

Activities by Nippon Steel Corporation and Group Companies for National Resilience

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Abstract

Natural disasters such as localized heavy rains, typhoons, and huge earthquakes have recently become more frequent and severe, causing enormous damage to people's lives. Nippon Steel Corporation has built a cooperative framework with group companies (Nippon Steel Group) and been expanding our activities for disaster prevention, mitigation, and national resilience. This paper introduces examples of representative products and solutions developed and deployed by the Nippon Steel Group that contribute to national resilience, based on the characteristics of steel construction materials and steel structures, and discusses the current status and future potential of the Group's collaborative activities.

1. Introduction

Japan has historically and repeatedly suffered major disasters due to its land characteristics. In recent years, natural disasters such as storms and floods have increased in severity and frequency under the effects of climate change. There was the 2016 Kumamoto Earthquakes and the July 2018 West Japan Heavy Rainfalls, both with a heavy death toll. The Typhoon Hagibis in 2019 brought about huge economic losses. Various disasters, such as earthquakes, heavy rains, torrential rains, and volcanic eruptions, have occurred and caused enormous damage to people's daily lives. There is also a high probability of the occurrence of large-scale earthquakes in the near future, including the Nankai Trough Earthquake and the Tokyo Inland Earthquake. Furthermore, without immediate measures to counter the obsolescence of infrastructure facilities constructed successively since the high economic growth period, our socio-economic system may malfunction.

Given these situations, the Japanese Government established the Basic Act for National Resilience Contributing to Preventing and Mitigating Disasters for Developing Resilience in the Lives of the Citizenry¹⁾ in 2013, followed by the Five-Year Acceleration Plan for Disaster Prevention, Disaster Mitigation, and Building National Resilience²⁾ in 2020. On this basis, the government is promoting three measures: (1) countermeasures against increasingly severe storms and floods and imminent large-scale earthquakes, (2) obsolescence

mitigation measures to shift to preventive maintenance of infrastructure, and (3) digitalization to efficiently promote measures related to national resilience.

To prepare for these natural disasters, disaster prevention as well as mitigation infrastructure and higher safety infrastructure are required. The steel industry and the Nippon Steel Group can contribute to national resilience by proposing products and methods that make the most of the features of steel structures: "lightweight construction materials," "quality stability by mill production," and "toughness due to high deformation performance." As aging infrastructure rapidly increases, there is a problem of decreasing construction workers who can carry out efficient inspection and repair as required for the proper maintenance and management of the infrastructure. Steel building materials prefabricated at shops and construction methods help to achieve labor saving or rationalizing construction operations and have extremely important roles to play in achieving national resilience.

This paper reviews the features of steel building materials and steel structures and introduces the Nippon Steel Group's representative products and solutions that contribute to national resilience.

2. Features of Steel Products and Steel Structures³⁾

Steel is a material with high strength and toughness and is extremely easy to weld and cut. It is an industrial product manufac-

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tured at steelworks under strict quality control. It has excellent quality stability at high levels and is extremely recyclable as material suitable for a recycling-oriented society.

Steel structures built by using steel have excellent strength and deformation performance. Various steel products and construction methods can be provided as measures against extremely severe disasters such as earthquakes, tsunamis, and debris flows. Rational designs that make full use of these functions make it possible to make steel structures lighter, more compact, and slimmer. Our steel products are easy to install in narrow areas and can contribute to the improvement of on-site productivity. Steel structures built of factory-prefabricated members help to shorten the on-site construction time. Our customers can rebuild their steel structures soon after disasters, enjoy the economic benefits of early restoration, and ensure their business continuity. These steel structures are expected to be effective in reducing economic losses, including traffic restrictions during the construction period. Steel is inherently exceptionally reliable in functional quality. When appropriately selected, steel can contribute to the construction of facilities with excellent long-term durability. Steel can also prove superior from a life cycle cost standpoint.

The merits of using steel have long been recognized. Many steels and steel structures have been used in the development of social infrastructure such as transportation infrastructure. To build national resilience, it is necessary to take hardware measures such as disaster prevention and mitigation infrastructure and also to repair or replace infrastructure. To satisfy these needs, the Nippon Steel Group develops and provides high-performance steels with excellent strength, toughness, and durability. The company also combines and deploys solutions that include structures and construction and design technologies to make full use of the properties of steel.

3. Nippon Steel Group’s Initiatives to Build National Resilience

Since the end of 2018, the Nippon Steel Group has established and strengthened a system of initiatives to build national resilience and has decided to strongly perform group-wide activities on a nationwide scale. The group companies established the “National Resilience Working Group” and launched cross-company initiatives to develop products that are better suited to government policies. **Table 1** lists major Nippon Steel Group companies that have displayed their products at exhibitions nationwide. Including these companies, 19 group companies are currently participating in the National Resilience Working Group. **Figure 1** shows representative target fields and major examples of risk mitigation products.

3.1 Initiatives in river basin flood control field

Flood disasters have been increasing in severity and frequency

Table 1 Group companies of the Nippon Steel Group

NIPPON STEEL CORPORATION
NIPPON STEEL ENGINEERING CO., LTD.
NIPPON STEEL Chemical & Material CO., LTD.
NIPPON STEEL Stainless Steel Corporation
NIPPON STEEL METAL PRODUCTS CO., LTD.
NIPPON STEEL ANTI-CORROSION CO.,LTD.
NIPPON STEEL COATED SHEET CORPORATION
GEOSTR Corporation
NIPPON STEEL TECHNOLOGY Co., Ltd.
NIPPON STEEL PIPELINE & ENGINEERING CO., LTD.
NIPPON STEEL WELDING & ENGINEERING Co., Ltd.

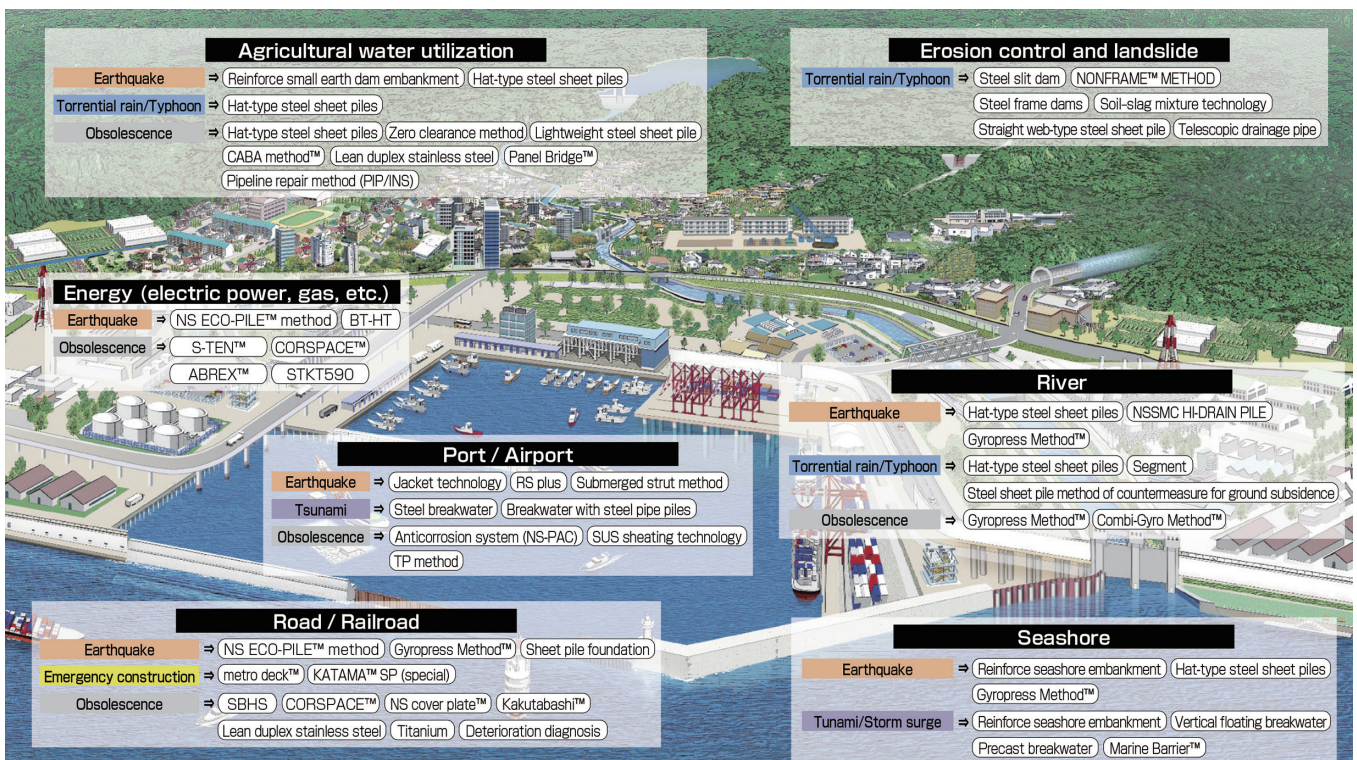


Fig. 1 Contributions in each field and application examples by the Nippon Steel Group for national resilience

under the effects of climate change. Typhoon Hagibis in 2019 wreaked damage amounting to 1.86 trillion yen, the largest amount of damage caused by a single flood since the start of statistics and also the largest amount of damage caused by flood disasters in the same year. Against this background, the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) is reviewing everything from flood control plans based on past records to flood control plans that consider increasing rainfalls due to climate change. The ministry is also implementing a river basin flood control project. Under the project, a catchment area, a river area, and a floodplain are treated as a single basin area. Pre-disaster control measures, including measures to prevent flooding in the entire basin area, measures to reduce flood areas and to lessen flood damage, and measures to achieve early restoration, are implemented in multiple layers by combining hardware and software. Budgetary measures are implemented. Flood control projects are formulated for a total of 121 river systems nationwide. Specific measures are underway. Considering the occurrence of dike breaches in 142 places during Typhoon Hagibis in 2019, the ministry has started a study aimed at building “resilient river dikes” that do not easily break while overtopped.

The Nippon Steel Group has product lines as shown in **Table 2** to contribute to river basin flood control and to the construction of “tenacious dikes.” Some products have worked well in construction projects. (Products under development are included in Table 2.)

Flood control dams are constructed and renovated to prevent flooding in the upper river areas. When dams are reconstructed, their

flood control functions must be augmented. Duplex stainless steels are used in the additional works of water intake facilities and effluent pipes. Steel sheet pile piles and steel pipes are effectively used to build temporary earth retaining walls and piers, respectively, to aid in the reconstruction of dams. The lean duplex stainless steel NSSC 2120 of the Nippon Steel Stainless Steel Corporation is an effective material that supports the service life extension of facilities. It is also a characteristic product⁴⁾ with its cost lowered by reducing the nickel content (**Fig. 2**).

Regulating reservoirs and diversion channels are key inland flood control measures. Nippon Steel first supplied NM segments



Fig. 2 Application examples of NSSC 2120 for dam facilities⁴⁾

Table 2 Contributions by the Nippon Steel Group for flood control along river area

Basin area	Countermeasure construction	Construction method	Variety	
Upper river area	Dam construction/reconstruction	Water intake facility (corrosion protection)	Duplex stainless steel (Nippon Steel Stainless Steel)	
		Foundation construction	Steel and precast formwork (GEOSTR)	
		Temporary retaining wall	Steel pipe sheet piles (Nippon Steel)	
		Temporary frame structure	Steel temporary frame structure (Nippon Steel)	
	Small earth dams flood control utilization	Dike reinforcement	Steel sheet piles (Nippon Steel)	
		Fill material	Slag (Nippon Steel)	
Lining substitution		Slag (Nippon steel)		
Floodplains	Inland flood	Underground river	Steel/composite segment (Nippon Steel)	
		Underground water storage		
		Flood barrier wall	Steel sheet piles (Nippon Steel)	
River area	Channel improvement	Earth retaining walls	Gyropress Method™ (Nippon Steel, GIKEN) Petrolatum & titanium cover (Nippon Steel Anti-Corrosion)	
		Consolidation work	Steel shell caissons (Nippon Steel Engineering)	
		Energy absorbing structure (corrosion protection)	Duplex stainless steel (Nippon Steel Stainless Steel)	
		Temporary frame structure	Steel temporary frame structure (Nippon Steel, HIROSE)	
		Excavation of the river bed/ countermeasures against scouring	Reinforcement of bridge pier foundations	Steel sheet pile foundation (Nippon Steel, Railway Technical Research, OBAYASHI)
	Dike maintenance	Embankment	Embankment material	Slag (Nippon Steel)
		Dike raising	Countermeasure for ground settlement	Steel sheet piles (Nippon Steel)
	River dike reinforcement	Free-supporting	Double steel sheet pile walls	Steel sheet piles (Nippon Steel)
		Surface-coated	Gabion works	Galvanized steel wire (Nippon Steel)



Fig. 3 Steel barrier wall for flood control: under construction (left) and completion (right)⁶⁾

for use in a regulating reservoir in the Neyagawa River, Osaka. Since then, the NM segments have been used in the construction of underground tunnels. Recently, Nippon Steel has been working to develop a new version of NM segments with longer durability and higher seismic resistance.⁵⁾ Steel barrier walls (**Fig. 3**)⁶⁾ are increasingly constructed as flood control measures in urban areas. Steel barrier walls (steel sheet piles) with a height of about 2 to 3 m are installed around factories and other important facilities. They function as important barriers against flooding and oil runoff from factories.

Many improvement works are carried out in rivers. Steel sheet piles and steel pipe sheet piles are sometimes used to build earth retaining walls for channel widening. The TP method (Nippon Steel Anti-Corrosion Co., Ltd.) is often used as a corrosion protection measure in this case. With the TP method, a steel sheet pile or steel pipe sheet pile is coated with a petrolatum (petroleum residue) based corrosion inhibitor and covered with a protective titanium sheet. This barrier corrosion protection method is mainly used for repair. Steel shell caissons (Nippon Steel Engineering Co., Ltd.) are sometimes used in consolidation works. Temporary piers are generally used for construction works in rivers. Instead of conventional H-shaped steel beam piers, long-span temporary piers constructed of steel pipes are increasingly used. Nippon Steel is working to achieve more labor saving and higher safety in such works.⁷⁾ Recently, use of the reinforced foundation by sheet-piles (Nippon Steel) is increasing. This method reinforces bridge pier foundations with steel sheet piles. It is often considered for use when the safety of bridge pier foundations is threatened by the excavation of the river bed to secure the river channel or when the river bed is scoured.

There is also concern about the occurrence of floods that exceed the capacity of flood control facilities. Even in such cases, it is pointed out that it is necessary to reinforce the river dikes to limit the flood damage as much as possible. Nippon Steel has been working on the development of a partially free-supporting dike with steel sheet pile double walls as one technology to reinforce the dike so that it does not become unstable. Nippon Steel is engaged in publicly invited research organized by MLIT and adopted and represented by Professor Takahashi of the Tokyo Institute of Technology. The partially free-standing dike technology is now being refined through this industry-government-university collaboration. The specific development status of the technology is described in the technical paper No. 130-05⁸⁾ in this No. 130 issue of the Nippon Steel Technical Report (NSTR). Another method to strengthen dikes against overtopping is to cover the dike with concrete or sheets. Use of galvanized steel wire mats (Nippon Steel) and steel cages made of steel bars and welded steel wire meshes (Nippon Steel Metal Products Co., Ltd.) is also expected in this application.

3.2 Initiatives in other fields

As shown in Fig. 1, the products of the Nippon Steel Group are diverse. Since it is difficult to introduce all of them here due to

space limitations, representative fields and example products are introduced below.

3.2.1 Initiatives in agricultural irrigation field

Small earth dams are agricultural irrigation facilities to provide water for agricultural use and are also used for flood control in the upstream area in the above-mentioned river basin flood control system. The need has been pointed out for repairing and reinforcing small earth dam embankments that may lack in seismic resistance or that may leak. Nippon Steel has developed and commercialized methods for repairing and reinforcing small earth dam embankments by using the steel sheet pile method and the slag method. The details are described in the technical paper No. 130-06.⁹⁾

3.2.2 Initiatives in erosion control and landslide field

In the erosion control and landslide field, the effects of reducing damage to sand control dams in the Kumamoto Earthquake were highlighted in the 2017 White Paper on Land, Infrastructure, Transport and Tourism in Japan. After that and in the wake of massive driftwood disasters caused by the Northern Kyushu Heavy Rainfall in July 2017, MLIT advised that new and renovated erosion control dams should be “facilities with permeable structures (or steel slit dams)” in principle. Nippon Steel Metal Products developed type AB steel slit dams (**Fig. 4**) and started marketing them in April 2022. This type AB steel slit dam has higher load bearing capacity and improved safety against the collision of gravel groups during debris flow overtopping when compared with existing erosion control dams. It is a product with great economy and is issued with a construction technology review certificate by the Sabo & Landslide Technical Center.

3.2.3 Seismic control measures for buildings

Nippon Steel offers a wide range of solutions with steel frames and steel building materials to deal with major earthquakes that are as severe as flood disasters. Many technology proposals for structures that can withstand earthquake ground motions are described in this issue No.130 of the NSTR. Other methods include damping structures that reduce earthquake ground motions to buildings and seismic isolation structures that do not transmit earthquake ground motions to buildings. Nippon Steel Engineering has developed and commercialized damping devices, such as Unbonded Braces and



Fig. 4 Steel slit dam (AB-type)

NS-SSB™, and isolation devices (Fig. 5).^{10,11)} In addition, titanium roof tiles are a characteristic solution that improves the seismic resistance of buildings by reducing their weight.

3.2.4 Obsolescence mitigation measures for bridges

Obsolescence mitigation measures are important initiatives in the road and railroad bridge field. Facilities built during the high economic growth period and more than 50 years old will increase at an accelerated pace in the future and are now rapidly deteriorating. From the viewpoint of national resilience, there are increasing needs for bridge renewal, inspection, and repair. Needs for technologies to realize “safety and security” efficiently and economically are only increasing. The S-C.A.P. steel deck replacement method¹²⁾ introduced in the technical paper No. 130-10 is a technology jointly developed with Yokogawa NS Engineering Corp. The S-C.A.P. method can replace obsolete bridge RC decks while minimizing traffic restrictions. In addition, the life cycle cost (LCC) of bridges can be reduced by using corrosion-resistant steels for steel bridges. One such steel is CORSPACE™ (Fig. 6).¹³⁾ In the 9th “Monodzukuri Nippon Grand Award” ceremony in January 2023, Nippon Steel was awarded an excellence prize for the “development of CORSPACE™, a steel that helps to extend the painting cycle and hence contributes to the life cycle cost reduction of steel bridges and harbor facilities”. Nippon Steel will continue to greatly contribute to the realization of a sustainable society and to the construction of a safe and secure society by minimizing the maintenance of steel structures such as bridges and harbor facilities, extending their service life and painting cycle, and consequently reducing their environmental impact.

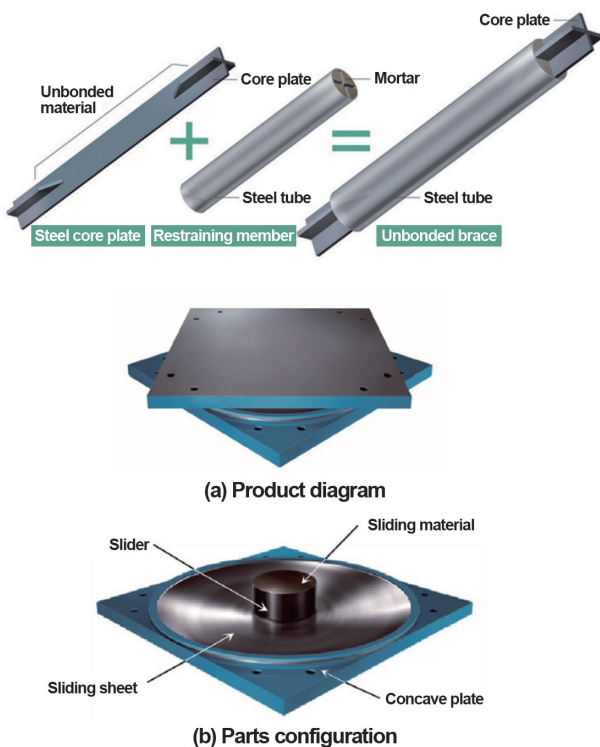


Fig. 5 Anti-earthquake solution by Nippon Steel Engineering Co., Ltd. (Unbonded Braces above, NS-SSB™ below)^{10,11)}

4. Proposal of Solutions by Nippon Steel Group

Nippon Steel and its group companies have a wide range of steel structure products and construction methods that contribute to our national resilience. The ability to respond to various needs is being strengthened. Nippon Steel will clearly show the solutions that can be provided by the product groups of the Nippon Steel Group to meet specific disaster types or disaster control measures for varying regions and fields and will make more specific proposals. Pamphlets and leaflets are prepared as shown in Fig. 7. In April 2022, Nippon Steel began to use videos so that customers can more readily understand our products and technologies (Fig. 8).¹⁴⁾

The Nippon Steel Group actively displays its products and technologies at exhibitions. First with the “Construction Technology Exhibition 2022 Kanto” and then from the “Hokkaido Disaster Risk Control Measure Promotion Exhibition 2022” to the “Advanced Construction and Disaster Prevention and Mitigation Technology



Fig. 6 Application example of CORSPACE™ (Higashiharimanamboku Road)¹³⁾



Fig. 7 Main brochures on each field for national resilience



Fig. 8 Video brochures of steel products and solutions for national resilience¹⁴⁾

Fair in Kumamoto 2022,” our products and technologies were displayed at eight exhibitions nationwide in fiscal 2022 and the initiatives of the Nippon Steel Group were introduced at the exhibitions.

These series of initiatives and activities will help our customers to clearly understand the construction time reduction, labor saving, service life extension and other features of our steels and steel structures and to use our steels and steel structures more readily. In this way, Nippon Steel would like to contribute to our national resilience.

5. Conclusions

Amid the increasing frequency and severity of torrential rains, typhoons, huge earthquakes, and other natural disasters, this report has introduced some of the representative products and solutions developed and deployed by the Nippon Steel Group to contribute to urgent disaster control, disaster mitigation, and national resilience measures. Nippon Steel and its group companies have a wide range of steel and steel structure products and construction methods that contribute to national resilience and are constantly improving their capabilities to respond to various needs. As is clear from the product groups introduced here, the Nippon Steel Group offers not only products, but also comprehensive solutions that combine products with their utilization technologies.

Nippon Steel is continuously working to have our products and technologies deeply understood so that tangible contributions can be made to our customers. To build a safe and secure nation, Nippon Steel will continue to seek and improve safety and reliability by making use of the advantages of our steels and steel structures and to have their benefits understood by the managers of social infrastructure and the residents who use the social infrastructure.

In the future, it will be necessary not only to contribute to national resilience, but also to provide new added values to society. Carbon neutral initiatives are essential in the infrastructure field as

well. It will become important for Nippon Steel and its group companies to collaborate beyond their respective business scope, work to solve social issues while demonstrating their respective strengths, and contribute to the realization of a sustainable society in the future. Nippon Steel would like to expand and strengthen our initiatives to these objectives.

Finally, many of the products and technologies introduced here have been developed through joint research not only with the companies of the Nippon Steel Group, but also with partner companies and customer companies. Nippon Steel would like to express our gratitude here. Nippon Steel will continue to collaborate with various stakeholders to further strengthen our contribution to national resilience and to ensure the safety and security of the people and the preservation of the national land.

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