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Application of New Concrete Using Small Pieces of Ice

Application de nouveaux bétons utilisant de petits morceaux de glace

Anwendung einer neuen Betonart unter Beimischung von Eisstücken

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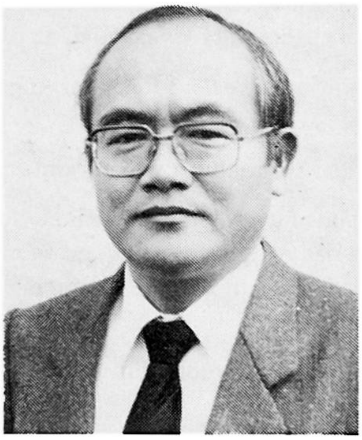
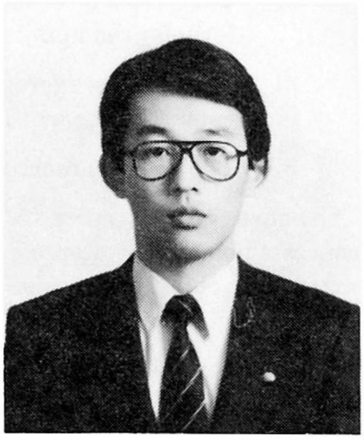
Toshiro Suzuki, born 1936, received his doctor's degree from the University of Tokyo in 1963. He was awarded the Prize from the Architectural Institute of Japan for his study on steel structure in 1981.



Katsuki Takiguchi, born 1945, received his doctor's degree from Tokyo Inst. of Techn. in 1972. His main research field is concrete structure.



Shin-ichi Miyashita, born 1959 received his master's degree from Tokyo Inst. of Techn. in 1983.

SUMMARY
The new concrete is obtained by using small pieces of ice instead of mixing water at the start of mixing. Various properties of fresh concrete are greatly improved by this new production method. The new concrete had been practically applied to several buildings quite effectively.

RÉSUMÉ
Le nouveau béton est obtenu en utilisant de petits morceaux de glace au lieu de l'eau de mélange au début de mélange. Différentes caractéristiques du béton frais sont considérablement améliorées par cette nouvelle méthode de production. Le nouveau béton a été pratiquement utilisé pour quelques bâtiments d'une manière très satisfaisante.

ZUSAMMENFASSUNG
Die neue Betonart entsteht durch Beimischung kleiner Eisstückchen zum Mischwasser bei Beginn des Mischvorgangs. Dieses neue Verfahren verbessert verschiedene Eigenschaften des Frischbetons erheblich. Für mehrere Bauwerke ist diese neue Betonart mit Erfolg praktisch angewendet worden.

1. INTRODUCTION

A new unique method has been developed for the production of concrete.

This new method takes advantage of small ice pieces and their melting process. The concrete is obtained by substituting small ice pieces for the mixing water, at the start of mixing. The ice should be completely melted prior to concrete placement. The various required properties of concrete during production, including mixing efficiency, placement performance and consolidation ability are greatly improved.

Concrete produced using small ice pieces in lieu of mixing water is characterized by the following advantages.

1) Mixing can be conveniently carried out almost irrespective of the mix proportions.
2) Small ice pieces of a wide variety of shapes, sizes and states can be used.
3) The viscosity of cement paste changes as the small ice pieces melt, reaching an appropriate level for the uniform mixing of special additives, such as fibers.
4) There is no aggregate segregation after uniform mixing because of the change in viscosity caused by the melting of the ice.
5) The hydrate reaction is retarded throughout mixing until final placement.

The above characteristics are advantageous for production of the following types of concrete. High quality concrete using less water, concrete with heavy aggregate, concrete mixed with fibers, concrete mixed with macromolecular materials, pressurized and undrained formed concrete, slow setting ready-mixed concrete, and so on.

The fundamental characteristics of this concrete production method were discussed in the previous papers [1], [2], [3] and [4].

Melting process of small ice pieces should play an important part in this production method. It should be affected by the volume of concrete in the mixer, mixing method and so on, as shown in Fig. 1. The data of large scale experiments and/or practical use of this method are important as well as those of fundamental tests in the laboratory.

As the first objective to apply practically this new method to, cast-in-place concrete / ready mixed concrete had been selected. This paper deals with the properties of the new concrete used in actual buildings.

This method of producing concrete was originally conceived by T. SUZUKI, primary author, and various experiments and examinations were undertaken jointly by T. SUZUKI and K. TAKIGUCHI. S. MIYASHITA lent a helping hand in the tests during practical use of the new concrete.

2. PLANT TRUCK SUPPLYING SMALL ICE PIECES

Transportable plant system supplying small ice pieces into the mixer of ready mixed concrete plant and the first experimental plant truck are shown in the previous paper [4].

After frequent tests and improvements, the plant truck shown in Fig. 2 was made. It is very convenient for experimental concrete works, and is working now without any serious trouble.

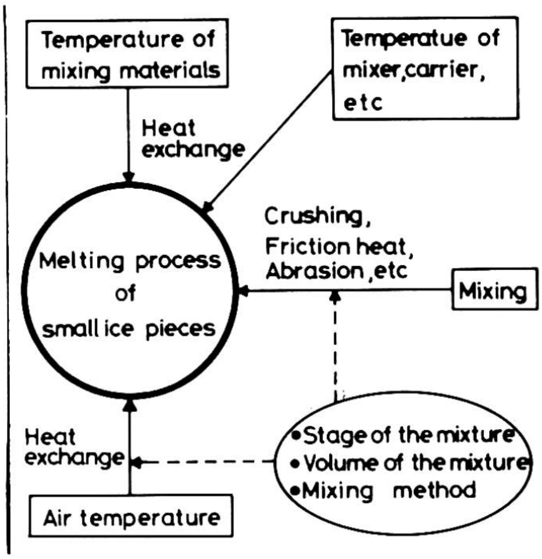


Fig. 1 Factors affecting the melting process of small ice pieces

Weight-measured small ice pieces are blown up into the mixer through a flexible hose. The maximum particle size of ice pieces can be controlled from 3mm to 5mm. The plant can continuously supply the small ice pieces of 200~250kg per a minute. Weight measuring error of the plant is within 1kg/200kg. Blowing up capacity is 15~20m height. Atmospheric temperature under which the truck can be operated ranges from −15°C to 35°C.

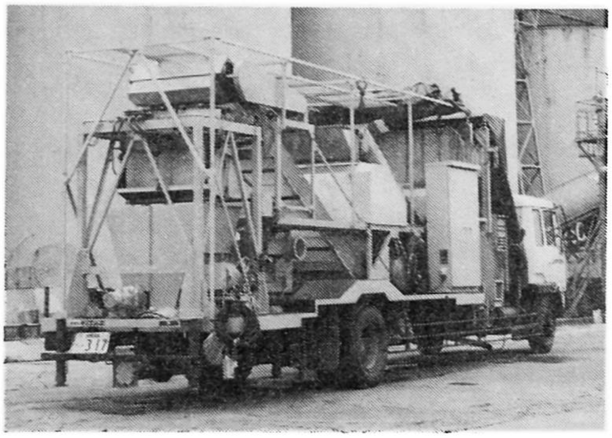


Fig. 2 Plant truck supplying small ice pieces

3. COLD WEATHER CONCRETE

Concrete mixed, transported, placed and cured under condition of low temperature should be prevented from damage by freezing at an early age.

(Low water-cement ratio)−(well mixed)−concrete having two properties mentioned below can be produced by the new method.

i) Freezing does not occur easily.

ii) Strength can be recovered even in case that the concrete has been suffered early freezing.

Strength recovery of early frozen concrete was discussed in the previous paper [1].

An experiment of cold weather concrete was carried out, in February 1987 in Hokkaido. The atmospheric temperature was about −5°C. The outline of the experiment is shown in Fig. 3.

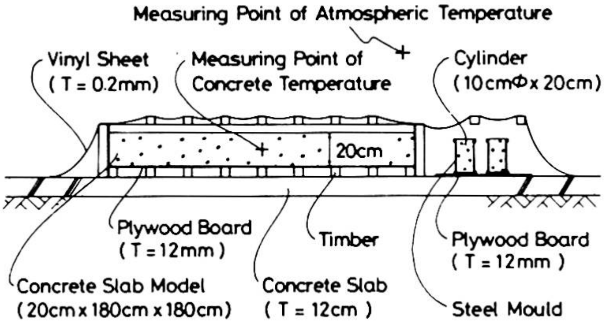


Fig. 3 Outline of experiment

The mix proportion of the concrete was : normal portland cement 448kg/m^3, powdery snow 161kg/m^3 in lieu of mixing water, land sand (2.5mm) 679kg/m^3, river gravel (25mm) 1163kg/m^3, AE water reducing agent 1.12kg/m^3. Water−cement ratio was 33%.

In case of cold weather concrete production, the temperature of aggregate should be controlled carefully. The fine aggregate temperature was 3°C. The coarse aggregate temperature was raised up to 40°C~50°C.

With the pan-type / forced mixing type / 3m^3 / mixer, 1m^3 concrete was mixed for 3 minutes. The slump of the concrete mixed up was 4.5cm.

Concrete of 2m^3 by two mixing was transported by the 4.5m^3 truck agitator. After 45 minutes transportation, the concrete was placed into the formworks. The concrete placing situation is shown in Fig. 4.

Fig. 4 Concrete placing under −5°C

After the completion of surface finishing of the concrete slab model and cylinders, concrete was covered with flimsy vinyl sheet as shown in Fig. 3, and left at the site. The concrete temperature history and the atmospheric temperature history are shown in Fig. 5.

After 3 days curing, the cylinders and core test specimens cut out from the slab model were tested. The compressive strengths of cylinders and core test specimens were almost equal and were about 20MPa.

High quality concrete / (low water-cement ratio) – (well mixed) – (early freezing proof) – concrete can be produced by the proposed method using small pieces of ice.

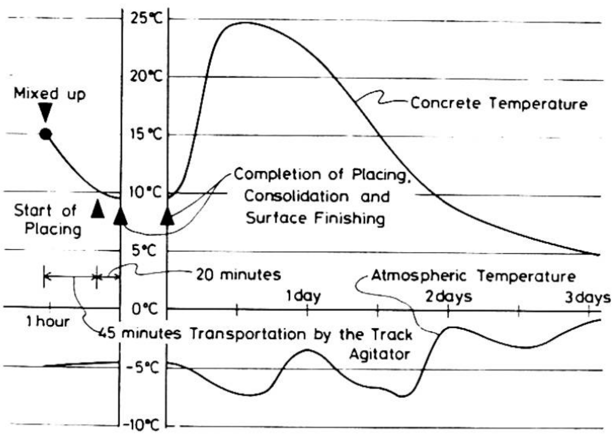


Fig. 5 Temperature history

4. PRACTICAL APPLICATION TO HOTEL BUILDING

The concrete produced by the new method was practically used in a hotel building, in Akita – prefecture in March 1987.

The atmospheric temperature ranged from –3°C to 0°C during the concrete works. The concrete was placed in columns, walls, beams and slabs. As the concrete works had to be done under the cold weather, early freezing proof concrete was required. At the same time, over 15cm slump value of the concrete at pumping was required.

Concrete of water-cement ratio 46% was produced. The mix proportion was : normal portland cement 358kg/m^3, crushed ice (3mm) 161kg/m^3, (1/2) sand from sand dune and (1/2) river sand (5mm) 616kg/m^3, river gravel (25mm) 1104kg/m^3, AE water reducing agent 3.58kg/m^3.

The temperature of the gravel was raised up to 40~50°C.

With pan type / forced mixing type / 2m^3 / mixer, 1m^3 concrete was mixed for 2 minutes as one batch mixing. The concrete was transported from ready mixed concrete plant to the building construction site by 6m^3 truck agitator.

Slump value, temperature and air content of the concrete are indicated in Fig. 6. Needless to say, mix proportions of the new concrete and of conventional concrete were equal.

It was confirmed by this practical use that the proposed method improves the workability of fresh concrete.

The hotel building completed is shown in Fig. 7.

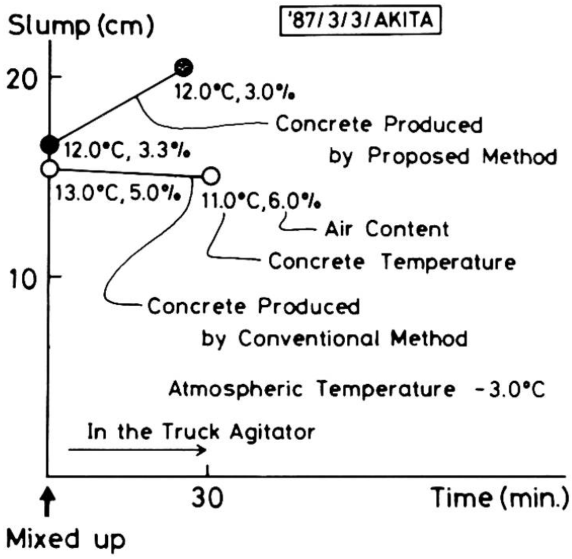


Fig. 6 Slump of the concrete produced by proposed method and of conventional concrete

5. HOT WEATHER CONCRETE

It was confirmed that this method can be used quite effectively in the concrete works under high atmospheric temperature, as described in the previous paper [4].

In August 1987, the new concrete was used in reinforced concrete slab of a warehouse in Osaka. In most cases, sea sand and crushed gravel have to be used in Osaka area. To get the same workability, more water is needed in the sea sand concrete than in the river sand concrete. To get the same workability, more water is needed in hot weather concrete than in mild weather concrete, because of slump loss.

In Osaka area, the concrete production method which can reduce the water is seriously required. Especially in hot season, the situation of concrete production is just so.

The mix proportion of the concrete used in the slab construction was : normal portland cement 311kg/m^3, crushed ice (5mm) 174kg/m^3, sea sand (2.5mm) 791kg/m^3, crushed gravel (20mm) 1023kg/m^3, AE water reducing agent 0.78kg/m^3.

With the variable speed type / horizontal twin shafts type / forced mixing type / 2.5m^3 / mixer, 2m^3 concrete was mixed for 2 minutes.

The concrete was transported by 4.5m^3 truck agitator. The atmospheric temperature was 28°C.

Slump, temperature and air content of the concrete are indicated in Fig. 8, together with those of the same mix proportion conventional concrete.

The concrete was placed in the formworks as shown in Fig. 9.

High workability of the concrete produced by the new method was confirmed as shown in Fig. 8.

As shown in Figs. 6 and 8, the slump value of the concrete produced with small ice pieces became larger as time passed, though the ice pieces were perfectly melted when the concrete was mixed up. This is one of the distinctive properties of the concrete with small ice pieces.

The strength of the concrete produced by the new method was discussed in the previous paper [4]. Curing period discussed in the previous paper [4] ranged from 1 day to 91 days. Curing conditions were in 20°C water, in the water at the site, in air, in mould and under sealing. Water–cement ratio ranged from 40% to 63%.

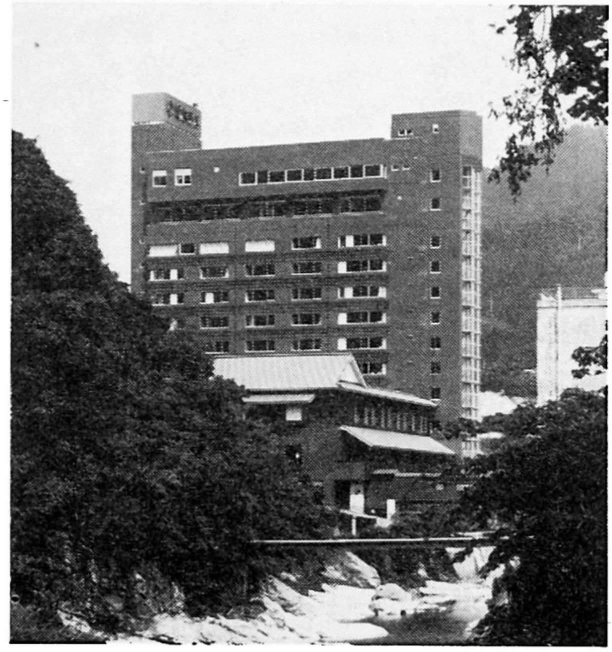


Fig. 7 The hotel building

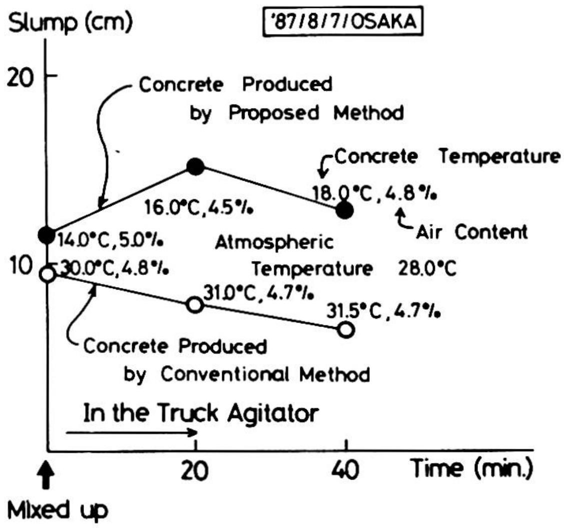


Fig. 8 Slump of the concrete produced by proposed method and of conventional concrete

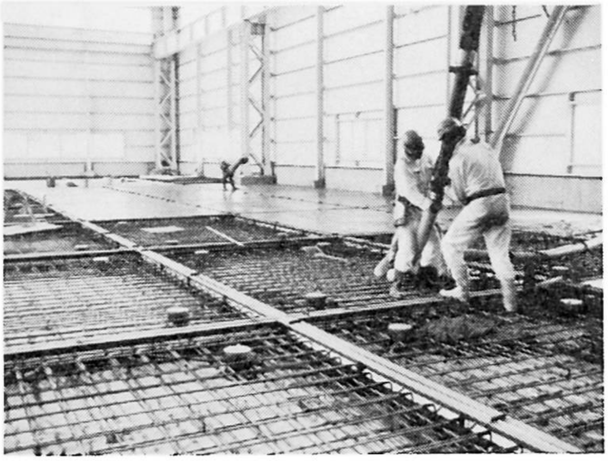


Fig. 9 Concrete placing under 28°C

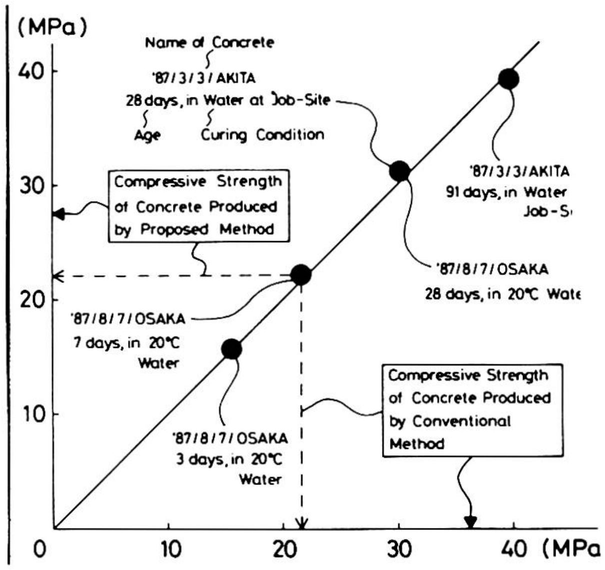


Fig. 10 Compressive strength of the concrete produced by proposed method and of conventional concrete

It was concluded in the previous paper [4] that the strength of concrete produced by proposed method is equal to that of the same mix proportion conventional concrete.

Plotted points in Fig. 10 mean that weight-measuring errors of small ice pieces and of mixing water did not occur during the production of the concrete described in this paper. It is not necessary to be anxious about weight-measuring error in evaluating the data shown in Figs. 6 and 8.

6. CONCLUSION

The new concrete production method using small pieces of ice was practically applied to actual building concrete works quite effectively.

Workability of fresh concrete is improved much by the new method.

The new method is powerful especially for hot weather concrete and for cold weather concrete.

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REFERENCES

1. SUZUKI T. and TAKIGUCHI K., Well Mixed Concrete Using Small Ice Pieces in lieu of Mixing Water. Nikkei architecture, 4-21 1986, pp.80-85 (in Japanese).
2. SUZUKI T. and TAKIGUCHI K., A New Concrete Production Method Using Small Ice Pieces. Transactions of The Japan Concrete Institute Vol. 8, 1986, pp. 81-88.
3. SUZUKI T., TAKIGUCHI K. and HOTTA H., Characteristics of Concrete Produced by New Method Using Small Ice Pieces. Transactions of The Japan Concrete Institute Vol. 8, 1986, pp. 89-96.
4. SUZUKI T. and TAKIGUCHI K., A New Concrete Production Method Using Small Pieces of Ice. IABSE Sym. Paris-Versailles 1987 Report, Vol. 55, pp. 339-344.