Development of Soft Plastic Material which has a Good Workability and Ability of Crack Prevention with Special Fiber

Hiroyuki Suzuki*,Toshifumi Nihari, Hideyuki Tasaki, and Yusuke Naito
NIPPONCRUCIBLE Co., Ltd.

Abstract

A Ladle used for cast iron involves heavy work to remove the hardened deposits on the inner face of the ladle. The deposits were created by slag and additives brought from melting furnace. So, the demand for the soft plastic material has been glowing because it makes possible to reduce the deposits removal work by applying 0 to 50 mm thick lining to the inner face of the ladle lining. We have developed the soft plastic material having ideal workability and crack preventing property with the organic and inorganic fibers.

1. Introduction

Various ladles were used in melting and pouring process of the cast iron. Monolithic refractory rather than shaped refractory are used for main lining in order to prolong the refractory life and reduce the working process by the non heavy work and the short installation time. The hardened deposits were created by slag and additives on the inner face of ladle. The removal work of hardened deposits involves hard work. The measure to reduce the hard work was performed by installing a soft plastic material which has 0 to 50mm thickness and removing the hardened slag and additives altogether. Such material is also called a patching material. The material which did not have enough moisture may have less cracks during curing and drying process. However, it does not have enough workability and is difficult to use. In contrast, the material which has enough moisture has an ideal workability but crack may appear during curing and drying process.

When cracks appear, the plastic material may collapse along the cracks. Slag may penetrate through the crack into the inner side of the plastic material. As a result, the removal work could not be sometimes performed. In material manufacturing process, it is possible to control its moisture value. However, it is difficult to control the workability and the numerical value of the workability. So we report here that we have developed a soft plastic material having an ideal workability and the installation control method.

2. Experiment to develop

The experiment to develop the material was based on the plastic material whose chemical composition was 67% of Al_2O_3 and 26% of SiO_2. The plastic material had a character of softening and improved its workability by adding mixed water but it had a disadvantage of increasing cracks after the installation. The relationship between the softness with the amount of the mixed water is shown in the Fig.1.

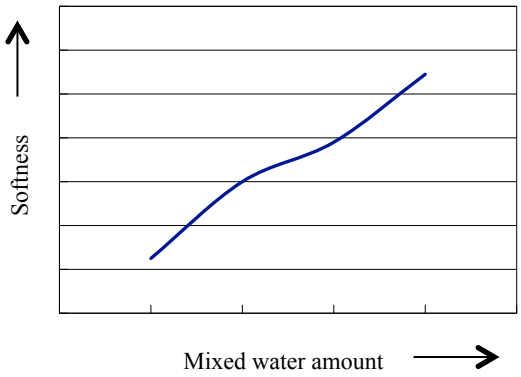

Fig. 1 Relationships between the softness and mixed water amount

As an evaluation 1, the workability was inspected by adding water to the plastic material. This was evaluated by the five skilled workers in the installation. Then they evaluated the workability by the score, which had four grades, and they scored the evaluation and summed up them. The result was shown in the Table1.

Table 1 Evaluation of workability

(better 4＞3＞2＞1＞worse)

Moisture %	9	10	11	12	13	14
Evaluator A	1	1	2	3	4	4
Evaluator B	2	2	2	3	4	4
Evaluator C	1	2	3	4	4	3
Evaluator D	1	2	2	3	4	3
Evaluator E	1	1	2	3	4	4
Total	6	8	11	16	20	18

Moisture %	15	16	17
Evaluator A	3	2	1
Evaluator B	4	3	2
Evaluator C	3	2	1
Evaluator D	3	2	2
Evaluator E	3	2	1
Total	16	11	7

As an evaluation 2, the inspection named Marshal

test was performed in order to evaluate the workability in numerical value. This evaluation is used for measuring the transformation character of the taphole mixture for the blast furnace. Sketch of the measuring equipment is shown in the Fig. 2.

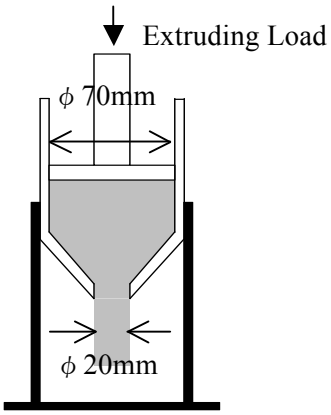

Fig. 2 Sketch of the measuring equipment

As shown in Fig. 3, the result showed that the workability was ideal with the Marshal value between 100 and 250.

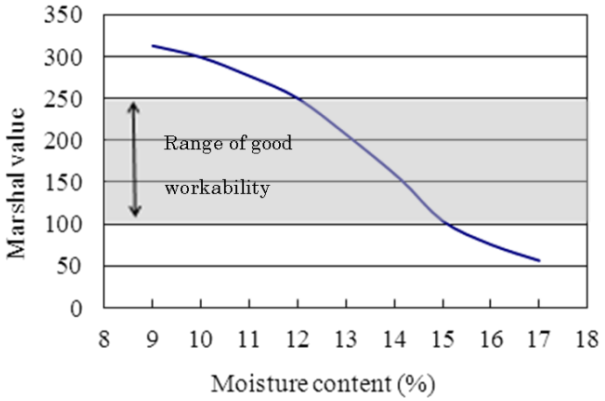

Fig. 3 Relationships between moisture and the Marshal value

As an evaluation 3, the inspection of the moisture and the curing were inspected. The soft plastic material became softer after adding mixed water and its workability was improved. However, there is a demerit that cracks during curing and drying process will increase. The relationships between the moisture value and the number of cracks are shown in the Table 2.

Table2 Relationships between moisture value and the number of crack.

Moisture (%)	9	10	11	12	13
Number of crack	0	0-2	0-3	2-4	2-5

Moisture (%)	14	15	16	17
Number of crack	2-6	3-7	4-8	4-9

*・Crack width is 2mm or more.

・Sample size is 600mm x 400mm with 30mm thickness

The result showed that cracks appeared during curing and drying process when the moisture value had a better workability. In order to prevent cracking during the curing to the drying process, an addition of special fiber was considered and prepared. The fibers used for the experiment are shown in Fig .4.

Sample 1	Sample 2	Sample 3
Organic fiber	Organic fiber	Organic fiber
		
Sample 4	Sample 5	Sample 6
Inorganic fiber	Inorganic fiber	Carbon fiber
		

Fig. 4 Samples of fibers used for the experiment

As an evaluation 4, each sample was charged into a beaker and the dispersion to water was evaluated. The result is shown in the Table 3.

Table 3 Evaluation of the dispersion

Fiber sample	Type	Dispersion
Sample1	Organic 1	◎
Sample2	Organic 2	◎
Sample 3	Organic 3	◎
Sample 4	Inorganic 1	×
Sample 5	Inorganic 2	×
Sample 6	Carbon fiber	◎

*Evaluation: Better dispersion ◎

Lower dispersion ×

The sample1, 2, 3, and 6 had a better dispersion character. In contrast, the sample 4 and 5 had a character of lower dispersion and they remained

as lumps in water. So, further inspection was stopped, because they could not add to the plastic material.

As an evaluation 5, the workability was evaluated by adding each fiber at the fixed moisture percentage of 13% for the soft plastic material. The evaluation was performed by five skilled workers same as the evaluation 1. The result is shown on the Table 4. In addition, the result by the Marshal value is shown on the Fig 5.

Table 4 Workability evaluation

Fiber addition	No addition	α %	2α %	3α %	4α %
Sample 1	20	18	17	11	6
Sample 2	20	17	16	9	6
Sample 3	20	10	8	6	5
Sample 6	20	10	9	5	5

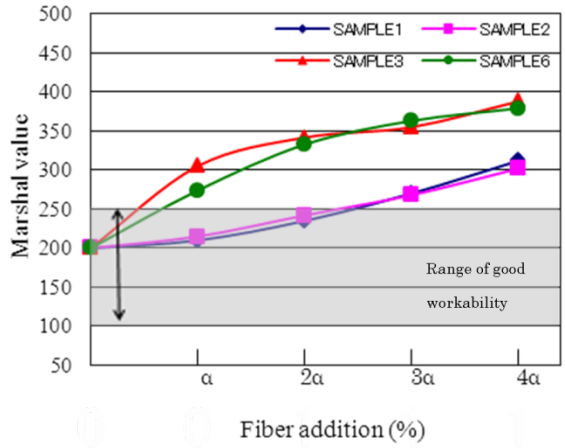

Fig. 5 Results of each sample by the Marshal Test

As the addition of the fiber increases at the fixed water amount, the Marshal value tends to increase. However, when the fiber amount increased with the fixed water amount, its Marshal value tends to increase. Depending on kind fiber, each Marshal value has different increase curve. The sample that could increase the Marshal value by the small amount of the fiber addition agreed with the samples that did not have ideal workability. In addition, the result showed that the Marshal value of such sample had the value which is out of the ideal workability 100 to 250.The further evaluation of the sample 3 and 6 was stopped because the workability would become worse. The amount of the addition was as α to 2α percent for an appropriate amount judging from the workability.

As an evaluation 6, appearance of the crack was inspected by adding each fiber by α when samples were dry. The result is shown on the Table 5.

Table 5 Crack appearance

Type	No addition	α%	2α%	4α%
Sample 1	×	△	◎	◎
Sample 2	×	×	△	◎

◎:No crack
△:Fine cracks
(The width is below 2mm)
×:Large cracks
(The width is more than 2mm)

As an evaluation 7, three samples of the plastic materials which were no addition, the 2α% addition of sample 1, and the 2α% addition of sample 2 were inspected. This inspection was performed by installing fibers in the sample with the size of 600x400length with 300mm thickness and the appearance of the crack by curing after the installation is inspected. The result is shown on the Fig.6.

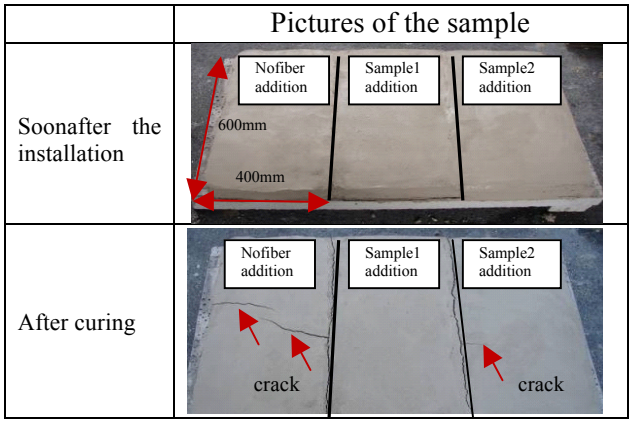

Fig .6Pictures of no addition (Left), 2α% addition offibersample1 (Center), and 2α%addition of fiber sample 2(Right)

As an evaluation 8, TG (Thermal Gravity analysis) was measured by a different thermal scale in order to inspect the difference of fiber contained in the sample 1 and 2.The result was shown in the Fig 7. The weight of sample 2 decreased by 10% up to 110 degrees Celsius, which was caused by water. It was expected that the moisture of this fiber had influenced the difference of the crack appearance.

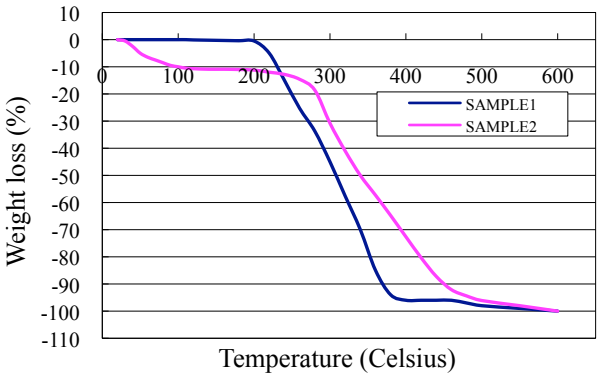

Fig .7 Results of TG

4. Conclusions

We could obtain following conclusions about the soft plastic material development that had an ideal workability and with less cracks.

1) Moderate water addition improved the workability in the plastic material but the cracks appeared during curing process.
2) The fiber was added to prevent the cracks but the applied fiber should have specific property.
3) The dispersion and the maintaining of the workability are required for the character of fiber in addition to the crack control.
4) A moderate range of fiber addition existed by maintaining the balance of workability and the crack control.
5) The workability could be evaluated by the Marshal value.