Developments and Accomplishments of Disaster Prevention Products and Technologies by JFE Metal Products & Engineering†

ASAI Nobuhide[*1] YAMAGUCHI Masakatsu[*2]

Abstract:

Japan is a country surrounded by the sea, and 70% of the land is formed by hills, plateaus and mountains. It is prone to natural disasters such as typhoons, earthquakes, and abnormal weather due to its steep geographical features. JFE Metal Products & Engineering has developed and supplied a wide range of disaster prevention products and technologies to protect the land from these various disasters aiming at contributing to creating safe and secure infrastructures. In this paper, developments and accomplishments of disaster prevention products and technologies by JFE Metal Products & Engineering are described along with on-going activities including countermeasures to the Great East Japan Earthquake.

1. Introduction

In Japan, 70% of the land area consists of hills, plateaus, and mountains with steep geographical features, forming an environment which is prone to natural disasters due to typhoons and abnormal weather.

Natural disasters have frequently occurred in Japan in recent years. Due to repeated earthquakes and localized torrential rains, and an increasing number of typhoons making a landfall or approaching the country, damage due to wind and rain and sediment-related disasters such as natural damming of rivers by landslides have become increasingly serious problems with each passing year. As a result, increasing the ratio of construction of disaster-prevention facilities in areas with a danger of sediment-related disasters and landslides has become an urgent matter. During fiscal year 2010, Japan experienced 235 mud and debris flow disasters[1)], which was close to 1.5 times the average number (167) during the previous 5 years, and in FY 2011, the country suffered unprecedented damage due to the Great East Japan Earthquake and typhoons 1112 (Talas) and 1115 (Roke), etc. Recovery and reconstruction following these disaster demands a national response.

JFE Metal Products & Engineering handles disaster prevention products and is engaged in disaster prevention projects, and is working to improve its products and expand its product line in order to contribute to the creation of safe and secure infrastructure. This paper introduces the history of disaster prevention products at JFE Metal Products & Engineering, product expansion, improvement and product line enhancement, and on-going activities in disaster-prevention projects up to the present. “Developments and accomplishments in disaster prevention” by JFE Metal Products & Engineering aiming at further contributions to disaster prevention projects are described, including efforts related to recovery and reconstruction following the Great East Japan Earthquake and preservation of the land and ecosystems.

2. Frequent Natural Disasters

Natural disasters can be broadly classified as meteorological disasters, which occur as a result of various atmospheric phenomena such as rain, wind, snow, climate, and the like, and earthquake and volcanic disasters, which are caused by phenomena occurring in the Earth’s interior, such as earthquakes, volcanic eruptions, etc.[2)].

In particular, recent years have seen an increasing

† Originally published in *JFE GIHO* No. 31 (Jan. 2013), p. 23–27

[*1] Manager,
Disaster Prevention Sec.,
Civil Engineering Dept.,
JFE Metal Products and Engineering

[*2] Deputy Manager,
Disaster Prevention Sec.,
Civil Engineering Dept.,
JFE Metal Products and Engineering

number of localized torrential rains, which are one phenomenon inducing meteorological disasters. The number of downpours with precipitation of 50 mm per hour or more is approximately 1.5 times greater than 30 years ago. Daily rainfall of 200 mm or more has also increased by about 1.5 times. Considering the predicted high possibility that this tendency will continue in the future, the risk of floods and sediment-related disasters will increase[3].

On the other hand, Japan also has 108 active volcanos and suffers more than 10 volcanic eruptions or anomalous non-eruptive volcanic events each year[4]. Thus, there is also a significant risk of disasters due to volcanic cinders, ash, mud flows, and debris avalanches.

2.1 Streams and Rivers with Danger of Mud and Debris Flows and Slopes with Danger of Slope Failure

Streams and rivers with danger of mud and debris flows and slopes with danger of slope failure are a latent factor in disasters. The results of a survey of these locations have been announced[1], showing that a total of 184 000 such stream and river locations exist in Japan, of which 90 000 fall under Class I, that is, affect 5 or more houses. Nationwide, 330 000 slopes with danger of slope failure were found, and of these, 114 000 are Class I, affecting 5 or more houses. Thus, increasing the ratio of disaster-prevention facilities at these locations is urgently needed for disaster prevention. Together with "hard" type countermeasures by erosion control (sabo) projects, slope failure countermeasure projects for dangerous slopes, and the like, "soft" measures are also being promoted based on the Law Related to Promotion of Measures for Sediment-related Disaster Prevention in a Restricted Area etc. due to Sediment-related Disaster[5].

2.2 Earthquake Disasters

Large-scale earthquake disasters have occurred in Japan and other countries. Earthquakes are a frequent occurrence in many parts of Japan. Representative examples include the 1993 Hokkaido Nansei Oki Earthquake, 1995 South Hyogo Earthquake (Kobe Earthquake), 2004 Niigata Chuetsu Earthquake and 2007 Niigata Chuestsu Oki Earthquake, 2007 Noto Peninsula Earthquake, and 2008 Iwate-Miyagi Nairiku Earthquake. Japan also suffered unprecedented damage as a result of the Great East Japan Earthquake and Tsunami on March 11, 2011. Large-scale earthquakes are predicted to continue in the future, and a high probability of a Tokai-Tonankai-Nakai coupled earthquake, mega-earthquake directly under the Tokyo Metropolitan area, and other gigantic earthquakes has been announced[6].

2.3 Sediment-related Disasters

In recent years, a large number of sediment-related disasters have occurred accompanying localized torrential rains, earthquakes, volcanic activity, etc. This type of disaster is the cause of approximately one-half of the dead and missing in all natural disasters in Japan[7]. In 2011, typhoon 1112 (Talas) caused widespread heavy rainfall from the end of August through the beginning of September, resulting in enormous damage due to large-scale landslides, river flooding, natural damming of rivers by landslides, etc. in many areas, centering on the Kii Peninsula.

2.4 Tsunami Disasters

Japan is among the world's most earthquake- and tsunami-prone countries. In the Aonae District of Okushiri Island, which suffered the 1993 Hokkaido Nansei Oki Earthquake, a large number of lives were lost when a tsunami attacked only 5 minutes after the earthquake[8].

The Great East Japan Earthquake of 2011 (Mw9.0) was one of the largest earthquakes in the world since observation of earthquakes began, and was also the largest earthquake ever observed in Japan[9]. This super-giant earthquake triggered a giant tsunami extending over much of the Pacific Coast of northeastern Japan (Tohoku), and caused massive damage.

3. History and Lineup of Disaster-Prevention Products of JFE Metal Products & Engineering

JFE Metal Products & Engineering was established in 2003 by a merger of Kawasaki Steel Metal Products & Engineering and Nippon Kokan Light Steel. After the merger, the new company has been strengthening its product lineup accompanying changes in marketability, response to customer needs, and diversification of performance requirements. Current product groups can be broadly divided into dams, gabion works type products, and rockfall protection products. This chapter presents the history and lineup by product class.

3.1 Dams

(1) Since the JFE "Steel Frame Dam" (**Photo 1**) was first marketed in 1978, these structures have played an important role as forest conservation dams and retaining walls. As reasons for their popularity, by employing a framework structure of steel materials filled with large round stones, these dams are superior to concrete structures in terms of bending properties and water permeability, and have also earned a high evaluation for shortening construction time and enabling construction throughout the year.

Photo 1 Steel frame dam

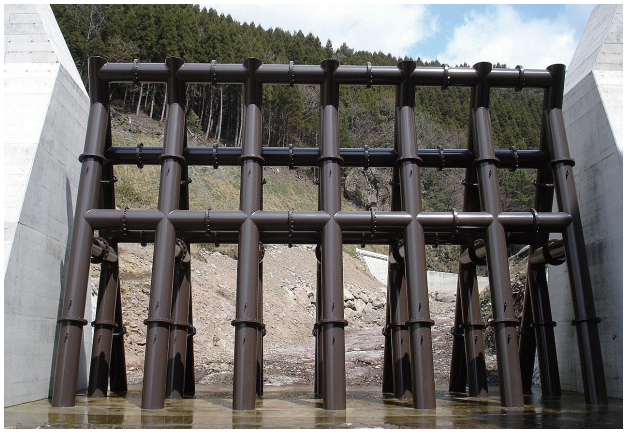

Photo 2 Steel slit dam (J-Type)

(2) Steel Slit Dam (J-Type) (**Photo 2**), which is a type of debris-flow capture work, is a permeable sabo dam which captures debris flows efficiently and reliability while also offering superior economy due to its rational structural design. This product integrates and improves the technologies cultivated in the previously-developed "Steel Slit Dam (L-Type)" and "Steel Slit Dam (I-Type)," both of which also have extensive records of actual use. The structure is an assembly of steel pipes which does not divide the river where it is installed and is ecosystem-friendly, as it allows harmless water and sediments to flow downstream under normal conditions. Results have continued to increase since sales began in 2006.

(3) In the Aso-Takeda Disaster of July 1990, floodwood formed a natural dam at a bridge over a national highway, causing a larger amount of sediments to overflow into the surrounding area more quickly, resulting in considerable damage[10]. The Guidelines for Floodwood Countermeasures (Draft)[11] prepared by the former Ministry of Construction in October of the same year stated that floodwood countermeasures shall be implemented for mountain streams and rivers where production and outflow of sediments are anticipated in order to protect life, property, the living environment, and the natural environment from disasters caused by floodwood flowing with sediments. Therefore, floodwood countermeasures are considered necessary as part of countermeasures for sediment-related disasters. The "Steel Slit Dam (D-Type)" (**Photo 3**), which is a steel floodwood capture dam that was planned, designed, and installed in accordance with the same Guidelines, has displayed its effectiveness in preventing floodwood disasters.

Photo 3 Steel slit dam (D-Type) which caught floodwood

Photo 4 Steel slit dam (Beam type)

(4) The "Steel Slit Dam (Beam-Type)" (**Photo 4**) was developed to control the size, etc. of secondary outflows of debris at existing concrete slit dams. Slit-type concrete dams were adopted by development from sabo facilities that were designed to stop sediments to sabo that allowed the sediments to flow through the structure. In general, concrete slit dams have the function of stopping sediments by damming up the flow. However, focusing on the fact that secondary outflow of part of the stopped debris occurs during floods, countermeasures for this problem had been desired[12]. The "Steel Slit Dam (Beam-Type)" is an effective countermeasure for this kind of secondary outflow, and there are many examples of installation.

(5) The JFE's "Super Wall Dam" is a gravity-type debris-flow protection dam with a double-wall structure, in which the upstream wall surface material and downstream wall surface material are connected by

tie rods, and local earth and sand or rubble is used as the filling material. Use of locally-produced earth and sand as the dam body material results in a low-environmental load structure that makes it possible to reduce surplus soil disposal.

3.2 Gabion-related Products

(1) Conventional gabion works are basket-like wire-mesh structures which are filled with rocks; the three basic types are called the gabion basket, gabion mattress, and gabion sack, depending on the shape. They are used in various applications, beginning with riparian works such as revetment works and groyne works, and also including protection for ravines and hillsides, road disaster recovery construction work, soft ground construction, etc. As advantages, gabions are flexible, have excellent water permeability, and are simple to construct. However, because their durability as permanent structures was a problem, gabion works with higher durability were desired. JFE's "KS Package" (**Photo 5**) is a product that offers the outstanding features of conventional gabion works while also providing the functions expected in a permanent structure.

(2) JFE's "Kagowaku (M-Package)" (**Photo 6**) is a boltless structure which saves labor in on-site construction. Greening is also possible by using local soil.

(3) JFE's "Kagomat" (**Photo 7**) was created for riverbank revetment works. In that mission, it secures a flood control function by providing a structure capable of withstanding the external forces that act on riverbanks, while also forming a riverfront space which considers the ecosystem, scenery, and use of the riverfront. Since sales began in 1989, JFE Metal Products & Engineering has repeatedly introduced new innovations that make it possible to respond to a wide variety of riverbanks and embankments, and has accumulated much know-how in the process. Applications in rivers are expanding and diversifying under the "Neo-Natural River Reconstruction" program initiated by the former Ministry of Construction in 1991, and JFE Metal Products and Engineering intends to responds to these needs.

Photo 5 KS Package

Photo 6 Kagowaku (M-Package)

Photo 7 Kagomat

3.3 Rockfall Protection Products

(1) Rockfall protection fences are rockfall protection works which catch falling rocks at the foot of a slope.

(2) Rockfall protection netting includes two types of rockfall protection works, i.e., a covering type, in which slopes with a danger of falling rocks are covered with wire netting and wire rope, and a pocket type, in which falling rocks fall into a pocket structure and then are led safely to the foot of the slope.

(3) "KS Net" and "Wire Net" (**Photo 8**) are rockfall protection works which hold dangerous slopes, potential rolling stones, etc. that could cause rockfall disasters at their original positions. Applications

Photo 8 Rockfalls protection wire netting

include slopes where there is a danger of separation and peeling from the bedrock part of a mountainside, and boulders washed out from the surface as a result of weathering of rock masses, spring water, or rain at slopes with geologies consisting of rock masses and gravel layers, among others. By using thick netting and wire rope, which have ample strength, toughness, and flexibility, these products restrain the initial movement of these rocks and prevent rockfalls in advance by fixing boulders and loose rock, which could cause rockfalls, securely to the rock mass.

Photo 9 Steel slit dam (J-Type)which caught debris flow

4. Aiming at Contribution to Safe and Secure Infrastructure

Considering sediment-related disaster prevention countermeasures based on the national government's Priority Plan for Social Infrastructure Development[13] and the current situation of frequently-occurring natural disasters and sediment-related disasters, JFE Metal Products & Engineering aims to contribute to the creation of safe and secure infrastructure. Assuming the large-scale earthquakes which are anticipated in the future, it is essential to carry out product development with safety and security as keywords in order to respond to diversifying needs.

4.1 Product Development Aiming at Safety and Security

Product development at JFE Metal Products & Engineering is not intended simply to expand the company's product lines; rather, it is an effort to listen to the voices of customers, answer their needs, and in turn, contribute to building safe and secure social infrastructure.

(1) Steel Slit Dam (J-Type)

JFE Metal Products & Engineering previously commercialized two types of debris-flow capture works, "Steel Slit Dam (L-Type)," which has the advantage of not requiring foundation concrete, and "Steel Slit Dam (I-Type)," which is constructed using buffering steel pipes and thus can respond to ultra-high energy flows. However, based on the needs of customers who desired greater economy, the company integrated and improved these two technologies and realized unification in "Steel Slit Dam (J-Type)." The number of cases in which this structure captured debris flows is increasing. An example in Hyogo Prefecture is shown in **Photo 9**.

(2) Floodwood Capture Works: Steel Slit Dam (D-Type)

Based on customer needs for improved workability, the workability and economy of Steel Slit Dam (D-Type) were improved while maintaining its functions.

(3) Screen Net

Heightened requirements are placed on protective netting which can respond to the high energy of larger falling rocks at slopes where rockfall measures are necessary. Screen Net is a pocket-type rockfall protection netting with a long-span structure that makes it possible to absorb more than 5 times greater energy of falling rocks than conventional rockfall protection netting.

(4) JS-Wall Dam

In recent years, construction methods which utilize sabo soil cement have attracted attention because locally-generated soil can be used in sabo projects, economy is improved, etc. JFE Steel Wall Dam is a construction method which realizes outstanding safety and workability by using sabo soil cement (INSEM: in-situ stabilized excavation materials) as the filling material and adopting a wall facing material with high workability.

(5) Steel Pipe Frame Dam

In cases where a large amount of sediment exists on the riverbed at a location where debris flows are a concern, installation of groundsill works that fix the riverbed and stabilize the gradient is effective. In general, however, such locations have steep geographical features, and there are large restrictions on construction work. The steel pipe frame dam was developed in response to these customer needs[14], and is a simple, lightweight structure using steel pipes, considering delivery of the materials. Construction time is also reduced by using local boulders as the filling material[15]. An example of construction is shown in **Photo 10**.

(6) Debris-flow Fence

In place where mountains are located close by residential areas, small valleys where water does not normally flow become like rivers when it rains, and there is a danger of small-scale debris flows during heavy rain. JFE's debris-flow fences are suitable for narrow locations where there are restrictions on installation,

Photo 10 Steel pipe frame dam

Photo 11 Tsunami barrier

and are simple debris-flow works that can provide protection against small-scale debris flows.

(7) Tsunami Barrier

During tsunami attacks, ships, automobiles, lumber and other floating debris, etc. can be floated and carried deep inland, causing serious damage. "Tsunami Barrier" (**Photo 11**) is a disaster-mitigation technology which mitigates disasters by capturing floating debris caused by tsunamis near the water's edge[16].

The structure comprises end support columns at the two ends of the facility and intermediate support columns between the end columns. The spans between columns are joined by capture screens. The impact energy of the floating debris is absorbed by local deformation of the columns, deformation of beams, and elongation of the capture screen.

5. Activities Related to the Great East Japan Earthquake

The Great East Japan Earthquake of March 2011 caused great damage, but the giant tsunami which followed caused a disaster of unprecedented scale. JFE Metal Products & Engineering, in cooperation with other companies in the JFE Group, proposed new and existing technologies so as to contribute, at least in some small way, to the recovery and reconstruction of the disaster-stricken area.

As technologies that can be expected to support recovery and reconstruction of ports and harbors and their surrounding areas, JFE Metal Products & Engineering proposed Tsunami Barriers, which are tsunami flotsam protection facilities, and tenacious, high durability port and harbor embankment mats, which can be used as a countermeasure against erosion (scoring) of seawall foundations, among others. For preventive and countermeasure works in river repair and sabo/forest conservation works which will form the basis for future reconstruction support, the company proposes not only existing technologies, but also technologies responding flexibly to needs of the occasion.

6. Further Contribution to Disaster Prevention Projects, Aiming at Preserving Japan's Land and Ecosystems

In Japan, improvement of the ratio of construction of countermeasure facilities for streams and rivers with danger of mud and debris flows and slopes with danger of slope failure is an important issue, as the ratio[1] is currently less than 30%. Needs related to preservation of the environment and ecosystems are expected to be higher than until now, and there is also an increasing need for technologies for mitigation of earthquake and tsunami disasters, etc.

In creating safe and secure infrastructure, it is important to implement countermeasures which reduce the damage from diverse types of disasters, at least to some extent. From this viewpoint, diverse countermeasure works are desired.

7. Conclusion

JFE Metal Products & Engineering has a history of more than 30 years in the field of disaster prevention projects, and takes pride in the fact that it has contributed to the creation of safe and secure social infrastructure by developing and supplying products, particularly for prevention of sediment-related disasters. On the other hand, in recent years, abnormal weather has become the new norm, and natural disasters have occurred frequently. As a result, the needs related to disaster-prevention projects have also become increasingly diverse.

JFE Metal Products & Engineering will continue to develop new products which are useful in preventing disasters and mitigating damage in diverse types of natural disasters in order to contribute to the creation of safe and secure social infrastructure.

References

1) Website, Sabo (Erosion and Sediment Control) Department, Water and Disaster Management Bureau, Ministry of Land, Infrastructure, Transport and Tourism.
2) Website, National Research Institute for Earth Science and Disas-

ter Prevention.
3) White paper on Land, Infrastructure, Transport and Tourism in Japan 2007. Ministry of Land, Infrastructure, Transport and Tourism.
4) Website, Cabinet office.
5) Law related to Promotion of Measures for Sediment-related Disaster Prevention in a Restricted Area etc. due to Sediment-related Disaster. 2000.
6) Central Disaster Prevention Council document. Cabinet office.
7) Website, Sabo (Erosion and Sediment Control) Department, Water and Disaster Management Bureau, Ministry of Land, Infrastructure, Transport and Tourism.
8) Website, Cabinet office.
9) White paper on Disaster Prevention in Japan 2011. Cabinet office.
10) Seminar text on driftwood control measures. Sabo & Landslide Technical Center. 1990.
11) Driftwood control guidelines. Sabo Division, Erosion and Sediment Control Depertment, River Bureau, Ministry of Construction. 1990-02.
12) The second meeting document. Investigative commission on sediment-related disaster prevention measures. 2005.
13) Briefing paper. Ministry of Land, Infrastructure, Transport and Tourism.
14) Yonamine, J. et al. Development of the steel structure groundsill "Steel pipe frame dam" which utilized local boulders (part 1). Collection of Japan Society of Erosion Control Engineering meeting for presenting research papers summaries 2011. JSECE publication no. 61.
15) Yonamine, J. et al. Development of the steel structure groundsill "Steel pipe frame dam" which utilized local boulders (part 2). Collection of Japan Society of Erosion Control Engineering meeting for presenting research papers summaries 2011. JSECE publication no. 61.
16) Website, The Society for Surge and Tsunami Barrier.