Indian Minerals Yearbook 2017

(Part- II : METALS AND ALLOYS)

56th Edition

SLAG - IRON AND STEEL

(FINAL RELEASE)

GOVERNMENT OF INDIA
MINISTRY OF MINES
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March, 2018

16 Slag - Iron and Steel

Slag is a by-product generated during manufacturing of pig iron and steel. It is produced by action of various fluxes upon gangue materials within the iron ore during the process of pig iron making in blast furnace and steel manufacturing in steel melting shop. Primarily, slag consists of calcium, magnesium, manganese and aluminium silicates and oxides in various combinations. The cooling process of slag is responsible mainly for generating different types of slags required for various end-use consumers. Although, the chemical composition of slag may remain unchanged, physical properties vary widely with the changing process of cooling.

In an integrated steel plant, 2-4 tonnes of wastes (including solid, liquid and gas) are generated for every tonne of steel produced. Pertinently, the concerns of today are to pay adequate emphasis on minimising waste generation, recycling and re-use of waste, and minimising the adverse impact of disposals to the environment. The major wastes produced in Integrated Steel Plants (ISP) include BF iron slag. Total steel slag accounting for nearly more than half a tonne for each tonne of steel produced in ISPs. Among all the solid/liquid wastes, slags generated at iron making and steel making units are in such a large quantities that management of slag has become a critical component of steel production. With increasing capacities, the mechanism for disposal of large quantities of slag that get generated have gained traction as the environmental issues that it could evoke could become critical for steel makers. Over the last few years, with better understanding of slags, its functions and improvements in process technologies have led to a significant reduction in the volume of slag generated. At the same time, the reuse of iron and steel has led to a significant reduction in the environmental impact of these by-products. However, slag generation remains inevitable and emphasis on its recycling remains one of the most serious concerns that needs redressal.

PRODUCTION

The slag produced at blast furnace during pig iron manufacturing is called blast furnace slag. The slag produced at steel melting shop is known as steel slag. Slag output obtained during pig iron and steel production is variable and depends mainly on composition of raw materials and type of furnace. Typically, for ore feed containing 60 to 65% iron, blast furnace (BF) slag production ranges from about 300 to 540 kg per tonne of pig or crude iron produced, whereas in steel making 150 to 200 kg per tonne of slag is generated per tonne of liquid steel. Lower grade ores yield much higher slag fractions, sometimes as high as one tonne of slag per tonne of pig iron produced. Steel slag output is approximately 20-30 % by mass of the crude steel output in the country.

Ferro Scrap Nigam Ltd (FSNL), a wholly owned subsidiary of MSTC Ltd undertakes the recovery and processing of scrap from slag and refuse dumps in the nine steel plants at Rourkela, Burnpur, Bhilai, Bokaro, Durgapur, Visakhapatnam, Dolvi, Dubari & Haridwar and also from Rail Wheel Factory, Bengaluru. The Company is also providing steel mill services for handling BOF Slag, etc.

During the year 2016-17, BSP reported production of Granulated Slag at 1,531,579 tonnes. Tata Steel Plant produced 3,783,844 tonnes of BF Slag.

During the year 2015-16, RSP reported production of BF slag, Granulated slag and Steel slag at 1,141,810 tonnes, 868,395 tonnes and 772,476 tonnes, respectively. Bokaro Steel Plant reported production of 748,836 tonnes of slag. Bhilai Steel Plant reported production of 1,557,343 tonnes granulated slag. KIC Metaliks reported production of 19,400 tonnes of granulated slag. Sky Alloys & Power Pvt. Ltd reported production of 12,471 tonnes of MS Slag. Tata Steel reported production of 3,563,651 tonnes of BF Slag.

The information regarding plant-wise capacity of iron and steel slag in the country is given in Table- 1.

Table – 1 : Plant-wise Capacity of Iron and Steel Slag in the Country

Steel Plant	Capacity for granulation ('000 tpy)
Bhilai Steel Plant, Durg, Chhattisgarh	2675
Bokaro Steel Plant, Bokaro, Jharkhand	7884
Rourkela Steel Plant, Rourkela, Odisha	1570
Durgapur Steel Plant, Durgapur, West Bengal	566
IISCO Steel Plant, Burnpur, West Bengal	400 kg/THM*
Visvesvaraya Iron & Steel Plant, Bhadravati, Karnataka	400 kg/THM*
Rashtriya Ispat Nigam Ltd, Visakhapatnam, Andhra Pradesh	1440
IDCOL Kalinga Iron Works Ltd, Barbil, Odisha	53
JSW Steel Ltd, Ballari, Karnataka	NA
Tata Steel Ltd, Jamshedpur, Jharkhand	2100
Visa Steel Ltd, Kalinganagar, Odisha	175
Neelachal Ispat Nigam Ltd, Kalinganagar, Odisha	-
Sona Alloys Pvt. Ltd, Satara, Maharashtra	100.8

**THM : Tonne Hot Metal*

Blast Furnace Slag

In the blast furnace, the slag floating over molten pig iron (hot metal) is flushed out in slag pot and then sent to slag granulating plant or to cooling pits.

Depending upon the cooling process, three types of slags are generated, namely, air-cooled slag, granulated slag and expanded slag.

Air-cooled slag is produced by allowing the molten slag to cool under atmospheric conditions in a pit. Under slow cooling conditions, escaping gases leave behind porous and low-density aggregates with special physical properties, making it suitable for many applications. When formed under controlled cooling, the slag tends to be hard and dense, making it especially suitable for use in ready-mixed concrete, concrete products, road bases and similar applications in construction.

Granulated slag is produced by quenching the molten slag by means of high-pressure water jets. Quenching prevents crystallisation, thus resulting in granular, glassy aggregates. This slag is crushed, pulverised and screened for use in various applications, particularly in cement production because of its pozzolanic characteristics.

Steel plants utilise cold slag for internal consumption and also for outside sale. The slag after cooling is crushed and used as road metal and railway ballast. Granulated slag produced in steel plants is also sold outside to cement plants. Slag application also reduces the overall cost of production of cement. JSPL has established 2 MTPA cement plant to produce portland Pozzolana cement by utilising blast furnace slag and fly ash generated from power plants.

Expanded slag is formed through controlled cooling of molten slag in water or water with combination of steam and compressed air. Formation of steam and other gases enhances the porosity and vesicular nature of slag, resulting in light weight aggregate suitable for use in concrete. However, expanded slag is not produced at any domestic iron and steel plant.

A fourth product made from blast furnace slag is mineral wool/slag wool. Cooled slag for this purpose is melted and poured through an air stream or a jet of dried stream of other gases to produce a spray of molten droplets or the same is also formed by passing the melt through a perforated or fast-spinning disc. The droplets

elongate to long fibres, which are collected mechanically and layered. The material has excellent thermal insulation properties.

The five different slags generated at various points of the steel making process are described below:

HMT Slag: This slag is primarily generated after de-siliconisation or de-phosphorisation treatment. It has high content of silica and lime. Sometimes it also contains BF slag.

HMDS Slag: This is the raked slag at the de-sulfurisation station. These slags are poorly mixed composites of spilled BF slag, spent and/or unreacted de-sulfurisation agents, lime fines and trapped droplet of hot metal and raked iron.

LD Slag: These slags are a well mixed aggregate of FeO, lime, silica and MgO generated at the LD converter. They are in the form of di-calcium and tri-calcium silicates. These slags also contain free lime and metal, which create problems due to expansion characteristics.

Steel Slag: These slags vary in composition with respect to the varied treatment. The common steel slags are fused calcium aluminates with less than 2% (FeO + MnO). These readily crumble to dust due to allotropic phase transformation at lower temperatures and are difficult to manage.

SGP Slag: LD slag is subjected to granulation through a quenching technology adopted at JSW, which houses the first of its kind in India. Due to sudden quenching of the molten slag, contraction of metal and slag occurs and results in good separation of metal and slag. Adequate granulation takes place and leads to good stability of the final slag. Process can be described as an accelerated ageing process that reduces the free lime content. Because of rapid cooling, it generates more glassy structure than the BOF slag. Removal of free lime also confirms its volumetric stability.

Steel Slag

BOF slag, commonly known as steel slag is another waste from Iron & Steel Industry. It has shown potential for use as a raw mix component up to 10% in the manufacture of cement clinker. Steel slag can also replace granulated blast furnace slag up to 10% in the manufacture of Portland Slag Cement. Steel slags are produced at steel melting shop during steel manufacturing. To produce steel, removal of excess silicon and carbon from iron is achieved through oxidation by adding limestone and coke. The steel slag contains higher amount of iron and its physical characteristics are similar to air-cooled iron slag. The LD slag is cooled, crushed and screened. The fines are utilised in sinter making and lumps are charged in the blast furnace.

The iron content is the major basic difference between BF slag and steel slag. In BF slag, FeO is around 0.70%, whereas in case of steel slag, total iron content varies from 16 to 25%.

JSW Steel has set up a unique BOF slag granulation plant, producing slag with lower free lime content and is vigorously pursuing with BIS. JSPL has set up country's largest captive brick plant (Make-Naptune Mahfana) with a capacity of 3 lakh fly ash-based products per day by utilising fly ash and slag generated from integrated steel plant.

The chemical analysis of granulated BF slag and steel slag generated in steel plants is given in Table - 2.

Table – 2 : Chemical Composition of Slag Generated in Steel Plants

Name of plant	Slag	Chemical composition (%)								Physical properties
		SiO_2	Al_2O_3	CaO	MgO	MnO	FeO	S	Basicity (CaO/SiO_2)	
Bhilai Steel Plant, Durg, Chhattisgarh.	BF	34.52	20.66	32.43	10.09	0.23	0.57	0.77	–	–
	Steel	14.20	1.40	42.90	9.59	1.69	18.20	1.70	–	–
Bokaro Steel Plant, Bokaro, Jharkhand.	BF	30.06 to 31.85	21.12 to 22.71	32.48 to 34.17	10.12 to 10.39	_	0.26 to 0.37	_	_	_
	Steel	12.15 to 15.82	1.07 to 1.63	46.52 to 53.52	8.14 to 13.12	_	17.01 to 18.58	_	_	Size: 0-5 mm & 10-40 mm –
Rourkela Steel Plant, Rourkela, Odisha.	BF	34.38 to 34.85	17.82 to 20.91	32.99 to 34.26	9.29 to 9.68	0.07 to 0.12	0.46 to 0.58	0.47 to 0.61	0.96 to 0.98	–
	Steel	13.7	1.82	44.4	6.7	0.81	22.6	0.09	3.28	
Durgapur Steel Plant, Durgapur, West Bengal.	BF	32.68	21.23	32.14	_	_	_	_	_	_
	Steel	17.9	1.0	49.4	_	_	_	_	_	_
Visvesvaraya Iron & Steel Plant, Bhadravati, Karnataka.	BF	32	18	33	9	_	0.5	_	_	Size : 1 to 5 mm Lumps
	Steel	30-35	1-2	35-40	9-11	_	10-15	–	–	300 mm & above
IISCO Steel Plant Burnpur, West Bengal.	BF	32.60	23.30	33.70	7.60	–	–	–	–	–
Rashtriya Ispat Nigam Ltd, Visakhapatnam, Andhra Pradesh.	BF	35.33	16.60	36.89	8.48	0.12	0.51	–	–	Size : -3 mm
	Steel	17.69	1.07	50.70	10.31	1.05	16.50	1.40	–	Size : +10 mm to (-)60 mm
IDCOL, Kalinga Iron Works Ltd, Barbil, Odisha.	BF	33.00 to 34.00	24.00 to 25.00	29.00 to 30.00	8.00 to 9.00	0.50 to 0.60	0.70 to 0.80	1.00	–	Size : 0 to 6 mm
Tata Steel Ltd, Jamshedpur, Jharkhand.	BF	34.5	20.8	34.3	7.3	0.052	0.6	–	–	-100 mesh to + 1 mm
	Steel	12.65	1.16	46.23	1.76	0.45	25.06	0.33	–	0 mm to + 300 mm
JSW Steel Ltd, Ballari, Karnataka	BF	35.20	19.00	34.90	8.76	0.14	0.039	–	–	–
Visa Steel Ltd, Kalinganagar, Odisha.	BF	33.8	15.39	35.38	10.25	0.64	0.74	0.92	–	Size : 0-5 mm & 10-40 mm
Neelachal Ispat Nigam Ltd, Kalinganagar, Odisha.	BF	32.62	32.62	33.25	9.91	0.40	0.55	0.62	–	–

USES

Slag based on their types has different uses. The air-cooled BF slag is crushed, screened and used mainly as road metal and bases, asphalt paving, track ballast, landfills and concrete aggregate. The expanded or foamed slag binds well with cement and is used mainly as aggregate for light weight concrete. However, it is not produced by domestic steel plants. Granulated BF slag is used as a pozzolanic material for producing portland slag cement. It is also used for soil conditioning. BF slag is used in making mineral wool for insulation purposes.

Steel slag has found its use as a barrier material remedy for waste sites where heavy metals tend to leach into the surrounding environment. Steel slag forces the heavy metals to drop out of solution in water run off because of its high oxide mineral content. Steel slag has been used successfully to treat acidic water discharges from abandoned mines.

Slags are useful alternative raw material for clinker production and such use can reduce a cement plant's fuel consumption and overall emission of carbon dioxide per tonne of cement. The granulated slag obtained from various steel plants is dried in slag dryer. The clinker is ground in ball mill with 40-50% dry slag and 6% gypsum. The resultant product is portland slag cement. Portland blast furnace slag cement contains up to 60% ground granulated slag from steel production processes.

Slag cement has low heat of hydration, low alkali aggregate reaction, high resistance to chlorides and sulphate and it can substitute the use of 43 and 53 grades of ordinary Portland Cement. For other consuming sectors like road making, landfilling and ballasting, the cooled slag is crushed by machines or broken manually by hammers into smaller pieces and supplied to the various end-use consumers.

The utilisation of SMS (particularly LD) slag is limited due to its (i) Phosphorus content (ii) high free lime content and (iii) higher specific weight.

CONSUMPTION

The BF slag in India is used mainly in cement manufacture and in other unorganised work, such as, landfills and railway ballast. A small quantity is also used by the Glass Industry for making slag wool fibres. Cement plants in the country producing slag cement require BF slag in granulated form. The chemical analysis of granulated slag consumed during the manufacture of slag cement is provided in Table-3.

SAIL utilised about 88.75%, 76.02% and 84.39% of BF slag, LD slag and total solid waste, respectively, generated during April - December, 2016. RINL sold about 81.11% of total BF slag generated in the plant and about 17.37% of total LD slag generated was utilised in sintering as a substitute to lime stone/dolomite. TSL utilised about 96.9%, 53.2% and 79.9% of BF slag, LD slag and total solid waste, respectively, generated during April - December, 2016.

PRICES

The prices of BF slag vary from plant to plant. Depending upon the distance between cement plants and the steel plants, much variation is observed in prices of granulated slag. The sale value of granulated slag and steel slag was ` 315 and ` 200 per tonne at Rourkela Steel Plant, respectively. The prices of granulated slag at cement factories for 2015-16 are furnished in Table-4. Consumption of slag/granulated slag in cement production for 2014-15, 2015-16 and 2016-17 is furnished in Table-5.

Table – 3 : Analysis of Granulated Slag Consumed for the Manufacture of Slag Cement

Cement plant	Analysis in %								
	SiO_2	Fe_2O_3 / FeO	MgO	Al_2O_3/ MnO_2	CaO	S/SO_3	MnO	Insoluble residue	Glass content & size
ACC, Jamul, Durg, Chhattisgarh.	33.0 to 33.4	1.0 to 1.4	9.0 to 9.8	21.5 to 22.4	33.0 to 33.8	0.40 to 0.48	–	–	
ACC, Jhinkpani, W. Singhbhum, Jharkhand.	32.80	0.4	7.2	23.3	32.6	0.80	–	0.80	>79%
ACC Ltd, Bargarh Cement Works, Bardol, Bargarh, Odisha.	33.69	0.63	9.07	19.38/ 0.61	35.13	0.58	–	-	-
Andhra Cements Ltd, Visakhapatnam, Andhra Pradesh.	33.32 to 35.19	0.46 to 0.50	8.86 to 9.91	17.98 to 19.35	34.75 to 35.98	–	0.10 to 0.16	–	–
Century Cement, Baikunth, Raipur, Chhattisgarh.	–	–	5.5 (max.)	17.0 (max.)	–	2.0 (max.)	–	–	–
Penna Cement Industries Ltd, Anantapur, Andhra Pradesh.	32.00	3.50	10.0	18.50	34.92	–	–	–	size : 0-2 mm
Shri Durga Cement Co. Ltd, Hazaribagh, Jharkhand.	30.00	0.80	8.00	24.00	34.00	0.80	0.2	2.4	–

Table – 4 : Prices of Granulated Slag at Cement Factories during 2015-16

Cement plant	`/tonne	Source of Supply
ACC Ltd, Durg, Chhattisgarh.	NA	SAIL, Sunflag, Monnet, JSPL, Uttam Galva, etc.
The RAMCO Cements Ltd, (formerly known as Madras Cements Ltd) Krishna, Andhra Pradesh.	765	JSW Steel Ltd, RINL, Sri Kalahasthi Pipes Ltd.
The RAMCO Cements Ltd, (formerly known as Madras Cements Ltd) Ariyalur, Tamil Nadu.	417	JSW Steel Ltd/ Sterlite
Vijay Cements,Trichy, Tamil Nadu.	NA	JSW Steel Ltd, Pottaneri
The India Cements Ltd, Kadapa, Andhra Pradesh.	450	Sri Venkateswara Enterprises, Chennai.

Table – 5 : Consumption of Slag/Granulated Slag in Cement Production, 2014-15 to 2016-17

(In tonnes)

Cement plant	2014-15	2015-16	2016-17
ACC Ltd, Durg, Chhattisgarh.	585094	621643	-
Shree Cement Ltd, Beawar, Rajasthan.	33838	-	-
Ambuja Cement, Gir Somnath, Gujarat.	16930	6710	-
Ultra Tech Cement Ltd, Kurnool, Andhra Pradesh.	128458	-	-
The India Cement Ltd, Kadapa, Andhra Pradesh. (Iron Slag).	17190	-	-
Vishnupuram, Wadapally, Nalgonda, Telangana (Granulated Slag)	13522	31444	-
Ultra Tech Cement Ltd, (Rawan Cement Works) Raipur, Chhattisgarh.	446619	493434	-
The RAMCO Cements Ltd, Krishna, Andhra Pradesh.	23635	60113	-
The RAMCO Cements Ltd, Alathiyar, Ariyalur, Tamil Nadu. Granulated Slag	13667	19848	-
Slag	78490	49054	-
EOF Slag	-	45958	-
Vijay Cements, Trichy, Tamil Nadu.	4055	3258	0
The RAMCO Cements Ltd, Govindpuram, Ariyalur, Tamil Nadu.	131651	112239	-
Dalmia Cement (Bharat) Ltd, Yadwad, Belagavi, Karnataka	-	190	6084
Bagalkot Cement & Industries Ltd Bagalkot, Karnataka.	-	102874	-
Century Cement Raipur, Chhattisgarh.	81204	-	-

Source: Returns received under Rule 45 of MCDR 2017.

RESEARCH & DEVELOPMENT

Increased utilisation of granulated slag benefits the portland cement producers. Producers can enhance the production capacity without additional greenhouse gas emissions like carbon dioxide.

A new granulator has been developed to cut the energy cost for granulation. This granulator consists of a variable speed rotating cup atomiser to break up the molten slag by centrifugal force and distribute it within a water-cooled cylindrical chamber. The process cools the molten slag rapidly enough to create small granules, thus minimising the need for additional crushing and grinding. Moreover, the new system offers the possibility of considerable energy recycling in the form of hot water or heated air.

During the year 2015-16, RINL has carried out studies on development of carbon dioxide (CO_2) sequestration technique using LD convertor slag to control the Green House Effect of carbon dioxide.

JSW steel conducted studies regarding alternative usage of slag in Construction Industry and has also developed a process to use SMS slag and fly ash in eco-friendly road pavements. JSW also developed a process to modify the EOF slag as course aggregate for concrete and as fine aggregate for partial replacement of river sand in cement mortar. JSW developed steam ageing process for accelerated weathering of steel slag using steam to convert steel slag into high quality aggregates.

Tata Steel Ltd (TSL) designed and developed a novel rotary reactor for harvesting hydrogen gas from molten ferrochrome slag. TSL also made an agreement with CSIR-Central Road Research Institute (Phase I & II) on 14th Jan. 2016 & 8th April, 2016 for Feasibility Study on utilisation of ferrochrome slag in road making .

To enhance utilisation of BF slag and LD slag, SAIL has adopted the following initiatives:

BF Slag

In order to achieve full utilisation of BF slag, Cast House Slag Granulation Plants (CHSGPs) will be installed at those BFs where the facility is unavailable. Similarly to enhance granulation of BF slag at RSP and ISP, new Blast Furnaces have been commissioned with CHSGPs. At BSP, the new Blast Furnace which is being installed as a part of the ongoing expansion-cum-modernisation programme, has in-built CHSGP. SAIL is also making an initiative for creation of databank on melting behaviour of various steel making slags of SAIL Plants at RDCIS, Ranchi.

Further, to maximise utilisation of the granulated BF slag, slag-based JV cement plants have been set up at Bhilai and Bokaro.

LD Slag

1. Use of Weathered LD Slag as Rail Track Ballast: The physical properties of weathered LD slag (WLD Slag) meet the specification required for stone ballast for use at rail tracks. In response to a proposal by SAIL, South Eastern Railway (S.E.R.) has agreed to conduct a field trial at the Bokaro Rail Yard with the weathered LD Slag from Bokaro Steel Plant. Commencement of field trial is expected shortly.
2. Development of Technology for Dry Granulation of LD Slag and Heat Recovery: Indian Institute of Technology, Kharagpur has been assigned as Consultant for "Laboratory Scale Study for Development of Technology for Dry Granulation of LD/BOF Slag (Hydro-Mechanical Study)". The study was scheduled to be completed in March 2016.

Texas Industries Inc. at Dallas, in Texas, USA had developed a process called Chem Star for cement clinker production. The process involves the use of steel slag. In this process, steel slag is fed into the

rotary clinker kiln as a part of the raw material mix. Texas Industries Inc. claimed that clinker production could be enhanced by 15% by using this process.

Commonwealth Scientific & Industrial Research Organisation (CSIRO) carried out investigations for value-added method for slag and proved a number of technically viable and commercially interesting applications of slag. The applications include (i) base course and top course to asphalt roads, (ii) anti-skid surfacing for roads on accident-prone intersections, (iii) low-strength concrete for footpaths, (iv) controlled low strength fill for backfill required for trench stabilisation and (v) concrete sub-base for rigid pavements.

The ASA annually undertakes an Environmental Monitoring Programme (EMP) to monitor and assess the iron & steel slag (ISS) produced, processed and sold by its members. The programme involves testing slag samples from member sites for their Total Metal (TM) concentration and wherever necessary, undertaking Toxicity Characteristic Leaching Procedure (TCLP) on the sample required and comparing the results against jurisdictional government regulations.

The National Slag Association has proved that iron & steel slag poses no threat to human health or to the environment. Iron & steel slags have been extensively tested using certified laboratories following USEPA and American Society for Testing Materials (ASTM) procedures.

Environmental Scientists and Toxicologists completed an industry-wise "Human Health and Ecological Risk Assessment" (HHERA) which demonstrated that iron & steel slag poses no meaningful threat to human health or environment when used in a variety of residential, agriculture, industrial and construction application. The chances of uptake of the metals in the slag matrix by human, other animals or plants are remote and therefore the possibility of their bioaccumulation in the foodweb are rather low and these are also not expected to bioconcentrate in plant tissue. Iron & steel slag may be applied safely in aquatic environment, such as, rivers, lakes or streams without impacting water quality or aquatic life.

The study carried out by an independent nationally renowned chemical laboratory has demonstrated that blast furnace and steel slag do not pose any threat to human or plant life. The study further revealed that the use of slag has very positive environmental benefits. The use of slag in cement manufacturing significantly decreases CO_2 emission and reduces the energy needed to calcine limestone. The use of slag as aggregate reduces the need for virgin material and helps conserve energy use that significantly reduces the emission produced during the mining, processing and transportation of those material. Ongoing developments that are taking place are expected to further improve by-product recovery rates and, more importantly, improvement in the quality of the materials recovered is likely to expand the scope of their applications. Also, the Steel Industry is making continuous efforts to achieve its goal of zero-waste for sustainable developments.

The Working Group on Cement for 12th Plan has described potential areas for R&D in the Plan period. Some of these which could benefit the cause of utilisation of slags in Cement Industry are: use of steel slag in road construction; use of non-conventional slags by different metallurgical industries in the manufacture of cement & activated slag cement and tiles/bricks/blocks from slag.

FOREIGN TRADE

Exports

Exports of slag (dross, etc.) in 2016-17 increased to about 385 thousand tonnes from 271 thousand tonnes in the previous year. Exports were mainly to China (55%), Philippines (37%) and Nepal (7%) (Table-6).

Imports

The imports of slag increased sharply to 114 thousand tonnes in 2016-17 from 21 tonnes in the previous year. Almost 100% import was from Japan & Korea, Rep. of (Table-7).

Table – 6 : Exports of Slag (Dross, etc. from Iron & Steel excl. granulated) (By Countries)

Country	2015-16 (R)		2016-17 (P)	
	Qty (t)	Value (`'000)	Qty (t)	Value (`'000)
All Countries	**271213**	**945575**	**384821**	**1390367**
China	156580	532255	211715	813827
Philippines	85608	296853	141054	492883
Nepal	5747	33434	26568	63153
Malaysia	1160	4321	2836	9700
Bhutan	4388	19871	1239	4885
Thailand	-	-	1176	3807
Oman	120	925	140	1114
Hong Kong	27	346	54	708
Gabon	-	-	26	206
Kenya	-	-	13	77
Other countries	17583	57570	++	7

Table – 7 : Imports of Slag (Dross, etc. from Iron & Steel excl. granulated) (By Countries)

Country	2015-16 (R)		2016-17 (P)	
	Qty (t)	Value (`'000)	Qty (t)	Value (`'000)
All Countries	**21**	**82**	**113818**	**496506**
Japan	-	-	58410	231072
Korea, Rep. of	-	-	55368	265103
Vietnam Soc. Rep.	-	-	40	331
Germany	21	82	-	-

FUTURE OUTLOOK

Slag is used as substitute for clinker. This slag otherwise would have been a waste and used as a filler material. Slag, if used properly, will conserve valuable limestone deposits required for production of cement.

Portland Slag Cement (PSC) has advantages of better performance, durability and optimal production cost, besides being eco-friendly. Currently, the laws in India allow up to 65% replacement of the clinker with steel slag. It is an eco-friendly alternative as it reduces energy intensity by 30% and water demand by 12-14% for 50% slag replacement. Blended cements like PSC have multiple benefits of tangible and intangible dimensions. India's slag production capacity is close to 10 million tonnes per annum from its existing steel plants. Indian Cement Industry consumes almost the entire granulated slag produced and can consume up to 70% of the blast furnace slag generated. There is scope for further consumption of granulated slag in order to enhance the total production of cement. Slag is also a sustainable product that can be recycled and reused multiple times in various construction projects. Using iron and steel furnace slag helps to preserve our natural resources and reduces green house gases.

Currently, the Government has plans to introduce a fourth type of cement in the market, Pozzolona Slag Cement, which will contain both steel slag and fly-ash. The total cement production capacity commissioned at the end of 11th Plan i.e., by 2011-12 was 331 million tpy, about 10% higher than the Plan target. By the end of 12th Plan i.e., by 2016-17, an additional capacity of 139.7 million tpy was expected to be added. The potentiality for consumption of slag in cement manufacture is bound for substantial rise in near future.