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Pumping-up Method of Concrete into Steel Tube Column*

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1 Introduction

It is expected that rapid progress will be made in steel tube concrete construction in which the interior of a steel tube column is filled with concrete (concrete filled steel tube: CFT) as a type of high-strength, high-ductility structures. In order to ensure that this excellent performance is fully realized itself, however, it is necessary that the interior of the steel tube be densely and solidly filled with concrete without also generating voids in the lower part of diaphragm.

To fill up concrete, the pumping method shown in **Fig. 1** has often been used. Currently, intensive efforts are being made to develop techniques for obtaining the filling properties.

Kawasaki Steel has also been studying the mix proportion of concrete suitable for filling-up and has established a filling-up technique based on the results of an actual-scale filling-up experiment.

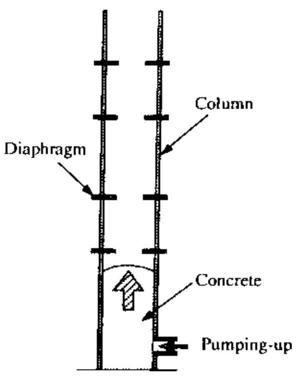

Fig. 1 Pumping method

2 Properties of Fresh Concrete

The fresh concrete used for filling-up must have excellent flowability and be free from segregation and bleeding. Therefore, the filling concrete selected here is high-flowability concrete that provides slump flow of 50 to 70 cm, 50 cm flow time of 5 to 10 s, and little performance loss within 90 min as target performance.

Examples of mix proportions are shown in **Table 1**. The water-cement ratio is reduced to suppress bleeding, and a high-range AE water reducing agent and Kawasaki Steel's own iron blast-furnace-slag powder "Riverment®" are added to obtain flowability.

As is apparent from the condition of the fresh con-

Table 1 Example of mix proportions

No.	Water-cement ratio W/(C + BFS) (%)	Fine-total aggregate ratio s/a (%)	Unit weight (kg/m³)					High-range AE water reducing agent (% × (C + BFS))
			Water W	Cement C	Riverment BFS	Fine aggregate S	Coarse aggregate G	
1	33.3	53.1	172	362	155	883	813	1.05
2	37.0	53.9	175	331	142	912	813	1.45

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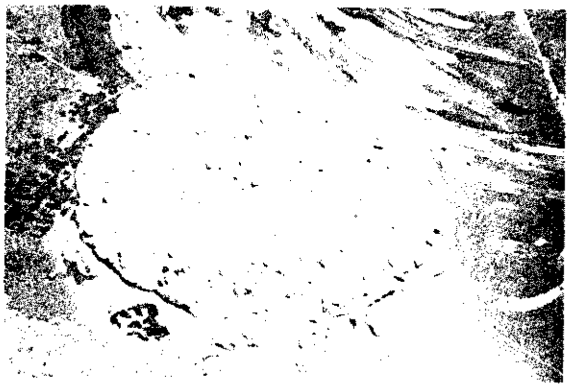

Photo 1 Fresh concrete

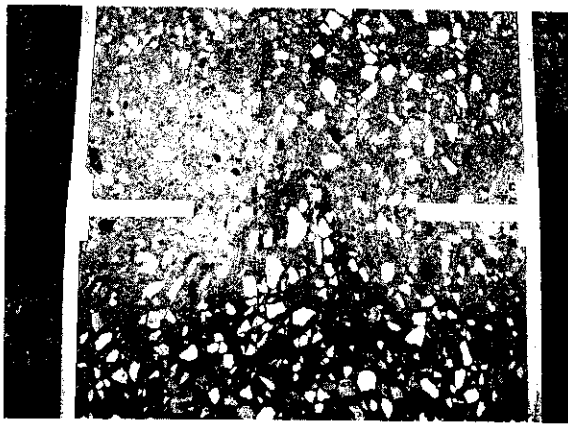

Photo 3 View of filled concrete

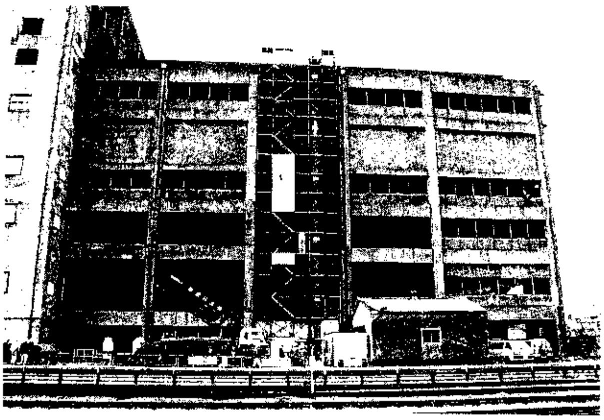

Photo 2 View of real scale experiment

crete shown in **Photo 1**, there is no segregation and almost no bleeding that occurs during the process.

3 Filling Property

The filling property was examined by conducting partial model experiments using the mix proportions of concrete, pumping rate, diaphragm pore diameter, etc. as parameters and then verified by an actual-scale (27 m) experiment (**Photo 2**). Although pumping rates of about 20 to 30 m^3/h have been adopted as the control standard, the pumping rate used in the experiments was 50 m^3/h.

The subsidence on the top surface of the column was as small as about 2 mm and subsidence itself almost stopped in 5 h. Furthermore, bleeding was not observed and there was no problem.

It is possible to estimate the stress generated in the steel tube during concrete casting from the internal pressure, as the fluid pressure of concrete and the structural safety during casting can be ascertained beforehand.

Dispersion of the strength of hardened concrete in the height direction has been observed and the strength in the upper part of hardened concrete tends to decrease. However, the concrete strength specified as a design criterion is always met.

Photo 3 shows the condition of a specimen cut at the diaphragm near 21 m after the hardening of the concrete. Near the diaphragm, the stress generated during an earthquake is large. This part is also important in terms of stress transmission from beams. Under this filling-up method, concrete is also densely and solidly filled in the lower part of diaphragm and no blockade or voids of concrete have been observed. Thus it is apparent that the filling conditions are good.

4 Conclusive Remarks

An outline of the properties and filling conditions of fresh filling concrete was presented on Kawasaki Steel's filling-up technique in CFT construction.

Although the authors believe that this filling-up technique ensures that the composite effect of steel and concrete fully manifests itself, there are still some factors that require further examination, such as the strength of hardened concrete and regional characteristics of the aggregate. The authors intend to further improve this technique by examining these factors in actual projects.

The authors would like to thank Mr. Tachiyama of Ando Construction Co., Ltd. for his cooperation in establishing this technique.

Reference

1) Y. Murakami, T. Iwasaki, S. Inaoka, Y. Ueda, K. Hongo, and H. Koizumi: "An Experiment on Pumping-up of Concrete into Steel Tubular Column", Summaries of Technical Papers of Annual Meeting, Architectural Institute of Japan (1996)

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