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Overview of Iron/Steel Slag Application and Development of New Utilization Technologies

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Abstract

Roughly 40 million tons of slag is generated in Japan annually from iron and steelmaking processes, and virtually all of it is effectively used according to its chemical, mechanical, and functional properties as the raw material for cement production, the material for road base courses, and for other civil engineering; such application led to the saving of natural resources and decreasing energy consumption and CO_2 emission. While increased use of iron/steel slag contributes to conservation of global environment, it has been mainly for civil construction, and its demand is expected to decrease in the long run. In view of this, Nippon Steel & Sumitomo Metal Corporation has been developing technology to solve the problems related to the use of slag and cultivate new applications by taking advantage of its characteristics. This paper reports the production, marketing, and material properties of iron/steel slag and the R&D activities to expand its effective use.

1. Introduction

Approximately 400 kg of slag is produced per ton of steel manufactured (all units herein are metric),[1] and most of it is used effectively as the material for cement production, road base course and civil engineering works or as fertilizer (see **Table 1** and **Fig. 1**). In the long term, however, domestic construction work is expected to decrease both in the public and private sectors. Further, social conditions may change such that the use of other recycled materials that compete with iron/steel slag is encouraged, and the environmental suitability of various materials will be evaluated increasingly severely. In this situation, Nippon Steel & Sumitomo Metal Corporation has developed slag as an ecological material and cultivated its new applications, making the most of its physical and chemical properties.[2]

Table 1 Production and sales of iron/steel slag (FY 2012)

			Production		Sales	
			Japan	NSSMC	Japan	NSSMC
Pig iron			81 860	43 902	–	–
Crude steel			106 624	43 958	–	–
Production	Blast furnace	Air cooled	4 590	2 689	4 855	2 685
		Granulated	20 049	10 384	21 030	10 792
		Sub total	24 639	13 073	25 885	13 477
	Steelmaking	BOF	11 036	5 572	11 810	6 569
		EAF	2 726	77	2 011	65
		Sub total	13 762	5 649	13 821	6 634
Grand total			38 401	18 722	39 706	20 111

(kton)

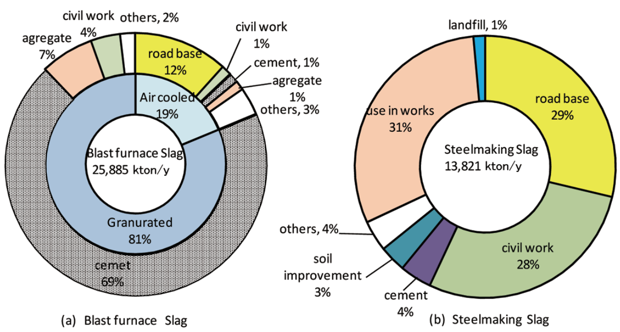

Fig. 1 Uses of iron/steel slag (FY 2012)

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This report deals with the present state of slag production and sale as well as the properties of slag products and challenges related to their use in the first half. In the second half, the technical development aiming at cultivating new applications of the slag from blast furnaces (BFs) and basic oxygen furnaces (BOFs) is discussed.

2. Overview of Iron/steel Slag

2.1 Iron/steel slag production

Slag is produced during iron and steelmaking processes, originating from the gangue in the mineral raw materials such as iron ore, coal, and limestone as well as those in the flux used at steel refining processes to remove Si, P, S, and other impurities in molten pig iron or to control steel contents. The production amount of BF slag is approximately 300 kg per ton of pig iron, and that of steelmaking slag is 100–150 kg per ton of molten steel. Overall, roughly 40 million tons of iron/steel slag is produced in Japan every year.

2.2 Characteristics of iron/steel slag

Iron/steel slag is composed mainly of CaO and SiO_2. Further, BF slag contains Al_2O_3, MgO, S, etc., and steelmaking slag contains iron oxides (FeO, Fe_2O_3), MnO, P_2O_5, etc. in addition to the BF slag components. Steelmaking slag also includes components arising from hot metal pretreatment processes (desiliconization, dephosphorization, and desulfurization), that BOF slag discharged form converter to ladles together with molten steel during tapping, and that generated in secondary refining.

Table 2 Typical compositions of iron/steel slag [1)]

	Blast furnace slag	BOF slag	EAF slag		Reference	
			Oxidation slag	Reduction slag	OPC *	Andesite
CaO	41.7	45.8	22.8	55.1	64.2	5.8
SiO_2	33.8	11.0	12.1	18.8	22	59.6
T-Fe	0.4	17.4	29.5	0.3	3.0	3.1
MgO	7.4	6.5	4.8	7.3	1.5	2.8
Al_2O_3	13.4	1.9	6.8	16.5	5.5	17.3
S	0.8	0.06	0.2	0.4	2	–
P_2O_5	<0.1	1.7	0.3	0.1	–	–
MnO	0.3	5.3	7.9	1	–	0.2

* OPC: Ordinary Portland Cement   Unit: %

Typical compositions of different kinds of iron/steel slag are given in **Table 2**. [1)] BF slag comprises mainly of CaO, SiO_2, and Al_2O_3, such as ordinary Portland cement (OPC). Granulated BF slag is highly active chemically; it is characterized by a strong latent hydraulic property, i.e., the tendency to form hydrate compounds and harden when in contact with alkali solution, and for this reason, is used as the raw material for BF slag cement. Steelmaking slag and air-cooled BF slag have appearance and characteristics similar to those of crushed rock or sand, and taking advantage of these properties, they are used for civil construction applications such as road base course, materials for civil engineering works, and the aggregate for concrete.

2.3 Slag treatment processes

Figure 2 [1)] shows the flow diagram of the processes to treat different kinds of iron/steel slag.

(1) Cooling and treatment of BF slag

As seen in Fig. 1, roughly 80% of BF slag is rapidly cooled with high-pressure water jets from the molten state at about 1 500°C into glassy sand called granulated slag. The granulated slag in slurry is dewatered in a separation tank, and then shipped to users. The remaining 20% is led to open yards, commonly called dry pits, cooled naturally, or sometimes with water spray, and solidifies into rock-like lumps. These lumps, called air-cooled slag, are crushed, classified through sieves, aged for stabilization not to emit yellow water, and then shipped as final products.

(2) Cooling and treatment of steelmaking slag

Steelmaking slag is shipped to final users after the following processing steps: (i) cooling at open yards to atmospheric temperature by natural cooling, sometimes with water spray; (ii) crushing and magnetic separation to recover mixed-in metallic iron; (iii) crushing and classification to control the grain size; and (iv) aging treatment to enhance and stabilize product quality.

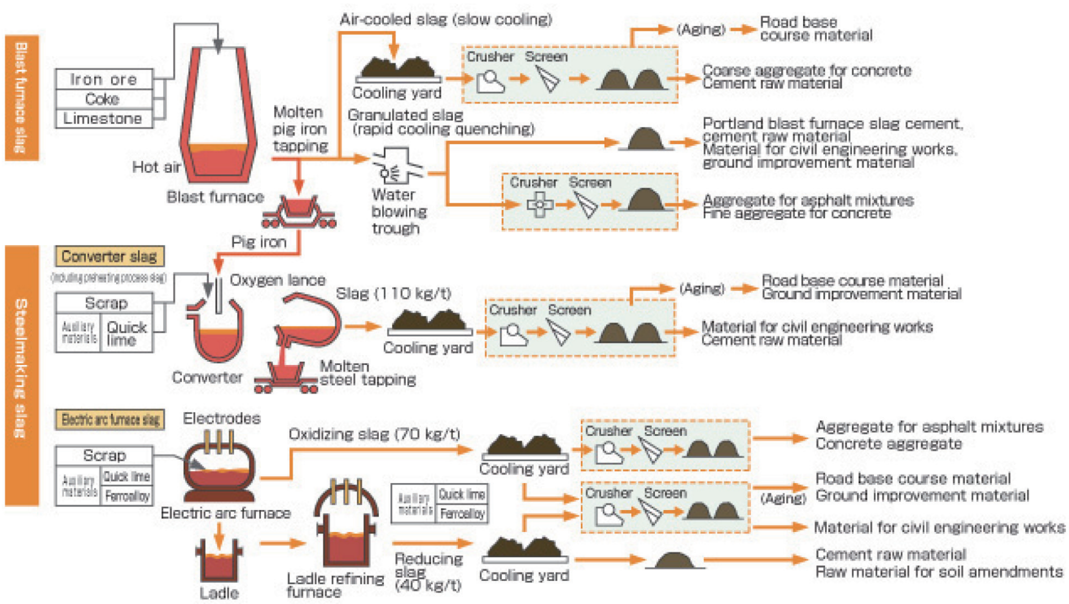

Fig. 2 Schematic flow of slag treatment processes [1)]

3. Problems in the Use of Iron/steel Slag and Countermeasures

3.1 Yellow water leaching from air-cooled BF slag

BF slag contains approximately 1% S, in the form of CaS, originating from coke, which is charged into BFs as the reducing agent, and other materials. As a consequence, when air-cooled BF slag gets in contact with water, CaS is hydrolyzed, and then through steps of reactions, forms polysulfide ions (S_x^{2-}), which sometimes causes yellowing and sulfuric smell of the water leaching from it.[3] To prevent this, air-cooled BF slag after crushing is subjected to aging treatment to stabilize the sulfur by making it react with oxygen in the atmosphere and form sulfate (SO_4^{2-}) or thiosulfate ions ($S_2O_3^{2-}$), or neutralized with CO_2. This is done by storing crushed and classified BF slag in open spaces.[3] In addition, it is common practice to confirm that the sulfuric contents have been well stabilized before shipment to users through leaching test for blast furnace slag[4] or similar.

3.2 Expansion of steelmaking slag

Lime (CaO) and other minerals are used as the flux for steel refining. Since the melting point of pure lime is as high as 2572°C, it does not melt during the steel smelting in BOFs or electric arc furnaces (at roughly 1300°C to 1700°C). For this reason, despite slag composition design to lower the melting point by having it form compounds with other elements, some of it may remain in the slag unreacted or as precipitate during slag cooling; such unreacted and unmelted CaO is called free CaO. When free CaO comes in contact with water, it hydrolyzes ($CaO + H_2O \rightarrow Ca(OH)_2$), and its volume duplicates. If free CaO in the slag used for road base course undergoes hydrolysis and expands, it may lead to bulging or cracking of the pavement.

Since steelmaking slag contains free CaO by some percent immediately after producing, we perform the aging treatment so that the hydration reaction of CaO is complete before shipment to users. Practical methods of slag aging treatment include atmospheric aging to have CaO hydrate with rain water in open spaces, steam aging treatment to blow high-temperature steam into stored slag to accelerate the stabilization, warm water aging to immerse slag in warm water, and pressurized aging treatment to make CaO hydrate rapidly with high-pressure steam (0.6 to 1.0 MPa, for instance) in an autoclave. Presently, steam aging treatment is most widely applied to steelmaking slag for road base course use. Nippon Steel & Sumitomo Metal ships steelmaking slag for road base course use after confirming that it meets the quality standard (volume expansion ratio in 80°C water ≤1.5%) by the test method according to JIS A 5015.[4]

3.3 Alkalinity

Because of the CaO content, water leaching from steelmaking slag after the hydrolysis reaction exhibits a pH of 10 to 12.5, which is the same alkalinity as that of road bed material of recycled concrete or cement-stabilization soil. However, note that the soil is mostly acidic in Japan, and even when alkali contents are leached from slag, they will be absorbed in soil and neutralized as far as the slag use is adequate, and thus there will be no environmental problem. However, when slag is used for civil engineering purposes in very large amounts locally, the slag may constitute a significant alkali source such as in the case of using recycled waste concrete. By considering such risk, we have put in efforts to comply with environmental regulations through the following measures: (i) according to our sales control rules, the suitability of slag use is judged where necessary through field investigation (on topography, alkali adsorption ability, and water permeability of the soil, underground water vein at the site and surrounding areas, etc.) prior to the contract, and in addition, the use conditions are confirmed at the site as required during and after the work; (ii) development of pH simulation technology to evaluate the risk of alkali leaching out and diffusion by considering the soil quality and topographic conditions at the site; and (iii) the development of methods for suppressing alkali leaching in ground and marine uses.

3.4 Heavy metal content

Before shipment, Nippon Steel & Sumitomo Metal inspects the quality of slag products by production lot to confirm that they satisfy the environmental quality standards for soil in the case of land use, and the dredged soil standard under the Act for the Prevention of Marine Pollution and Maritime Disasters in the case of marine and land reclaiming uses.

4. Effective Use of Iron/steel Slag

4.1 BF slag cement

As shown in **Fig. 3**, granulated BF slag is used, after being finely crushed and mixed with plaster, as a raw material of BF slag cement. After the first petroleum crisis in 1973, the energy-saving advantage of BF slag cement was recognized anew, and the demand

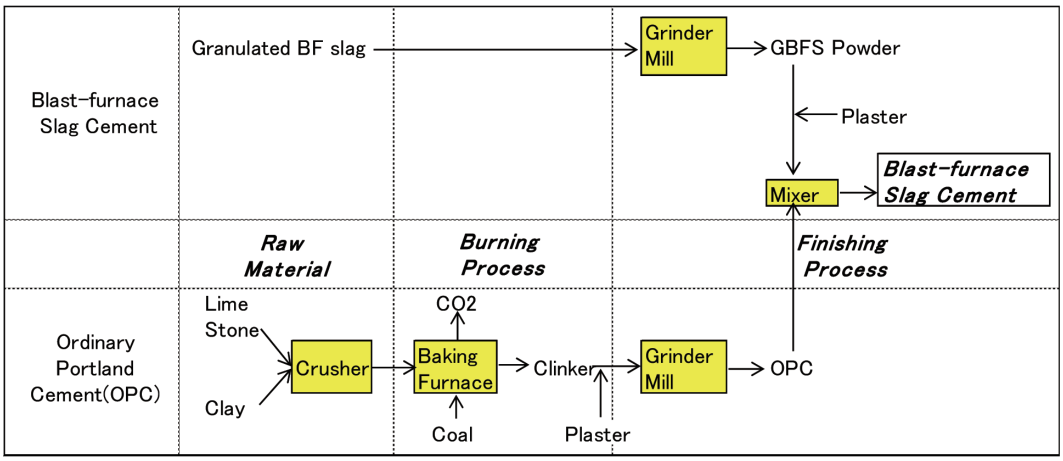

Fig. 3 Manufacturing processes of BF slag cement and OPC

for it grew rapidly; presently, BF slag cement accounts for roughly 20% of the whole cement production in Japan.[5)]

BF slag cement is classified according to the content of ground granulated BF slag into Class A (slag content being more than 5% and 30% or less), Class B (more than 30% and 60% or less), and Class C (more than 60% and 70% or less); of these, Class B is produced in more quantity than the others and used for a wide variety of applications. BF slag cement has the following advantages over OPC: (i) better resistance to sea water and chemicals and consequent higher durability; (ii) smaller coefficient of Cl ion diffusion, and consequently less corrosion of concrete reinforcing bars; (iii) suppression of alkali aggregate reaction; (iv) strength increase over a long period because of the latent hydraulic property of BF slag; (v) less CO_2 emission at cement production than that of OPC by approximately 40% because of less use of lime stone, which releases CO_2 during cement production, and elimination of the clinker burning process; and (vi) less leaching of hexavalent Cr in soil improvement applications.[5)] Conversely, it has the following drawbacks: (i) lower initial strength and longer curing time to attain design strength and (ii) larger temperature dependence and slower strengthening at low temperatures, making it necessary to consider a longer curing time for construction work especially in winter time.[5)]

4.2 Road base course use

To make roads that last long under traffic loads, aggregate material is spread and compacted beneath the pavement to form road base. In 1979, the use of air-cooled BF slag for the application was included in the JIS system (JIS A 5015 Steel Slag for Road Base Course),[4)] and in 1992, the use of steelmaking slag for the same was additionally included in the system. In addition, since steelmaking slag, especially BOF slag, is hard and excellent in wear resistance, it is used also as the aggregate for the asphalt pavement mix. It was also included in the Specific Products to Procure under the Law on Promoting Green Purchasing (the purchase of ecologically suitable products by the public sector) in 2002 together with slag for road base course use.

The most important aspect in the quality control of BOF slag when it is used for road base course is the prevention of expansion, and in consideration of this and study results to the effect that the cause of past troubles was the hydration expansion of free CaO, we always ship the slag for road base use after applying steam aging or other adequate treatment and confirming that the product satisfies on equal terms with JIS standards.

4.3 Road pavement use

Nippon Steel & Sumitomo Metal has developed materials for economical and simplified pavement by controlling the latent hydraulic property of steel slag. The key aspects are to adequately control the mixing ratio and the grain size of granulated BF slag and BOF slag such that the BF slag is stimulated by the alkalinity of the BOF slag and undergoes a pozzolanic reaction and, in parallel, Ca ions supplied from the latter react with carbonate ions in the atmosphere and spray water to form calcium carbonate and harden.

This slag product, named KATAMA™ SP, is used for a low grade pavement, whereby granulated BF slag and BOF slag are mixed at a prescribed ratio, spread, and then compacted by rollers with optimum water content; the method is capable of securing the strength required for forest and farm roads, parking areas and the like. KATAMA™ SP was identified as the Specific Recycled Products of Oita Prefecture in 2010,[6)] and following that, it has been approved for similar accreditations of the prefectures and municipalities where the steelworks of the company are located. In addition, the low-grade paving method was registered (QS-130016-A) in the New Technology Information System run by the Ministry of Land, Infrastructure, Transport and Tourism in 2013, and its use is being steadily expanding over the last few years for the finishing of roadside slopes, the anti-weed covering of areas along railway tracks, the ground surface of photovoltaic power plants, etc.

4.4 Ground improvement

The ground in the coastal areas of Japan often consists of sedimentation of soft and sticky soil. The sand compaction pile (SCP) method, whereby tightly compacted sand piles are formed into the ground, has been a typical measure to improve this type of unstable ground. In the middle of the 1990s, however, in consideration of the limited sources of natural sand and environmental conservation, use of other materials began to be studied, and the development of methods of using BOF slag for port and marine construction has been encouraged. The effects of the slag on water as well as its physical properties were examined, and the studies confirmed that its use would not lead to a significant increase in the pH of seawater due to the elution of alkaline components, and thus BOF slag was considered adequate as a substitute for natural sand.[7)] In addition, taking advantage of the hardening ability peculiar to BOF slag, which natural sand lacks, we developed a new hydraulic material, called Eco-Gaia-Stone™ (compaction type), usable for the SCP method; the SCP method using the product has been approved by the Coastal Development Institute of Technology.[8)]

4.5 Fertilizer and soil improvement

The use of the slag as fertilizer or for soil improvement of agricultural fields in the fiscal year 2012 (starting from April 2012) in Japan totaled about 250 000 t, accounted only for 0.6% of the total amount of iron/steel slag. Use of air-cooled BF slag has been tested to clarify its effects as silicate-lime fertilizer, and it has been found that silicate is deposited at the surfaces of the leaves and stalks of wetland rice plant, prevents harmful germs and insects from entering the plant body, helps the leaves stand upright to better receive sunlight, accelerates photosynthesis, and thus leads to an increase in harvest.[9)] Then, in 1955, the then Ministry of Agriculture and Forestry included silicate fertilizer in the officially approved fertilizers for the first time in the world, and at the time of a revision of the Fertilizer Control Act, BF slag was qualified as ordinary fertilizer.

Through R&D thereafter,[10)] BOF slag was officially approved as an ordinary lime fertilizer in 1981. Presently, we supplies iron/steel slag to fertilizer manufacturers as the raw materials for four types of fertilizers: BF and BOF slags for silicate fertilizer and BOF slag for lime and phosphate fertilizers as well as special fertilizer containing iron; by so doing, we provide agriculturists with fertilizer and soil improvement agents. Among these slag types, BOF slag contains various trace elements such as iron oxides, manganese, and boron in addition to calcium, magnesia, and silica. It also exerts quick alkaline effects due to calcium as well as slow but long-lasting effects due to calcium silicate. Therefore, it is characterized by being able to offer improvement effects for acidic soil lasting longer than those of ordinary fertilizers such as magnesium lime and hydrated lime.[11)]

4.6 Steel slag hydrated matrix

The steel slag hydrated matrix has been developed aiming at obtaining a substitute for concrete that causes less environmental loads, not requiring natural materials such as gravel and sand. Ground-granulated BF slag is used as the cementation agent of concrete and BOF slag as the aggregate.[12)] It can be used in the same manner as concrete by adding an alkali stimulant to accelerate hardening as required, mixing the materials with water, and pouring into molds to form substitutes for unreinforced concrete blocks, or crushing into random lumps of artificial stone or the like. Since the main binder is the ground-granulated BF slag, as a side effect of the reduction of specific surface area due to lump forming, the dissolution of alkaline components in seawater is limited and the rise in pH is suppressed.

The product line-up of the steel slag hydrated matrix of the company includes Frontier Rock™ and Frontier Stone™ *1 for use as substitutes for natural stones for back-filling, revetment, slope finishing, etc., and Vivary™ Block and Vivary™ Rock for forming algae beds taking advantage of silicate and iron contents of slag to facilitate adhesion of seaweeds and sea-bottom animals.

4.7 Iron ion source for seaweed bed formation and effectiveness evaluation of slag in coastal sea area applications

Since the 1970s, seaweeds have perished and disappeared from various areas along the coastal sea area of Japan (commonly called macroalgae depletion). It is considered that this results from combined effects of meteorological changes such as high water temperature and decrease in nutrients due to global warming, changes in the biota such as increase of algae-eating animals, and insufficient nutrient supply from rivers caused by human activities such as flow modification and embankment reconstruction.

In relation to the under-nutrition of sea water, regarding especially the hypothesis of insufficient iron concentration,[13] Sadakata, Professor Emeritus of the University of Tokyo, began studies involving using BOF slag as the supply source of iron ions, which algae readily take in, in 2002. After finding the solution to the problem of white turbidity in the use of BOF slag in seawater, i.e., carbonation of the slag, we started the development study of fertilizing technology for algae using BOF slag as the source of iron ion supply, jointly with the University of Tokyo, Eco Green (a recycling processing company for woody biomass), and Nishimatsu Corporation (a general construction contractor).

Through tests in coastal waters, the algae revitalizing effects of supplying iron ions to seawater were investigated by packing a mixture of artificial humus soil and carbonated BOF slag in water-permeable bags of coconut fiber (Vivary™ units) or in specially designed steel boxes (Vivary™ boxes) and adequately arranging these iron ion sources on the sea bottom. The tests began in the autumn of 2004 offshore Mashike Town, Hokkaido, and a type of alga, more specifically laminaria religiosa, was found to have settled and then thickly grown in the area;[14–17] through periodical observations thereafter, the alga colonies have been confirmed to continue.[18, 19]

Simultaneously with the above, to academically clarify the mechanism of algae multiplication under the supply of iron ions, we continued the development of methods for verifying the indispensability of iron in the lifecycle of the alga[20, 21] and those for analyzing the concentration of iron ions in the water at the test site to enhance the detection sensitivity from the ppm level to ppb.[22, 23]

Further, to collect objective data on the effectiveness and safety of BOF slag on the biota and natural environment, we constructed marine environment simulation facilities (named "Sea Lab" and "Sea Lab II") offshore the Research & Engineering Center, Futtsu, Chiba Prefecture, on the Bay of Tokyo.[24–26]

Based on the results of the studies and ocean tests mentioned above, the algae fertilizing products using BOF slag have been set at 30 or so locations along the coastal sea area of Japan, some under joint study with the Fisheries Agency.[18]

*1 These two are the fruits of joint development with JFE Steel Corporation.

4.8 Improvement technology of dredged soil

More than 20 million cubic meters of dirt and sand are dredged annually from sea bottoms along the coast of Japan; they are mostly used for landfill, or otherwise damped to the sea. In view of the dwindling space for damping and environmental problems, however, the need for their recycling is increasing rapidly. Conversely, decreasing the use of land sand, gravel, and stone for civil engineering work is required. Thus, we are developing a technology for reforming dredged soft dirt into CaO-improved soil and recycling it as a substitute for natural sand gravel and stone.[27] The process comprises mixing dredged soil and BOF slag, which is prepared through composition control and classification by grain size. The mixture hardens and its strength increases as the silica and alumina in the dredged soil and the free CaO in the slag undergo hydrolysis to form hydrates of calcium silicate and calcium aluminate. The product is expected to be suitable for the work involved in restoring marine environment such as refilling of sea bottom depressions, forming seaweed beds and mounds, etc. The characteristics of the product are as follows: (i) it suppresses the rise of pH, (ii) prevents the formation of phosphorus and sulfur compounds, and (iii) has adequate strength for structural use.

5. Effective Use of Iron/steel Slag for Restoration Work after the 2011 Great East Japan Earthquake

5.1 Recycling of tsunami deposit soil

The amount of the large-size debris that arose in the six prefectures in East Japan along the Pacific coast because of the tsunami caused by the great earthquake on March 11, 2011, was estimated at 23 million tons, and that of the tsunami deposits (sludge and sand) mixed with comparatively small debris was estimated at 13–28 million tons,[28] and how to clean and treat them is still a difficult problem. As a solution, the company, jointly with then Nippon Steel Engineering Co., Ltd. (now Nippon Steel & Sumikin Engineering Co., Ltd.), developed a process whereby soft tsunami deposits containing debris is mixed with the BOF slag soil in a rotary mixer to crush and remove the debris and transform the soft deposit into good soil strong enough for the material as civil use. This process received the Construction Technology Examination Certificate by the Public Work Research Center in August 2013 and was used for the disaster waste recycling project of the municipality of Kamaishi, Iwate, to treat and recycle approximately 200 kilo ton of tsunami deposit. The soil thus recovered will be used for reconstruction work of the city.

5.2 Restoration of farmlands after inundation by tsunami

According to an estimation, roughly 24000 ha of farmlands in the six prefectures on the Pacific coast were inundated by the tsunami of the 2011 earthquake.[29] In addition to the deposit of dirt and debris that the tsunami brought and the brine damage, the soils turned very strongly acidic with sulfuric acid that formed as a result of the oxidation of pyrite (iron sulfide) contained in the tsunami sludge.[30] Aiming at restoring the farmlands hit by the tsunami in Soma City, Fukushima, Prof. Goto of Tokyo University of Agriculture (TUA) et al. started the "Soma Project," wherein fertilizer made from BOF slag from the company was applied to rice paddies that had been treated to remove tsunami debris only. This, together with washing of salt by rainfall, proved effective at substituting Na with Ca and adequately controlling the pH of the soil.[31] The TUA method was employed to restore 12 ha of farmland in the FY 2012 and 50 ha in the FY 2013; the advantage and effectiveness of the BOF slag fertilizer in the recovery of damaged farmland over other salt-removing agents such as calcium carbonate have thus been verified.[31, 32)]

In appreciation of the above, a farmland recovery project for an area of 200 ha in the municipality of Soma using BOF slag fertilizer was approved for the government subsidy in FY 2014. The BOF slag fertilizer is expected to demonstrate its effectiveness through use in yet wider areas.

Besides the above, under the framework of the "recovery of the tsunami-stricken rural zones using BOF slag," as part of the Innovative Program for Advanced Technology promoted by the Iron & Steel Institute of Japan, Prof. Kitamura of Tohoku University et al. are studying, from a scholastic viewpoint, the salt-removing and soil-improving effects of BOF slag fertilizer as well as its effects in general. This study is expected to lead to quantitative evaluation of the potentials of slag fertilizers.

6. Future Prospects

Slag generation is inseparable from steel production. As long as steel is produced in Japan, it is imperative to effectively use the amount of slag corresponding to the steel production, and it is necessary to cultivate methods of safe and stable use of iron/steel slag. To this end, we will continue development studies from the following viewpoints:

6.1 Compliance to regulations

Prevention of quality and environmental problems is of the highest priority in the production of slag products just as it is in the production of steel products; this will remain unchanged in the future. As stated earlier, slag has inherent problems of volume expansion and alkali elution, and development must continue for implementing their fundamental solutions and for the methods for evaluating environmental effects that will prevent troubles resulting from the use of slag.

Once an environmental problem occurs because of the use of slag, it will adversely and fatally affect not only the manufacturer but also the entire slag-derived products. It is essential, therefore, for the whole steel industry to establish and practice sales control rules in a thorough-going manner.

6.2 Cultivation of new functions and markets

As seen in Table 1 and Fig. 1, almost all of the slag arising from steel production is effectively used at present, but most of these applications, except for that for BF slag cement, make use of only the physical properties of iron/steel slag, i.e., for low-added-value applications such as road base course and civil engineering work as substitutes for natural sand and gravel However, the demand for these materials is expected to decrease in the long run. It is, therefore, essential to cultivate new applications of slag by taking advantage of its characteristics.

Using slag by utilizing the most of its chemical properties may bring about higher added value. Except for the use of granulated BF slag for cement production, only a very limited amount of slag is used as fertilizers, which is an application of its chemical composition. It is, therefore, desired to develop new slag products that take advantage of the alkaline properties of iron/steel slag and new applications to add more value; such development may be made by further expanding the CaO improvement of dredged soil in the marine use or the property modification of soft soil for ground improvement. The development of such new applications will inevitably take a long time as it requires process verification, evaluation of environmental effects, acquisition of public approval, and agreement and understanding of relevant authorities and stakeholders. Nippon Steel & Sumitomo Metal is committed to conservation of the natural environment through resilient R&D efforts for expanding slag application.

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