

Ferroform™ Blocks†

1. Introduction

In the field of concrete construction, efforts to deal with environmental issues such as the depletion of natural resources and generation of CO₂ accompanying the production and extraction of raw materials are demanded. On the other hand, because Japan has few natural resources, further promotion of recycling of iron and steel slag is desirable, and there are moves to actively use these industrial byproducts in port and harbor construction, etc¹⁾. Based on this background, JFE Steel developed a steel slag hydrated matrix production technology that fully utilizes iron and steel slag and other industrial byproducts as a substitute for cement concrete²⁾. As shown in **Fig. 1**, steel slag hydrated matrix (Ferroform™) is applicable to a wide range of uses in port and harbor construction, including armor stones and blocks, materials for seaweed beds, backfill stones, etc.

This article introduces the manufacturing process for “Ferroform Blocks”, which is a type of steel slag hydrated matrix produced in block form, together with an example of application.

2. Outline of Ferroform™ Blocks

2.1 Steel Slag Hydrated Matrix

Steel slag hydrated matrix is a product which was developed as a substitute for cement concrete. Ground granulated blast furnace slag, which is the raw material for blast furnace cement, is used as the binder, steel-making slag is used as the aggregate and fly ash is used as an admixture (**Fig. 2**). The possible manufacturing processes are (1) site manufacture (casting using molds), (2) factory manufacture (vibration/pressure molding and vibration molding) and (3) manufacture of artificial stones (crushing after casting in yard). As

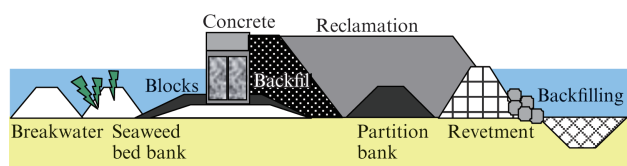


Fig. 1 Application of hydrated matrix with steel slag

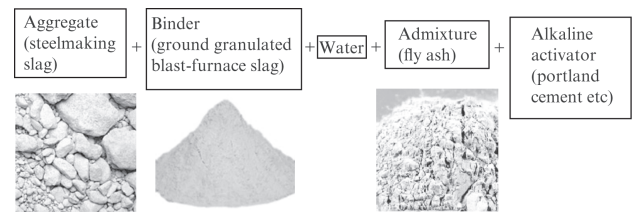


Fig. 2 Materials of hydrated matrix

in the case of ordinary concrete, this product is manufactured based on a prescribed quality control method, and existing ready-mixed concrete plants can be used. Due to the high density of steelmaking slag, it is also possible to achieve high density in Ferroform™ Blocks manufactured by this technology, and since the blocks can be made more compact than those produced by the conventional technology, a reduction of manufacturing costs can be expected.

2.2 Examples of Production of Ferroform™ Blocks

Ferroform™ Blocks are manufactured in the same manner as ordinary cast-in-place unreinforced concrete (plain concrete) secondary products. After steel slag hydrated matrix is mixed at a concrete plant, it is transported by a truck agitator, unloaded and cast in forms. Production of the blocks is completed by removing the forms and performing curing (**Fig. 3**). Products are inspected to confirm that physical properties such as strength, etc. and environmental safety quality satisfy the standard values. **Figures 5** and **6** show the condition of production of 15 t cuboid lump blocks and X-type blocks, respectively.

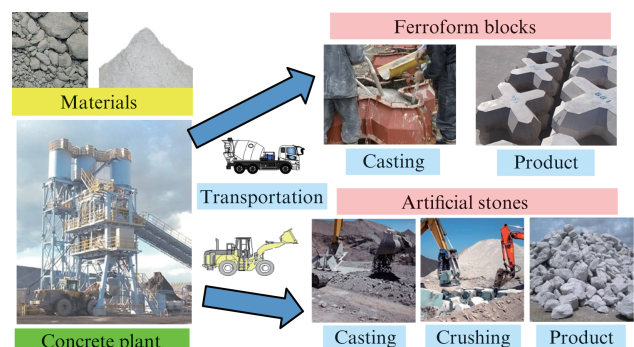


Fig. 3 Manufacturing process

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Fig. 4 Production of cuboid lump blocks



Fig. 8 Covering blocks (Ferroform blocks)



Fig. 5 Production of X-type blocks

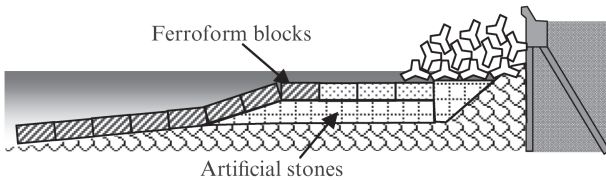


Fig. 6 Construction of shallow place



Fig. 7 Installation of stones and blocks

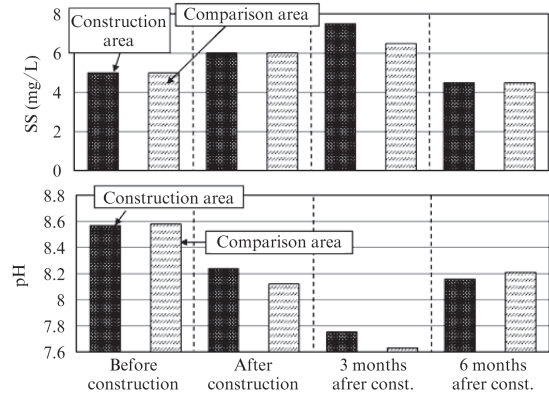


Fig. 9 Water quality survey



Fig. 10 Biological survey

3. Example of Application of Ferroform™ Blocks

A shallows construction experiment using steel slag hydrated matrix (Ferroform™ Blocks and Artificial Stones) was carried out at the West Revetment of JFE Steel's East Japan Works (Chiba). The purposes of the experiment were reinforcement of the revetment and restoration of the coastal environment (shallows construction and environmental improvement). As a preliminary study, a seismic analysis of the revetment reinforcement part was carried out, and improvement of earthquake resistance was confirmed, including suppression of displacement of the revetment crown in the event of a Level 2 earthquake.

The cross section and condition of construction in the demonstration experiment are shown in **Figs. 6–8**. Ferroform Blocks weighing 10 t (2 m×2 m×1 m) and 15 t (2 m×3 m×1 m) were installed as armor blocks, and Ferroform Stone was used as the infilling material.

Water quality surveys were conducted to determine the effect of block construction on the marine environment. Changes with time were investigated before construction, immediately after construction (August 2015) and 3 months and 6 months after construction (**Fig. 9**). No changes in turbidity (suspended solids: SS) or pH were observed in the construction area or the comparison area (near the revetment about 800 m from the construction area), confirming that the installation of Ferroform Blocks has no effect on marine areas.

In addition, the marine life in the area around the shallows and adhering to the blocks was also investigated. In the survey 3 months after construction, parrot fish and greenfish were seen in the waters surrounding the blocks (**Fig. 10**), and seaweeds and shellfish were also found adhering to the blocks. Thus, this study confirmed a condition of restoration of the marine environment by improvement of the bottom sediments from a mud-like condition to a shoal made

blocks.

4. Conclusion

It was shown that Ferroform™ Blocks can be manufactured in the same way as concrete blocks, and application for seismic reinforcement of revetments and restoration of the marine environment are possible. In the future, JFE Steel will promote application of Ferroform Blocks as an effective material for port and harbor construction.

References

- 1) Ports and Harbours Bureau and Civil Aviation Bureau, Ministry of Land, Infrastructure and Transport. Recycling technology guidelines for harbor and airport construction and maintenance (Revised). 2015.
- 2) Coastal Development Institute of Technology. Technical Manual on Hydrated Matrix of Steel Slag-Technology for Effective Use of Steelmaking Slag (Revised edition). 2008.

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