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Study of the applicability of the concrete protection method by sulfuric acid-proof mortar

Ken-ichi Fujisawa[1], Keisuke Inoue[1*]

[1]*NIPPON JIKKOU Co.Ltd,Japan*
[*]*3-4-7 suzuri-tyou, Akashi-shi, Hyougo-ken,673-0028, Japan*
, [1] laboratory@jikkou.co.jp [1]k-inoue@jikkou.co.jp*

ABSTRACT

In this research, the performance of the developed sulfuric acid-proof mortar was checked in the laboratory. The contents of the performance check are adhesive strength, bending strength and compressive strength on the conditions, which changed temperature in consideration of construction environment.

Moreover, sulfuric acid-proof performance was checked by long-term sulfuric acid solution immersion.

Sulfuric acid-proof mortar was applied at on construction site. As a result, construction application was checked the high level of applicability

It was thought by setting up the thickness of the mortar set by the environment or a utilization plan that the fall of repair expense was enabled.

Keywords. Sulfuric acid proof mortar, Mortar lining, Applicability, Concrete protection, Wastewater treatment plants

INTRODUCTION

In general, the concrete of facilities related to the wastewater treatment facilities deteriorates with sulfuric acid resulting from hydrogen sulfide. When the degradation of concrete sewer pipes under the road, some cases lead to subsidence accident of the road. Until now, the epoxy resins etc. were applied to the concrete surface as a measure against sulfuric acid degradation. (Japan Sewage Works Agency, 2012)

If resin is applied in a high humidity environment, the trouble of resin may occur. For this reason, concrete protection with resin was difficult in the pipeline facility. On the other hand, also in the high humidity environment, mortar is hardened normally and fits concrete protection material in the pipeline.

By the improvement of the sulfuric acid-proof performance of mortar, it was thought that it became the concrete protection materials instead of resin

In this research, the performance of the developed sulfuric acid-proof mortar was checked in the laboratory. Sulfuric acid-proof mortar was applied at on construction site. As a result, construction application was checked the high level of applicability

DEVEROPMENT TARGET, AND MATERIALS SELECTION

In this research, it aims at using mortar material instead of resin lining as a measure against sulfuric acid degradation in sewage treatment facilities.

Since the life of the resin lining material generally considered is ten years, the capability to protect concrete for ten years is required for it.

The speed of sulfuric acid degradation is considered in about 5 mm per year under severe environment. Therefore, it is necessary to make degradation speed of mortar material about into 1/5 of concrete. At this time, thickness of a concrete protecting layer is made to 10-20 mm.

With the sulfuric acid-proof mortar development blast furnace cement (contents of blast-furnace-slag is 60-70%) and alumina cement were used. These cement differs in a hydration product from ordinary portland cement, for this reason, these cement has high sulfuric acid-proof performance. (Japan Sewage Works Agency, 2012)

We used alumina cement as an effective material to the target of this research.

MATERIALS AND METHODS

Materials. Developed mortar was used alumina cement and special mixture material. Moreover, alumina clinker was used as aggregate.

For the improvement of bonding strength etc., acryl-emulsion was used as mixture liquid.

The standard mortar used for the purpose of the check of sulfuric acid-proof performance. The combination of standard mortar was used for JIS R 5201 (Physical testing methods for cement).

Table 1. Materials

Name	Materials	Compounding ratio （mass ratio）
Sulfuric acid proof mortal	Blended materials: Acryl-emulsion: Water	100:10:8.5 （W/C＝35%）
Standard mortal	Cement (OPC): Sand: Water	25:75:12.5 （W/C=50%）

Methods. Sulfuric acid-proof performance and adhesion stability are required for performance of concrete protection materials.

About sulfuric acid-proof performance was checked by immersion to a sulfuric acid solution. Moreover, characteristic of adhesion stability was checked under several temperatures condition.

Workability test. In order that sulfuric acid-proof mortar is applied by trowel, it is required for that good trowel workability.

The flow test was carried out according to JIS R 5201 (Physical testing methods for cement), and the amount-of-water range suitable for trowel workability was determined.

Sulfuric acid-proof test. The sulfuric acid-proof performance was checked by sulfuric acid 5% solution immersion test for 4 months, and checked the sulfuric acid penetration depth by the 1% alcohol-phenolphthalein solution.

The first one-month sulfuric acid solution was exchanged every 7day, and after one month it exchanged every one month. Specimen size was φ50mm×100mm cylinder.

Adhesion test. On site, construction is performed also in summer and winter. Therefore, the examination, which changed temperature conditions, was required.

Adhesion strength examined according to JIS 6916(Surface preparation materials for finishing). The examination was carried out at each temperature of 5 ℃, 10℃, 20 ℃, and 30 ℃.

Compressive strength and bending strength test. Compressive strength and bending strength examined according to JIS R 5201 (Physical testing methods for cement). The examination was carried out at each temperature of 5 ℃, 20 ℃, and 30 ℃.

RESULTS

Workability test. Amount of water and workability was checked. The flow value with good trowel workability was around 165 mm.

In order to obtain high sulfuric acid-proof nature, water cement ratio was small. For this reason, workability changes a lot by addition of a little water.

The range of amount of water suitable for sulfuric acid-proof mortar is 8% to 10% of blended materials. The amount of Acryl-emulsion is fixed to 10%.

Table 2. Results of table flow test

Compounding ratio (Blended material /Acryl-emulsion/Water)	100/10/8.0	100/10/8.5	100/10/9.0	100/10/10.0
Table flow (loss、30min)	155 (+3%)	159(+4%)	163 (+4%)	170 (+6%)

Sulfuric acid-proof test. The sulfuric acid-proof mortar has secured high sulfuric acid-proof performance as a result of the sulfuric acid immersion examination.

In amount-of-water within the limits united with construction, the big difference to sulfuric acid-proof performance did not confirmed.

The result of having compared the sulfuric acid-proof paerformance of standard mortar with the sulfuric acid-proof mortar of the amount of maximum water is shown in Figure 1.

Degradation of the mortar by sulfuric acid was advancing linearly for 120 days at sulfuric acid solution concentration 5%. The degradation speed of acid-proof mortar was about 1/5 of standard mortar.

Table 3. Corrosion depth with Acid resistance test (immersion 5% sulfuric acid solution at 20℃)

	Corrosion depth(mm)		
	30days	60days	120days
Standard mortal	4.75	9.65	collapse
Sulfuric acid proof mortal 100/10/8.0	1.20	2.04	3.04
Sulfuric acid proof mortal 100/10/9.0	1.28	2.08	3.06
Sulfuric acid proof mortal 100/10/10.0	1.30	2.22	3.24

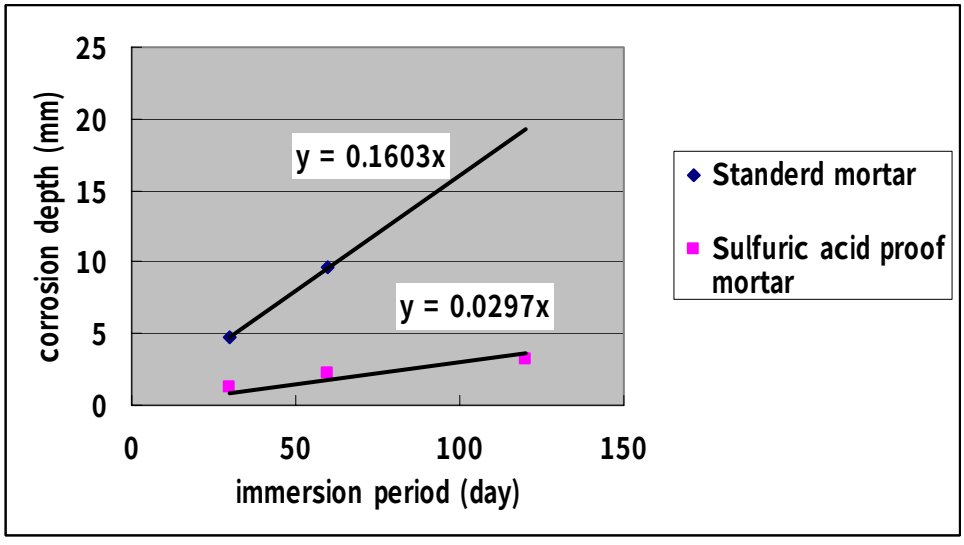

Figure 1. Deterioration rate of mortal immersed in 5% sulfuric acid solution

Adhesion test. In the examination by the maximum amount of water, hardening of mortar was delayed. Finally, the adhesive strength of mortar reached to target value (1.5N/mm^2)

Table 4. Results of adhesion test

curing conditions	Period	Adhesion strength (N/mm^2)
5℃ RH50%	3d	1.71
	7d	1.86
	14d	1.51
	28d	1.82
10℃ RH50%	3d	1.70
	7d	1.63
	14d	1.65
	28d	1.69
20℃ RH50%	3d	0.90
	7d	1.40
	14d	2.00
	28d	2.20
30℃ RH50%	3d	2.10
	7d	2.60
	14d	2.70
	28d	2.80

Compressive strength and bending strength test. In consideration of construction, the amount of water used for mortar has prepared the range for adjustment of viscosity. The influence of additional water was not confirmed as a result of the examination.

As a result of strength tests according to temperature, in the cryogenic period, hardening of mortar was delayed, but in four weeks, the compressive strength of mortar reached to target value (45N/mm^2) and it has checked that winter could also be used.

Table 5. Results of compressive and bending strength test according to amount of water

curing condition		Compounding ratio (Blended material/ Acryl-emulsion/ Water)	100/10/8.0 (N/mm^2)	100/10/8.5 (N/mm^2)	100/10/9.0 (N/mm^2)	100/10/10.0 (N/mm^2)
20℃	bending strength	3d	7.5	7.7	7.5	7.1
		7d	9.1	8.6	8.7	8.9
		28d	10.8	11.1	13.4	12.6
	compressive strength	3d	37.6	37.0	42.1	43.0
		7d	43.5	42.0	47.8	47.7
		28d	52.8	51.3	58.8	59.5

Table 6. Results of compressive and bending strength test according to cure conditions

curing conditions		Period	strength (N/mm^2)
5℃	bending strength	3d	4.0
		7d	5.5
		28d	7.6
	compressive strength	3d	24.5
		7d	33.3
		28d	45.4
20℃	bending strength	3d	7.7
		7d	8.6
		28d	11.1
	compressive strength	3d	37.0
		7d	42..0
		28d	51.3
30℃	bending strength	3d	7.7
		7d	8.6
		28d	11.1
	compressive strength	3d	32.2
		7d	42.5
		28d	57.4

CONSTRUCTION EXPERIMENT

The construction of sulfuric acid-proof mortar was carried out by the repair work of the manhole of sewer culvert. Although concrete protection lining by an epoxy resin was examined by the general design, however construction environment was high humidity, we were concerned about the performance of a lining affected by dew condensation.

Then, the sulfuric acid-proof mortar was selected. It is because sulfuric acid-proof mortar is not affected for performance with high humidity.

The covering thickness of sulfuric acid-proof mortar was determined according to the environmental condition considered from the hydrogen sulfide concentration and the degradation depth.

Site 1. This manhole was in the hot-springs resort side. It constructed in the night when amount of water decreases.

Outside air temperature was less than 0 ℃. It is concerned that acryl-emulsion solution and water for mixture may have been frozen, and so emulsion and water were warmed and used for mixture. The inside of a manhole temperature was about 5 ℃.

When the manhole was opened, the open air flowed in and the surface of a wall dewed. Then, construction implementation was carried out, drying the surface of a wall with a fan.

Although the sulfuric acid-proof mortar viscosity was a little high, the workability of mortar was good. And the same quantity as usual has been worked.

Site 2. The second example was also manholes. The degradation part of concrete removed with the high-pressure water of 200MPa.

Sulfuric acid-proof mortar covered with 20-mm thickness. Mortar was applied in 2 steps. Workability was good like the site 1

Photo 1. The sulfuric acid-proof mortar construction situation

CONCLUSION

In the repair work of sewage treatment facilities, the measure against degradation of concrete was performed using the protective lining which used the epoxy resin etc. until now.

In this research, as a result of examining the applicability of the protective lining construction method by the mortar, which improved sulfuric acid-proof performance, the following conclusions were obtained.

- The performance of sulfuric acid-proof mortar was about 5 times from standard mortar, and had sufficient performance as a protection material.

- It was thought that the sulfuric acid-proof mortar had sufficient physical properties in on-site construction of winter and a summer.

- As a result of checking workability in site construction, workability was equivalent to the usual mortar.

REFERENCES

Japan Sewage Works Agency. (2012). *Corrosion restraint technique of the sewer concrete structure and prevention of corrosion technology manual*.

Japan Sewage Works Agency. (2008). *Technical evaluation report of the prevention of corrosion technology by sulfuric acid resistant mortal*.