



TITLE:

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AUTHOR(S):

Takewaki, Izuru

CITATION:

Takewaki, Izuru. New Architectural Viewpoint for Enhancing Society's Resilience for Multiple Risks Including Emerging COVID-19. *Frontiers in Built Environment* 2020, 6: 143.

ISSUE DATE:

2020-09

URL:

<http://hdl.handle.net/2433/263011>

RIGHT:

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New Architectural Viewpoint for Enhancing Society's Resilience for Multiple Risks Including Emerging COVID-19

Izuru Takewaki*

Department of Architecture and Architectural Engineering, Kyoto University, Kyoto, Japan

The spread of COVID-19 all over the world since the beginning of the year 2020 requires a re-thinking of the meaning of the term “resilience” in the field of architecture and architectural engineering. Resilience from the viewpoint of architecture and architectural engineering has been investigated primarily in terms of conventional natural disaster risks (see, for example, Bruneau et al., 2003; Cimellaro et al., 2010; Architectural Institute of Japan [AIJ], 2020a). However, COVID-19 reminds us of the need to investigate resilience also in terms of infection risks. The places where people become infected are principally within buildings and transportation systems. Especially in buildings, three factors considered to be main risks for infection (closed spaces without ventilation, dense gatherings, close connection) often occur. For this reason, the role of architecture and architectural engineering is essential from the viewpoint of reducing the risk of infection, using versatile knowledge and technologies from the fields of architectural and regional planning. Following the appearance of COVID-19, architectural designers and engineers have an important mandate to think about the role of buildings and their related fields.

Keywords: cities and urbanization, COVID-19, infrastructure, local and regional development, manufacturing and production, resilient building, supply chain and transport, sustainability

OPEN ACCESS

Edited by:

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*Correspondence:

Izuru Takewaki
takewaki@archi.kyoto-u.ac.jp

Specialty section:

This article was submitted to
Transportation and Transit Systems,
a section of the journal
Frontiers in Built Environment

Received: 16 June 2020

Accepted: 29 July 2020

Published: 04 September 2020

Citation:

Takewaki I (2020) New
Architectural Viewpoint for Enhancing
Society's Resilience for Multiple Risks
Including Emerging COVID-19.
Front. Built Environ. 6:143.
doi: 10.3389/fbuil.2020.00143

Since the beginning of 2020, the COVID-19 virus has spread all over the world, requiring us to re-think the meaning of “resilience” in the fields of architecture and architectural engineering. In architecture and architectural engineering, resilience has traditionally been investigated primarily in terms of conventional natural disaster risks (see, for example, Bruneau et al., 2003; Cimellaro et al., 2010; Architectural Institute of Japan [AIJ], 2020a). COVID-19 reminds us of the need to also investigate resilience in terms of infection, due to the fact that the places where people become infected are principally buildings and transportation systems. At present, the three main factors that increase risk of infection (closed spaces without ventilation, spaces that encourage dense gatherings, and environments that foster close physical connections) often occur in buildings. Versatile knowledge and technologies from the fields of architectural and regional planning could play an essential role in reducing these risks. Following the appearance of COVID-19, architectural designers and engineers have an important mandate to re-think the role of buildings and other related fields.

By focusing on aspects of architecture, it is possible to consider a society of resilience that encompasses health-related risks like COVID-19 alongside conventional natural disaster risk. Aspects of “resisting ability” and “recovering ability” offer a way of classifying factors at multiple scales that might enhance resilience toward both COVID-19 risk and conventional natural disaster risk. These abilities represent the two main constitutive factors of resilience (see **Figure 1** and **Table 1**). Resisting ability describes the process of being able to “plan and absorb” (Linkov and Trump, 2019), and recovering ability corresponds to the process of being able to “recover and adapt” (Linkov and Trump, 2019). These abilities also provide new concepts of multiple scales, factoring in the human scale, building scale, regional scale, and cyber scale, among others. In conventional natural disaster risk the factors related to the human scale are not significant to its experience, but the added dimension of COVID-19 risk reminded us of the importance of taking into account these other factors, illustrated in **Table 1**. This aspect is the original point in this perspective to be focused.

As discussed here, important points in COVID-19 risk are different from those in conventional natural disaster risk. Firstly, at the **human scale** for COVID-19 risk, resisting abilities include the improvement of hand hygiene, wearing masks and faceguards, maintaining social distance, and maintaining strong immunity (through nutrition and exercise). On the other hand, recovering abilities include boosting immunity, digitization of business data, adaptation to DX (digital transformation), and the creation of communication hubs for people from various fields. These resisting and recovering abilities should also be considered for conventional natural disaster risks, except for the maintenance of social distance which drives the three

occurrence probabilities (closed spaces, dense gatherings, close connections), which increase the risk of transmitting and contracting COVID-19.

Secondly, at the **building scale** for COVID-19 risk, resisting abilities include ventilation planning to prevent aerosol infections, flow line planning to prevent unnecessary human contact, equipment planning (electricity, water supply, and drainage), and structural engineering planning for building space usage. On the other hand, recovering abilities include the flexibility to make changes to building usage (hotels, rental residences, care facilities), digitization of design data (DX adaptation), promotion of building information modeling (BIM) technology, and shelter planning in maintaining social distance. While the reduction of vulnerabilities in buildings is usually considered to be the main objective for conventional natural disaster risk; the primary focus for COVID-19 risk is the prevention of infection and an increase of flexibility in how buildings are used. This is a new analysis, differentiating between the characteristics of conventional natural disaster risk and COVID-19 risk.

Thirdly, at the **regional scale** for COVID-19 risk, resisting abilities include changes in commuting style (time-lag commuting, flex time), promotion of telework (DX adaptation), avoidance of dense dwellings and workplaces, leading to reduction of concentration. In addition, return to provincial areas (pastoral city planning) could also lead to reduction of concentration, as could the renovation of old houses and buildings for remote working. Furthermore, the planned relocation of hospitals, schools, and city halls, as well as the distributed allocation of the main functions of a company, could also lead to a reduction of concentration. On the other hand,

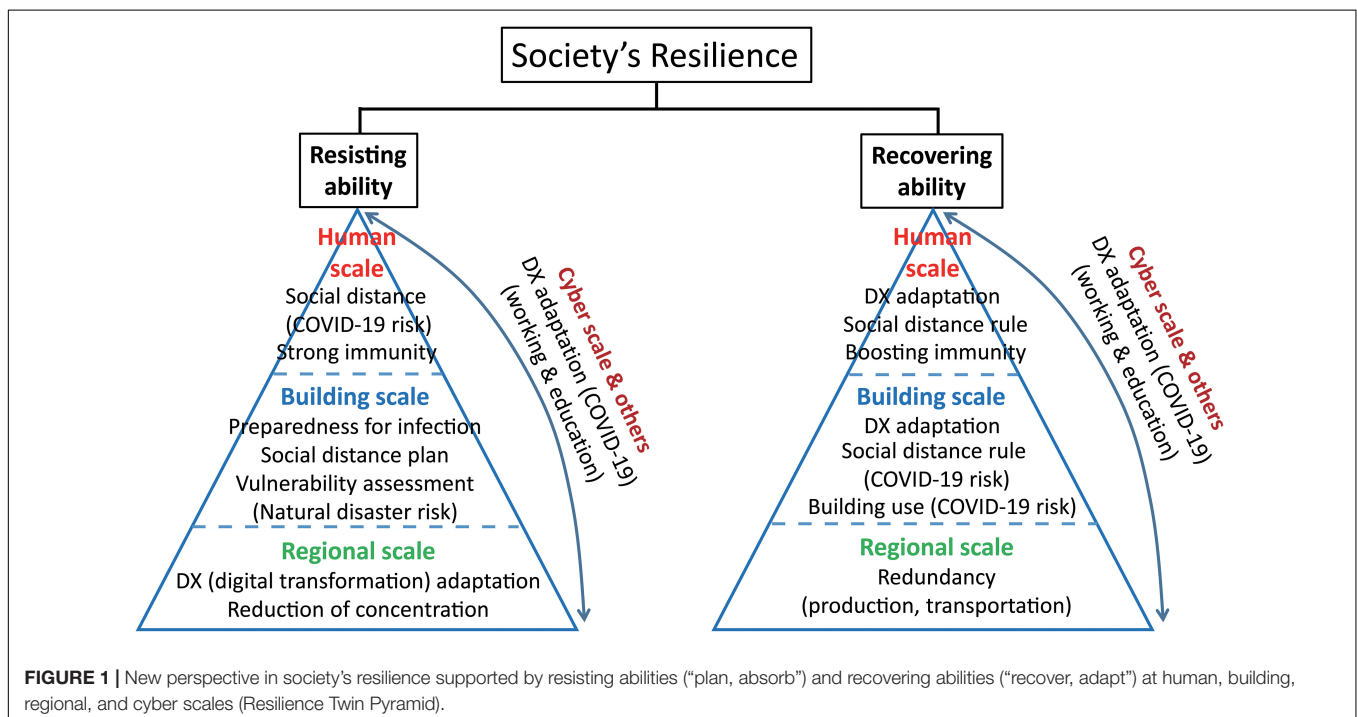


TABLE 1 | Classification of factors in several scales enhancing resilience for COVID-19 and natural disaster risks.

	COVID-19 risk			
	Natural disaster risk			
	Human scale	Building scale	Regional scale	Cyber scale and others
Resisting ability ("plan, absorb")	Strengthening of hand hygiene	Ventilation plan	Change of commute style (Time-lag commute, Flex time)	Online ability of working tool and data in company (DX adaptation)
	Wearing of mask and faceguard	Flow line plan (Prevention of unnecessary people's contact)	Promotion of telework (DX adaptation)	Online ability of educational tool (DX adaptation)
	Keep of social distance	Equipment plan (Electricity, water supply and drainage)	Avoidance of dense dwelling and working	Strengthening of global analysis ability of information
	Keep of strong immunity (Food and exercise)	Structural engineering plan	Return to local area (Pastral city plan), Renovation	Advanced use of AI and robotics technologies for architectural design and construction
Recovering ability ("recover, adapt")	Boosting immunity	Flexibility for change of building use (Hotel, rental residence, care facility)	Multiplication of supply chain	Insurance
	Digitization of business data	Digitization of design data (DX adaptation)	Strengthening of domestic production	Keep of internal reserves
	Adaptation to DX (Digital transformation)	Promotion of BIM technology	Strengthening of home delivery service	Online of subsidy from government to company and people
	Construction of communication hub with people in various fields	Shelter plan for keeping social distance	Duplication of transit and transportation	Producing ability of multiple different products
				Strengthening of intelligence network
				Advanced use of AI and robotics technologies for architectural design and re-construction

recovering abilities include the multiplication of supply chains, strengthening of domestic production, strengthening of home delivery services, and duplication of transit and transportation options. For COVID-19 risk, the prevention of infection and the multiplication and increased diversity in social activities are a strong point of focus in differentiating the characteristics of conventional natural disaster risk from those of COVID-19.

Finally, at the **cyber scale and others**, resisting abilities include the online abilities facilitated by working tools and data sets within companies (DX adaptation), and the online ability of educational tools (DX adaptation). Other resisting abilities include the use of advanced technologies such as AI and robotics in architectural design and construction, and as a way of strengthening the global analysis of information. Recovering abilities include insurance contracts, maintenance of internal reserves, subsidies from the government to companies and people, the production capability of multiple different products, advanced use of AI and robotics technologies for

architectural design and re-construction, and strengthening intelligence networks. In the past, most natural disasters have occurred locally, making it unnecessary to respond to disasters at a national or global scale. However, nationwide responses, such as DX adaption, are necessary in managing COVID-19 risk. It should be noted that the cyber scale encompasses all human, building, and regional scales (see **Figure 1**).

Several previous studies in the field of resilience science are closely related to this perspective, which factors in health and pandemic related risk. Four domains of resilience (physical, cyber/information, cognitive, and social) were introduced in studies by Linkov et al. (2014, 2018), and Linkov and Trump (2019). Each of these studies define "resilience" as the ability to absorb/respond, recover, and adapt. Linkov et al. (2014) have discussed the concept of resilience from the viewpoint of the relationship between risk and the resilience management, by assessing the resilience of a town facing various risks including those of infection. This study discussed factors related to the

human scale historically, including those effecting the city of Venice during a plague in the fourteenth century. They conclude that better overall system management can be achieved in the face of unknown or unquantifiable threats by integrating risk and resilience management and assessing the system over multiple domains: including the physical, those related to information, the cognitive and the social. Although it was not aimed at the field of architecture, a notion of resilience directly related to COVID-19 was also discussed by Hynes et al. (2020). Similarly, Kurth et al. (2019) have presented a comprehensive review mainly from the viewpoint of conventional natural hazards, except for infection risks. They discuss related notions of functionality, recovery, adaptation, indeterminacy, modeling and uncertainty, regulatory mechanisms, economic challenges, and so forth. It is expected that these notions and ideas will in future be applied to infection risks such as COVID-19.

Over the next 100 years, the fields of architecture and architectural engineering are expected to play an important role in responding to and overcoming infection risks as well as natural disaster risks. Since resilience enhancing factors comprising the human scale, building scale, regional scale, cyber scale, and others have strong and complex correlations, it is necessary to

consider systematic challenges and evolve examination of risk in architecture and architectural engineering. In response, the Architectural Institute of Japan launched the COVID-19/HUB (see Architectural Institute of Japan [AIJ], 2020b) in June 2020, a forum on its homepage for institute members to submit useful information. Although it is important to note that cultural circumstances and technologies are different from country to country (and that the perspectives presented here may be affected in this way), the essential points underlying this discussion may be of use.

AUTHOR CONTRIBUTIONS

IT wrote the whole perspective.

ACKNOWLEDGMENTS

I grateful to Dr. Thomas Daniell, Professor of Architecture and Architectural Engineering, Kyoto University, for providing valuable comments for revision.

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