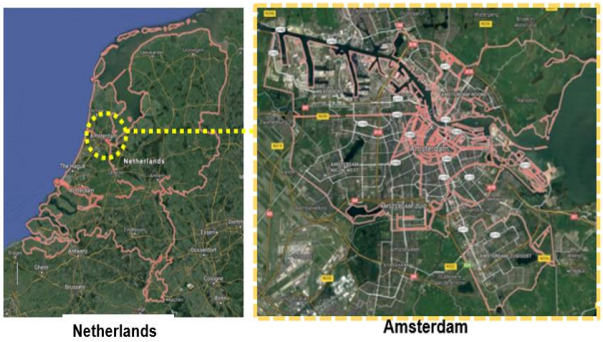

Figure 5 Map of Amsterdam locations
Source: City Map of Amsterdam [31], downloaded February 23, 2020

Amsterdam, one that started the strategy of smart cities in Europe, has followed the strategic approach of smart cities since 2008. At the moment the city is a famous smart city in Europe. The application of technology as a smart city concept in Amsterdam includes energy-efficient lighting, reduction of recyclable waste, helps reduce energy use by 10% [32], Amsterdam gave birth to the concept of an approach as a smart city taken from several indicators of existing theories, namely;

a) Amsterdam Smart City Approach
The holistic approach modeled on the concept of four layers is the key to creating a smart city, such as government, business, research institutions, and citizens. Cities include all areas of action relevant to the municipality, summarized with smart governance indicators, smart economy, smart mobility, smart life, smart people, and smart environment.

b) Smart Collaboration
Smart collaboration as a concept that makes city development successful with a platform to group ideas and solutions into six main project areas:
- Circular City (City facilities that are spread out)
- Infrastructure and Technology
- Mobility
- Energy, Water, and Waste
- Citizens and Life

c) Amsterdam's Smart City Solutions Ecosystem
This wide involvement and strong support network provide a strong foundation for testing innovative ideas and projects from technologies that work in energy processing such as electricity, gas, solar, wind, and kinetic energy, as well as other treatments such as water, waste, and climate. This processing ultimately leads to the realization of the entire smart city solution ecosystem. The solution of this ecosystem is a manifestation of sustainability that the mutual relationship between living things and the natural environment cannot be separated.

d) Activated Initiatives
First, in the world, the life of the IoT is a combination of several companies that build the 3400-meter iBeacons network in the city. IoT with the concept of the Amsterdam Smart Citizens Lab approach, which seeks to involve people in scientific discussions and to monitor their environment, such as monitoring the activities of the elderly and disabled community or sufferers of certain diseases. Smart Kids Lab helps children contribute to the city's future by equipping their children as the main resource by using open-source software and hardware to build their monitoring system. Security, surveillance cameras can also be applied to the concept of smart cities that can connect the situation between residents or users with relevant agencies. For example, in this latter case, monitoring for suspects of the Covid-19 virus can be identified through a detection device with a remote thermal camera.

e) Community Social Initiatives
The Buur smartphone application, a network with freely available third parties, acts as a collaborative low-scale platform that encourages a stronger sense of community by connecting neighbors and making them play an active role in the security of their environment. The system of the application is an embodiment of the community.

f) Mobility Initiative

Smart Flow as smart traffic management. Rely on the IoT cloud to manage and monitor Amsterdam's sensors and report traffic flow and parking availability. Smart Flow is an embodiment of mobility.

g) Circular City Initiative

Try hard not to throw anything away. Resources are reused as much as possible, and then component materials are re-managed and turned into new products. The concept of resources leads to significant reductions at both ends of the traditional linear economic cycle, namely reducing of source material and waste output.

One of the city initiatives that can be used as a modernization of buildings in Amsterdam is one of the consequences of the industrial revolution 4.0, as a result of innovations provided by new technologies, namely the cybersecurity system, to make their own decisions and carry out tasks as independently as possible.

Cybersecurity is not only to ward off internal and external dangers, but there are also shortcuts. Humans can also take over certain authority in the independence of IoT itself.

The concept of the city of Amsterdam that exists today that all the activities of the lives of its citizens have been connected with the latest technology from IoT to realize Amsterdam Smart City.

7. CONCLUSION

Based on existing theories and case studies in several countries as well as the above analysis, it is generally concluded that the design guidelines for the settlement with industrial revolution 4.0 digital infrastructure-based facilities deliver to 5 points in the classification of more compact implementations, namely;

1) Design concept

a) Efficient and effective (modules, dimensions, and operations)
b) Integrated (macro and microprograms)
c) Visually, the dominance of 3-dimensions or more

2) Sustainability

a) Energy processing (electricity, gas, solar, wind, kinetic/friction)
b) Water treatment (clean water, dirty water, sewage, and rainwater)
c) Waste treatment (organic and inorganic waste)
d) Climate change (settlement scale)

3) Efficiency

a) Sensor optimization (automation of tools and equipment)
b) Mobility (parking systems, special lanes between transportation)
c) Robotic (placement of human resources in a more appropriate place)
d) Big Data (speed and consistency of performance in activities)

4) Community

a) Cloud computing (nonphysical data storage container)
b) Network with third parties (e.g., with the government)
c) Elderly and disable supervision (monitor the lifestyle of the elderly and disabled who also live in a residential environment in general, in a house specifically)

5) Security

a) Cybersecurity (preventing abuse of digital infrastructure facilities, both external and internal settlements)
b) Surveillance cameras (linking the situation between residents or users with related institutions such as hospitals, police stations, schools, etc.

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