

Case study of India's first steel slag road construction at Hazira Industrial Area in Gujrat's Surat

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Abstract— In a critical stage toward supportability, India has built its very first steel slag street which is one kilometer long 6 path street. The street, situated in Hazira Industrial Area Gujarat's Surat. The street is a brainchild of the Central Road Research Institute (CRRI), the public authority think-tank NITI Aayog, and the Council of Scientific and Industrial Research (CSIR). It has been worked by ArcelorMittal Nippon Steel India Ltd, a main steel maker, and has gotten the sponsorship of the Steel Ministry and the Ministry of Transport. The steel slag street, made from squander material from steel businesses. It is sturdy and costs 30% less expensive than customary streets. Its thickness is 30% less contrasted with regular streets made of black-top, soil, bitumen, and normal totals. The utilization of steel slag additionally makes the street more sturdy.

Index Terms: Construction, Solid waste management, Recycling, Steel slag, Industrial waste material, Sustainability etc.

INTRODUCTION

Total is gotten from normal rocks. Mining of the total, prompts the decrease of normal assets. The nations having restricted assets of normal total are remembering to save their regular assets for their group of people yet to come. An enormous area of land is used for the removal of steel slag strong squanders, creating by the steel and iron making ventures. Factors like ecological, financial, specialized and lack of legitimate development material definitely stand out enough to be noticed of scientists towards the steel slag the best option of regular aggregate. The result creates from the dissolving of scratch to deliver steel by an electric

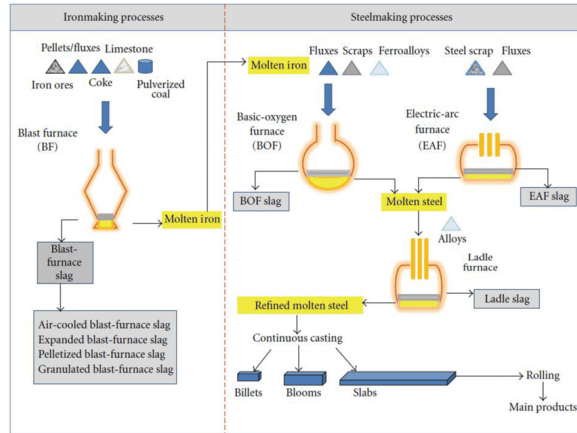
circular segment heater (EAF), and through the change of iron to steel by a fundamental oxygen heater (BOF).The steel slag acquired from these heater appears as though comparable however the properties might vary in view of the grade of steel delivered and the heater, while the compound organization stays inside the reach. As contrast with electric curve heater, the principle issue with essential oxygen heater is the abundance amount of its free lime and free magnesia contents. Specific ability are expected to deal with it in an appropriate manner to stay away from the volumetric development if not it might result asphalt disappointment. The unpleasant finished surface of steel slag gives high pallet obstruction. The high unambiguous gravity and the legitimate interlocking because of rakishness of steel slag result better soundness and opposition against rutting also.

PRODUCTION OF STEEL SLAG

During the development of three tons tempered steel around one ton of steel slag is produced. It has been seen that each year fifty million tons of steel slag is created from various steel businesses all through the world. Just in Europe, around twelve millions ton of steel slag is created consistently. Steel slag is a leftover material that creates during the development of treated steel by various assets either from the dissolving of scratch to deliver steel in electric curve heater or by changing iron over to steel in essential oxygen heater. Hot fluid metal, scratch and motions along with lime and dolomite lime handled in fundamental oxygen heater. The pollutants like

carbon monoxide and silicon, manganese, phosphorous and iron in fluid state consolidates with lime is and dolomite lime are isolated by infusing oxygen with high strain to frame steel slag.

PROCESS



ENGINEERING PROPERTIES OF STEEL SLAG

Designing properties impact the degree of execution and appropriateness of the material being utilized for street development. Taking everything into account. Adequate exploration has been done on the synthetic and mineral structure as contrast with the physical and mechanical properties of steel slag. Geotechnical properties of steel slag like the bearing limit, compaction and shear strength have been disregarded.

LOAD TEST

More than 30 weighty stacked trucks utilize the carriageway consistently. The steel slag street, which is additionally important for an examination review, has been built utilizing instrumented test segments, containing strain checks, pressure cells, removal measures and thermocouples to quantify load-initiated twisting, and anxiety in the asphalt regions. "We are additionally observing the temperature variety in the asphalt layer utilizing thermocouples," while adding that CSIR CRRRI will additionally screen its exhibition for another year.

THERMAL PROPERTY OF STEEL SLAG

It has been seen that steel slag, can possibly hold the hotness as longer than normal total. The hotness maintenance property of steel slag total is a benefit.

As indicated by Bhatt, the upper surface of the street will associate with "1-2 degree higher in mid-evening when contrasted with ordinary ones".

Thermocouple has been utilized to keep up with the temperature of the external surface of the street. Not withstanding, the carbon impression for such streets is a lot of lower as the ones assembled it are mined and handled to utilize normal totals. Furthermore, subsequent to mining and pulverizing, the material additionally should be shipped starting with one spot then onto the next. With regards to steel slag street, there is no impacting, penetrating or pulverizing as the material is squander emerging from a steel industry which is handled and changed over to the type of total material utilized for development. "The use of waste steel slag for street developments lessens contamination made by stacks of waste unloaded close by. The particles of steel squander likewise get high up and even saturate the ground, arriving at the underground water table," Bhatt made sense of. Coming to the effect of such streets on the vehicles, specialists said that the impact on tires would be unimportant. "The steel slag liquefies at north of 200 degree Celsius, while the temperature during top summer in India isn't over 45 degree Celsius. Additionally, the upper layer is comprised of bitumen layers," Bhatt added.

SPECIFIC GRAVITY

Steel slag contains adequate measure of iron oxide, along these lines it has more noteworthy worth of explicit gravity as contrast with the regular totals. Number of analysts have assessed the particular gravity of other development materials and that of steel slag fall inside the scope of 3 to 4. Steel slag is around 20 % heavier than the lime stone and rock. This might be a monetary detriment, yet isn't thought of, as it gives more benefits like high strength and solidness.

SHEAR RESISTANCE

Steel slags are unpleasant in surface, cubical and precise as contrast with the regular material. It gives better interlocking and contact which results security, protection from rutting and higher pallet obstruction. The grinding point of steel slag is accounted for 40° to 50. As a result of its better shear obstruction, can be utilize every one of the layers of asphalts.

GRAIN-SIZE DISTRIBUTION

Grain size circulation, a significant component which is profoundly affected the mechanical properties of the cooling system, it separates into various molecule size containing bigger size as stones up to the extents of residue. Further it is handled to get legitimate grade of steel slag by pulverizing plants as talked about before. particles depend on 64mm. The fine degree resembles all around evaluated sand comprising of shifting sizes of The coarse degree particles found in the scope of around 64mm to 200mm, comparatively the medium size rock up to the sediment size particles, held at No.4 strainer; 4.75mm and going through No 200 sifter ;0.075mm. The sediment size molecule %age stays inside the scope of 10% to 15% material. It is hard to break it in to particles of various sizes during its age in the steel factory.

Table 1 Chemical Composition of Steel Slag

Steel slag	CaO	SiO ₂	Al ₂ O ₃	FeO/Fe ₂ O ₃	MgO	MnO	TiO ₂	SO ₃	P ₂ O ₅	Free Cao
BOF	39.30	7.75	0.98	-/38.06	8.56	4.24	0.94	0.02	-	-
EAF	35-40	9-20	2-9	15-13/-	5-15	0-8	-	0.08-2.3	01-2.5	-
BOF	47.5	11.8	2.00	-/22.6	6.3	1.90	0.50	-	2.70	-
EAF	30-40	10-20	<10	15-35/-	<10	10	~/-	<0.25	<2	<1.5
BOF	41.30	12.50	2.40	-/31.20	4.3	6.10	0.8	-	1.10	-
EAF	25-40	10-17	4-7	-/-	4-15	<6	-	-	<1.5	<3
BOF	47.88	12.16	1.22	26.30/-	0.82	0.28	-	0.28	3.33	-
EAF	40.78	17.81	4.23	9.25/3.97	8.53	9.79	-	0.3	0.74	-
BOF	40.1	17.80	2.04	12.92/6.58	6.32	6.52	-	0.46	1.13	3.9
EAF	45.5	32.2	3.7	3.3/1	5.2	2	-	-	-	-
BOF	41.3	15.60	2.20	-/-	6.90	8.90	0.50	-	-	3.3
EAF	32.1	19.4	8.6	-/-	9.4	6.8	0.4	0.6	-	-
BOF	41.44	15.26	4.35	13.95/9.24	8.06	5.2	0.72	-	1.15	3.9
EAF	35.7	17.53	6.25	-/26.36	6.45	2.5	0.76	-	-	-
BOF	45.41	13.71	3.8	21.85/3.24	6.25	3.27	-	-	1.42	-
EAF	29.49	16.11	7.56	-/35.26	4.96	4.53	0.78	0.63	0.55	-
BOF	45	11.10	1.90	10.70/10.90	9.6	3.10	-	-	-	-
EAF	23.9	15.3	7.4	-/-	5.1	4.5	-	0.1	-	0.45
EAF	52.3	15.30	1.30	-/-	1.10	0.39	-	-	3.10	10.0
EAF	24.4	15.35	12.21	34.36/-	2.91	5.57	0.56	-	1.19	-

Table 2 Mineralogical composition of steel slag

Slag	Mineralogical composition
EAF	CaCO ₃ , FeO, MgO, Fe ₂ O ₃ , Ca ₂ Al (AlSiO ₇), Ca ₂ SiO ₄
--	2CaO.SiO ₂ , 3CaO.SiO ₂ , 2CaO.Fe ₂ O ₃ , FeO, (Ca.Fe)O
EAF	Ca ₂ SiO ₅ , Ca ₂ Al (AlSiO ₇), Fe ₂ O ₃ , Ca ₁₄ Mg ² (SiO ₄) ₂ , MgFe ₂ O ₄ , Mn ₂ O ₄ , MnO ₂
BOF	2CaO. Al ₂ O ₃ .SiO ₂ .Fe ₂ O ₃ .CaO.FeO
EAF	MnO ₂ , MnO, Fe ₂ SiO ₄ , Fe ₇ SiO ₁₀
BOF	2CaO.Fe ₂ O ₃ 2CaO.P ₂ O ₅ , 2CaO. SiO ₂ , CaO
BOF	β-Ca ₂ SiO ₄ , FeO-MnO-MgO solid solution, MgO
EAF	Ca ₃ MgSiO ₄) ₂ . β-Ca ₂ SiO ₄ spinal solid solution (Mg,Mn)(Cr,Al) ₂ O ₄ wsuite-type solid solution ((Fe,Mg,Mn)O),Ca ₂ (Al,Fe) ₂ O ₃
EAF	Ca ₂ SiO ₄ ,4CaO.Al ₂ O ₃ .FeO ₃ , Ca ₂ Al(AlSiO ₇), Ca ₂ SiO ₅ , 2CaO.Al ₂ O ₃ SiO ₂ , FeO, Fe ₃ O ₄ , MgO, SiO ₂

PHYSICAL AND MECHANICAL PROPERTIES OF STEEL SLAG

Streets are exposed to static and dynamic powers, including the unforgiving climate like downpour, temperature, freezing and defrosting. The proposed material ought to give sufficient physical and mechanical properties to oppose and perform well. The physical and mechanical properties are given as: total pounding esteem, misfortune points scraped area, total effect esteem, adequacy, cleaned stone worth, water retention, surface, stripping, explicit gravity and flakiness. The physical and mechanical properties of steel slag gainfully meet the necessities of a fashionable material. As contrast with regular total, it gives an optimal strength, penetrability, security and obstruction against scraped spot, breaking and long-lasting twisting. The physical and mechanical properties of steel slag are given in Table 3.

Table 3 Physical and mechanical properties of steel slag

Steel slag	G,	Bulk Density (Kg/m ³)	Water absorption (%)	LAA (%)	Soundness	ACV (%)	AIV	Polished stone value	CBR	Stripping (%)
EAF	3-3.7	1800 to 2000	0.2-2	20-25	<12	-	-	-	-	-
-	3.69	-	-	15	2.2	15	11	-	<400	>97
-	-	-	-	20-25	<12	-	-	-	300	-
EAF	3.38	-	-	24	-	-	-	0.05	-	0
EAF	3.91	-	-	15.5-21.5	-	-	-	0.05	-	0
-	3.5	>1900	0-2	14	0-1.5	20	14	-	>200	-
WCS	3.4	-	1.6	13	0.4	-	-	-	-	-
ACS	3.3	-	1.8	16	0.8	-	-	-	-	-

COMPACTION CHARACTERISTICS

Restricted investigations have been done on the compaction of general steel slag. The aftereffects of past explores show higher upsides of most extreme dry unit weight of steel slag than normal total. The compaction content and greatest dry load of EAF steel slag were in the scope of 3%-6% and 23-26kN/m³. attributes of EAF steel slag of various grades by standard delegate compaction test strategy.

UTILIZATION OF STEEL SLAG IN THE CONSTRUCTION OF ROAD

Steel slag have been effectively used for the development of streets in wearing course, base and sub base too. Particularly Europe, Canada, Australia and USA have not regarded it as a modern waste but rather a valuable development material, and effectively utilizing steel slag as total in surfacing and base of adaptable asphalts. As indicated by the Indian Road Congress rules for development of a weighty traffic street that is equipped for taking the heap of 1,000 to 1,200 trucks each day, around 600 to 700 mm thickness of street layers are expected on the establishment with 8% CBR (California Bearing Ratio). As indicated by CRRI head researcher Satish Pandey, in contrast with ordinary thruways, the ones made from steel slag are 30% less thick due to better material attributes. "The development expenses of such steel slag streets will likewise associate with 30% less expensive. The Hazirastreet utilizes around 1 lakh huge loads of handled steel slag." The CRRI will presently get ready rules and determinations for the usage of steel slag in street development. "The boundaries and execution pointers will be consolidated in the street rules and will be given to Indian Road Congress, Ministry of Roads and Highways, to use steel slag for the developments of public expressways".

CONCLUSION

Surat Municipal Corporation (SMC) Road Development division authorities say the usage of handled steel slag in street development makes ready for feasible utilization of waste and diminishes the dependence on transient normal totals. This cycle is likewise expected to diminish Green House Gases

(GHG) discharges and carbon impression in street development movement and is in accordance with India's obligation to the United Nations Sustainable Development Goal No. 9 for building versatile framework through comprehensive and reasonable industrialization and green advances.

Chief Engineer at SMC's Road Development Department, B R Bhatt, said: "The inexact development cost per square meter of a handled steel slag street is Rs 1,150 as against Rs 1,300 for a bitumen street and Rs 2,700 for a concrete or a substantial one. The life expectancy of a concrete or substantial street is north of 30 years while that of bitumen and steel slag street is around 15 years."

The development of the six-path street was finished toward the beginning of March. The street is currently being utilized for the drive to and from the modern home and sees a great deal of hard core traffic including trucks and rhythms. In any event, 20 stacked trucks supposedly go through this stretch every day.

The street is likewise financially savvy. "The development expenses of such steel slag streets will likewise associate with 30% less expensive. The Hazira street utilizes around 1 lakh huge loads of handled steel slag," CRRI head researcher Satish Pandey told The Indian Express, Sources said that the Hazira street in Surat was picked due to the vicinity to the ArcelorMittal Nippon Steel (AM/NS) plant and the accessibility of weighty traffic out and about for concentrate on purposes. This stretch was at that point in a haggard condition and is presently re-fabricated utilizing the handled slag totals according to the riding standard of a products parkway. Specialists have said that these streets are additionally substantially more sturdy during the rainstorm. AM/NS produces around 2 million tons of steel slag yearly which can be used for the development of streets.

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