Committee Report: JCI-TC153A

Technical Committee on Improvement of Durability of Concrete Structure by Control of Bleeding Behavior

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Abstract:

The decline in performance in structures due to bleeding is being pointed out in recent years. This is thought to be because when excessive bleeding occurs, there is an adverse effect on the structure's mechanical performance as well as it's durability, and if too few, it is difficult to apply the screeded finish. However, since the effect of bleeding on the properties of concrete is not quantitatively understood, and with no universal testing method, the current status is that it's not being adequately controlled. Against this backdrop, the goal of the committee's activities was to secure the performance of concrete structures through appropriate bleeding control. This report summarizes the results of this committee's activities.

Keywords: bleeding, free water, constricted water, characteristics values of concrete, questionnaire, simple test method

1. Introduction

Bleeding has become a frequent cause of defects in concrete structures in recent years. This is considered to be due to insufficient bleeding control, which is one of the concrete material segregations. Although the bleeding evaluation method is defined in JIS A 1123, due to the difficulties in measurement work, and since it is not often performed in actual practice, the actual situation is that is it not handled in accordance with the specification item of JIS A 5308 "Ready Mixed Concrete." Against this backdrop, the Japan Concrete Engineers Association founded the two-year "Technical Committee on Improvement of Durability of Concrete Structure by Control of Bleeding Behavior", in order to address both old and new issues. The committee member composition of this committee is shown in **Table 1**, and is divided up into the Performance Evaluation Workgroup, Control Technology Workgroup, and the Test Method work group, in consideration for achieving our objectives.

Table 1 – Committee Composition

Committee Chair:	Shigeyuki,SOGO, Hiroshima Institute of Technology
Vice Chair:	Hirotaka KATO, Tokyo University of Science
Secretary General:	Kazuto FUKUDOME, National Institute of Technology, Ishikawa College
Secretary:	Hiroshi JINNAI, Taisei Corporation
Secretary:	Yoshihisa NAKATA, Nihon University
Performance Evaluation WG	
Chief Examiner:	Kazuto FUKUDOME, National Institute of Technology, Ishikawa College
Deputy Chief:	Takeshi IYODA, Shibaura Institute of Technology
	Mariko KAWAZATO, Tobishima Corporation
	Shinichi KOIZUMI, BASF Japan Ltd.
	Kenji HAYAKAWA, Tokyu Construction Co., Ltd.
	Kenzo WATANABE, Kajima Corporation
	Yoshitaka KATO, Tokyo University of Science
Control Technology WG	
Chief Examiner:	Hiroshi JINNAI, Taisei Corporation
Deputy Chief:	Toshitsugu INUKAI, National Institute of Technology, Gifu College
Deputy Chief:	Kuniaki SAKURAI, Obayashi Corporation
	Akio TANAKA, HACHIYO Consultant Co.,Ltd.
	Tomohiro MATSUZAWA, FLOWRIC Co.,Ltd.
	Kazuki MIYANO, Maeda Corporation
Test Method WG	
Chief Examiner:	Yoshihisa NAKATA, Nihon University
Deputy Chief:	Shuzo OTSUKA, Institute of Technologists
	Masako ASAMI, National Federation of Ready-Mixed Concrete Industrial Associations
	Kentaro KAYATA, Japan Testing Center for Construction Materials
	Takeshi SAITO, Nihon University
	Naoko TSUCHIYA, National Institute for Land and Infrastructure Management
	Shigeyuki SOGO, Hiroshima Institute of Technology

The Performance Evaluation WG primarily discusses the influence of bleeding on the concrete's properties, and summarized the influences on appearance, successive jointing, fresh consolidation, strength, shrinkage characteristics, and durability.

The Control Technology WG, with considerations to the bleeding mechanism, examined how to control bleeding, and with a grasp of the factors that cause bleeding to fluctuate, such as the materials used, mixture proportion, construction method, etc., indicated the control method.

The Test Method WG investigated by questionnaire why bleeding tests aren't conducted and the reason why, and with considerations for the influence of the test procedure and measurement method on the bleeding measurement result, proposed a simple testing method. The outline of this committee's activities is as follows.

2. Bleeding Mechanism

2.1 What is Bleeding?

Bleeding is “the phenomenon in which part of the mixing water is separated and ascends due to segregation and segregation in the solid materials for fresh concrete or mortar according to JIS A 0203 “Concrete Terminology”. The primary cause of the occurrence is considered to be that water, which has the lowest density of the concrete composition materials, such as water, cement, aggregate, rises easily.

The rise of water due to bleeding is the cause of sinking cracks, laitance, sand streaks, etc., which are undesirable influences in the quality of hardened concrete.

2.2 Terminology Definitions

In JIS A 1123, a sample is packed into a size-specified container, over time the water that permeates through to the top surface of the sample is collected, and the bleeding amount and rate is calculated. In general, in regards to concrete bleeding, the 2 indicators above are used, but not all of the water that has separated from the solid particles, such as cement, aggregate , elevates to the top surface of the concrete – there is some water that accumulates inside of the rebar and coarse aggregate. Therefore, this research committee defines terminology relating to bleeding as follows. The classification of this water is shown in **Figure 1**, and the conceptual diagram of bleeding water and internal bleeding water is shown in **Figure 2**.

- Free Water: Water that can freely move about within fresh concrete.
- Constricted Water: Water other than free water in fresh concrete – for example, water absorbed on the surface of solid particles, such as cement and aggregate, water constrained between powder particles with a small particle diameter, etc.
- Bleeding Water: Part of the free water that had been elevated through bleeding, that has emerged to the top surface of the concrete. This is sometimes called external bleeding water, in contrast to internal bleeding water.
- Internal Bleeding Water: Part of the free water that had been elevated through bleeding, that has not emerged to the top surface of the concrete.

In other words, the water within fresh concrete is classified in accordance with whether or not it can move around freely or is constricted – within the free water, water that rises to the surface is external bleeding water, and the water that remains within the aggregate and rebar, or reaches the side formwork surface but not the surface, as well as the water that exists within the cement matrix is defined as internal bleeding water.

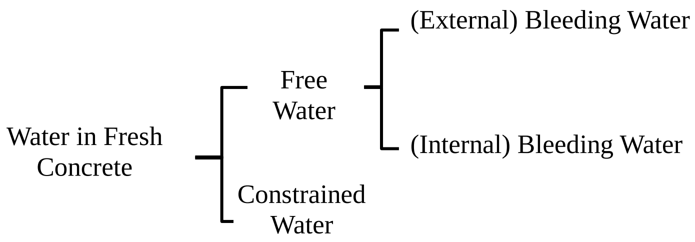

Figure 1 - Classification of "Water" in Fresh Concrete

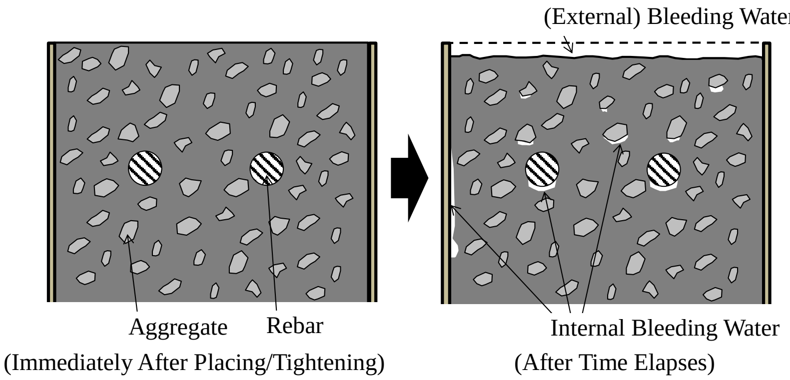

Figure 2 – Conceptual Diagram of Bleeding Water and Internal Bleeding

2.3 Case Studies Regarding the Bleeding Mechanism

(1) Prediction Method for the Free Water Amount Accompanying Bleeding

In the research regarding the prediction method for the amount of free water that's elevated through bleeding, there are many cases involving the free water that can move freely and the constricted water that were constricted to the surface of the cement and aggregate, or between the spaces. Specifically, paste and mortar are subjected to a centrifugal dehydration tester to remove free water, and using a model in which the degree of agglomeration of cement changes from the method[1)] for obtaining residual water, and the condition of mixture proportion , methods for predicting the amount of free water have been proposed[2)].

(2) Behaviors of Free Water Within Concrete

In the research regarding the behaviors of free water within concrete, a method of observation involving injected colorized liquid into fresh concrete or a simulated material for visualization has been implemented[3)]. It has been discovered that the free water within concrete uses the interface between the coarse aggregate and the mortar, water routes formed for some reason in the test sample material, and the side of the mold as primary movement routes.

3. Bleeding Influence on the Characteristics of Concrete

Bleeding causes an increase in moisture, which causes a sinking of the solid particles. As a result, cracks may form in reinforced concrete due to the formation of gaps or sinking on the rebar lower surface. In CFT there is a possibility that gaps may be formed at the interface between the steel sheet and the concrete, serious problems may occur such as insufficient adhesion in a composite structure. However, these issues can mostly be considered to not be a problem, if the concrete bleeding amount is suppressed. On the other hand, as shown in **Figure 3**, we can consider that bleeding in concrete causes various other phenomena, which influences the characteristics of concrete. In this section, we will introduce the results of past findings on the influence of bleeding on the characteristics of concrete.

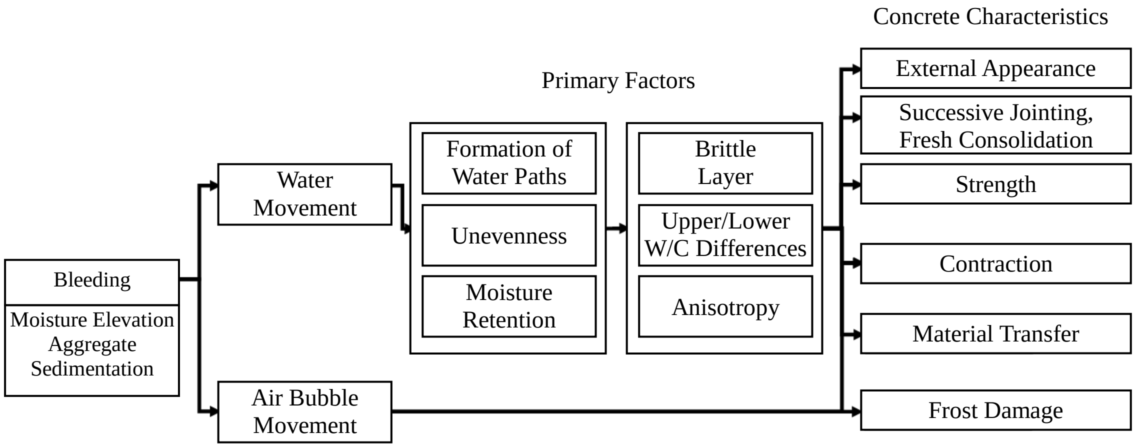

Figure 3 – Influence of Bleeding on Concrete Characteristics

(1) Impact on the External Appearance

In many cases, the influence of bleeding on the appearance is evaluated in relation to the occurrence of deformities such as color unevenness, surface bubbles, and sand streaks. An increase in the bleeding amount promotes deformities and is the cause of ~~a~~ deterioration in appearance. This is considered to be due to the presence of excess water in the vicinity of the mold framework, which leads to color differences~~,~~ and foaming due to vibration compaction.

(2) Influence on Construction Jointing and Fresh Consolidation

Most of the studies on the influence of bleeding on construction jointing and fresh consolidation are carried out as countermeasures against cold joints. Among them, the literature referring to the influence of the bleeding amount has been sorted, however, it is not a guarantee that greater bleeding amounts will lead to damage in the fresh consolidation's unity, and even for cases where the bleeding amount was $0.1cm^3/cm^2$ or below and the compaction was insufficient, there are concerns that the strength will be lowered. On the other hand, in the case of non-bleeding the unity of the fresh consolidation is lowered due to the influence of drying of the lower layer concrete's outer surface, so some degree of bleeding is desirable.

(3) Influence on Strength Characteristics

In the actual large scale, strength differences occur between the upper and lower levels due to the rise of bleeding water, and if the bleeding amount is large, then the variation will also become large. At the test sample level, the influence on the strength distribution is not large, excluding cases of excessive bleeding. Also, strength anisotropy has been recognized due to defects in the aggregate lower surface due to internal bleeding.

The influence of bleeding on the adhesive properties of rebar is considered to be the cause of the formation of gaps, due to bleeding water remaining on the rebar lower surface. Subsequently, an increase in the bleeding amount leads to a decrease in the average adhesion stress degree is observed, however the adhesion properties can be improved by reducing the bleeding amount through the segregation reducing agent. The degree of retention of bleeding that influences properties is considered to be affected not only by the amount of bleeding, but also by a number of factors such as the direction and position of the rebar, the rebar diameter, etc., making quantitative interpretation difficult.

(4) Influence on Shrinkage Characteristics

The influence of bleeding on the dry shrinkage characteristics is considered to be the influence of sedimentation of solid particles such as cement and aggregate—in addition to a change in the amount of water in concrete, due to the free water movement that accompanies bleeding. According to studies on concrete using slag, dry shrinkage is reduced as the bleeding amount increases. Due to the occurrence of bleeding, the unit water amount and the water cement ratio in the test sample will be reduced, which can be considered to result in a reduction of dry shrinkage. However, in an actual structure, an increase in the bleeding amount leads to an increase in the unit water amount and water cement ratio at the upper part, so attention must be given to this.

(5) Influence on Durability

As the concrete micro structure changes due to changes in the proportions of constituent materials of concrete and the formation of water paths due to bleeding, bleeding is considered to have an influence on the mass transfer resistance of concrete. As a result, the influence on the bottom surface of the test specimen and the member is small, and large at the surface. Additionally, since water from bleeding also moves to the formwork surface, the influence on the mass transfer resistance becomes large at the side surface and in particular at the driving upper direction. The degree of influence varies depending on the concrete bleeding amount, and even in concrete with the same water cement ratio, the correlation between the bleeding amount which changes due to the influence of the aggregate type and unit water content, and the mass transfer resistance, is quantitatively shown.

As the flow of water that accompanies bleeding has an influence on the stability of air bubbles, there's an influence on the formation of bubble structure as indicated by the spacing factor, bubble diameter distribution and it can be said that this decides the freeze-thaw resistance. In other words, the coalescence and breakage of bubbles occurs due to an increase in the bleeding amount, and it is considered that the freeze-thaw resistance decreases by the coarsening of the bubble structure.

4. Considerations for Setting a Target Value for Bleeding

Established cases and experiences were investigated for the control value of the bleeding amount from past guidelines, with considerations for setting a target value for bleeding. Additionally, we collected the bleeding influence in regards to pumpability, finishability, and plastic shrinkage cracking, that has the possibility to not always allow for good effects for bleeding suppression. Based on the results of these surveys, we will introduce how to set target values for bleeding, based on the results of Chapter 3, and introduce examples of target value settings based on the past data of some items.

4.1 Regulating Bleeding Amount from Past Guidelines

(1) Regulating Bleeding Amount

The Architectural Institute of Japan, hereinafter AIJ, has set bleeding amount target values in accordance with the AIJ Standard Specification for Reinforced Concrete Work JASS5 ,hereinafter, JASS5, as well as the AIJ Recommendation for Practice of Crack Control in Reinforced Concrete Buildings (draft~~1~~)~~,~~ hereinafter, crack control recommendation , the AIJ Recommendation for concrete pump construction hereinafter, pump recommendation , and the AIJ Recommendation for the mixture propotion design, and construction of concrete using blast furnace slag fine aggregate.

Item a.of "3.6 Workability and Slump" of JASS5 "Section 3 – Types and Quality of Concrete" states that "bleeding and material segregation is assumed to be few". However as there is an insufficient accumulation of data, concrete numerical values are not shown. On the other hand, specific values are specified at 0.1 cm^3/cm^2 and below for steel tube filled concrete, 0.3 cm^3/cm^2 and below for water-tight concrete, and 0.3 cm^3/cm^2 and concrete subjected freeze-thaw action. Similarly, specific values are specified at 0.3 cm^3/cm^2 and below for crack and pump recommendations.

(2) History of Bleeding Amount Target Value Settings

The bleeding amount target value was first listed in the 1975 edition of JASS 5, with a draft (**Table 2**) showing the bleeding amount target value corresponding to the concrete quality class. This table is quoted from Kaga's proposal[4], however it is stated that the numerical values are hypothetical values, which should be expected for future research. No descriptions regarding the basis for defining target values for bleeding such as this could be found.

Table 2- Proposal for Target Performance of Each Class[4]

Item / Concrete Quality Class	Bleeding Amount (cc/cm^2)	Dry Compression Ratio ($\times 10^{-4}$)	Durability Index (300 Cycles)
High	Within 0.3	Within 9	70 and above
Regular	Within 0.5	Within 8	-
Simple	Within 0.7	Within 10	-

4.2 Influence of Bleeding Suppression

(1) Influence on Pumpability

When the bleeding amount is excessive, the pumpability of concrete cannot be secured in some cases. On the other hand, when bleeding is suppressed, although clogging due to dehydration rarely occurs, the pressure load is influenced. For this reason, when concrete with bleeding suppression is used, there are cases where the pumping load becomes large, so it is necessary to pay attention to the selection of the concrete pump and , piping plan.

(2) Influence on the Finishability

For cases where the bleeding amount is excessive, there are concerns about the decrease in quality due to delays in the finish work, settling cracks, etc., and improvements can be planned through the suppression of bleeding. However, when the bleeding amount is too small, there is a high possibility that defects such as cracking and surface layer peeling will occur, depending on environmental conditions such as moisture evaporation rate. Furthermore, since the finishability also becomes worse, countermeasures such as leveling and finishing aid agent must be considered.

(3) Influence on Plastic Shrinkage Cracking

Plastic shrinkage cracking is considered to occur when the water evaporation rate from the upper surface of the concrete is greater than the water supply rate to the upper surface due to bleeding. Therefore, when the moisture evaporation amount exceeds the bleeding amount, attention will be required after the concrete placing And while paying attention to the temperature, humidity, and wind speed of the construction environment, together with the implementation of appropriate curing, measures such as tamping will be necessary when cracks occur. In other words, it will be essential to take measures to prevent plastic shrinkage cracking in accordance with weather conditions,regardless of the bleeding amount.

4.3 How to Consider Setting Bleeding Target Values

(1) How to Consider Setting Values from the Appearance

From previous research, we can consider that the greater the bleeding amount, the greater the adverse influence on the external appearance. Therefore, it is desirable to appropriately control bleeding from the appearance point of view. However, it was determined that proposing the bleeding amount upper limit from the influence on the appearance is difficult. This is because research on the occurrence cause of color unevenness have not progressed, and there is not enough quantitative data on appearance and bleeding amount. Furthermore, we can also consider the lack of any quantitative target and specified values regarding the appearance in the current recommendation as another reason. An accumulation of data and research into causes is desirable in the future.

(2) How to Consider Setting Values Based on Strength Characteristics

It has been made clear from past research that a large amount of bleeding leads to strength reductions at the upper layer. Additionally, it has been shown that if the bleeding amount increases, the tensile strength decreases more than the compressive strength, and anisotropy occurs due to the increase in bleeding that remains on the lower surface of the aggregate. These macroscopic defects not only influence strength, but also may have an influence on the mass transfer resistance. Furthermore, it has been shown that the increase in bleeding amount affects the adhesion properties of rebars. The influence on the adhesion properties depends on the gap formation due to the retention of bleeding at the rebar lower level. And it has also been pointed out that these gaps influence rebar corrosion may also contribute to the influence.

As described above, there is a necessity to appropriately control bleeding from the viewpoint of the influence on the strength characteristics. , However the relationship between the bleeding amount (rate) and the strength characteristic has not been quantified, and are influenced by many factors, such as construction conditions, the structure’s geometry, arrangement conditions, etc. So, it is difficult to set specific target values at present. It is desirable that further studies will be made, leading to an appropriate control of bleeding.

(3) How to Consider Setting Values Based on Shrinkage Characteristics

Previous studies have shown a reduction in dry shrinkage following an increase in the bleeding amount due to the usage of slag. This is presumed to be the effect of reductions in the unit water content and water cement ratio in the test specimen due to the occurrence of an excessive bleeding amount. In other words, in actual structures with a high placing of concrete, increases in the unit content and water cement ratio occur due to an increase in bleeding, leading to concerns over an increase in dry shrinkage. While it is difficult to evaluate the influence on the dry shrinkage characteristics of the structure's upper level due to bleeding, it is desirable to implement proper control by understanding the phenomenon.

(4) How to Consider Setting Values Based on Mass Transfer Resistance

From past studies, it has been clarified that large amounts of bleeding leads to a reduction in the mass transfer resistance even at the same water cement ratio, and if the reduction at the upper part of the members becomes large. Referencing the Japan Society of Civil Engineering, hereinafter JSCE, standard specifications for concrete structures, the concrete material coefficient of 1.3 for neutralization and salt damage is given for the upper part of members. Though it's possible that this considers the reduction in mass transfer resistance at the upper part of the members due to bleeding, if the bleeding becomes excessive, then the material coefficient of 1.3 may be considered to be insufficient. At present, there is little data on the influence of the bleeding amount on the mass transfer resistance, making it difficult to set a specific target value. However, it is desirable to proceed with considerations in the future, leading to ensuring the mass transfer resistance through appropriate bleeding control.

(5) How to Consider Setting Values based on Freeze-Thaw Resistance, and Setting Examples

As shown in 4.1, the upper limit value for the bleeding amount for freeze-thaw action concrete is shown in JASS5, but the basis for this is unknown. Therefore, from the quality control target value in the JASS5, and the minimum limit value at time of verification regarding frost damage in the JSCE standards specification , the three cases of a) a relative dynamic elasticity coefficient of 60% or above, b) a relative dynamic elasticity coefficient of 85% or above, and c) air bubble interval coefficient of 250 μm or below, have been set, and the bleeding amount that satisfies these were confirmed from past literature. An example[5)] is shown in **Figure 4**. The result is that the bleeding amount that allows for the securing of the freeze-thaw resistance is a) 0.12 to 0.40 cm^3/cm^2, b) 0.05 to 0.40 cm^3/cm^2, and c) 0.30 cm^3/cm^2, and the bleeding amount varied depending on the materials used and mixture proportion . As stated in Section 3, it's highly probable that what exerts an influence on the freeze-thaw resistance are the spacing factor and the bubble diameter distribution, which are representative of the bubble structure of hardened concrete, and we can infer that a reduction in bleeding amount merely reduces the influence of internal bleeding water on bubbles. Therefore, it is difficult to unequivocally indicate the threshold value for the bleeding amount that satisfies the freeze-thaw resistance of concrete. Additionally, even if there is a large amount of bleeding in the concrete, the freeze-thaw resistance may be secured in some cases as long as the bubble structure after hardening satisfies the conditions.

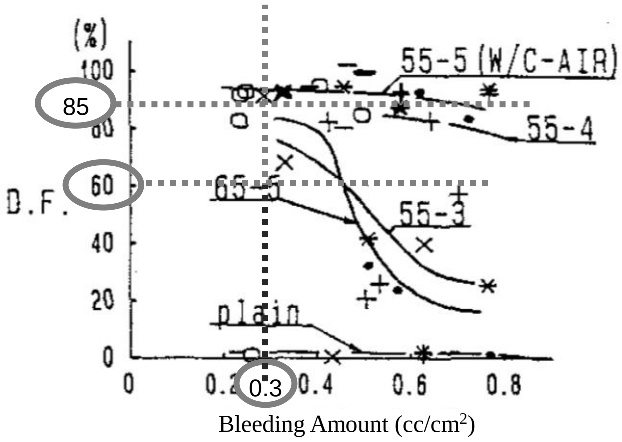

Figure 4 - Relationship Between Durability Index and Bleeding Amount[5)]

(6) Summary and Future Issues

Although there are many issues, such as not being able to quantify the influence of bleeding on the characteristics of concrete, and we could not present specific values for most items. On the othe hand, we can clearly say that it is possible to secure the performance of the concrete structure through appropriate bleeding control. Accumulating data and clarifying phenomena in order to set bleeding targets that have a basis are issues for the future.

On the other hand, it was clearly shown that bleeding causes a deterioration of compressive strength and mass transfer resistance, etc., at the material upper part, and also has a large influence on "homogeneity after hardening." This means that, depending on the degree of the bleeding, there is a possibility that the characteristic values of the concrete set at the design may not be exhibited within the structure. Through future efforts, through an appropriate control of bleeding, we can expect to secure the "homogeneity after hardening," which leads to securing the structure's performance.

5. Bleeding Control Method

From the bleeding mechanism, the basis for the bleeding control method is the suppression of free water in fresh concrete. It is also effective to make fresh concrete more minute, which restricts the movement of free water. Furthermore, if the setting time is fast, this leads to a shorter time of easy movement for free water, which suppresses bleeding. Here, considering the mechanism as described above, we will consider methods for bleeding control from the three viewpoints of materials used, mixture proportion conditions, and construction conditions.

5.1 Influence of the Materials Used on Bleeding

An example of the relationship between the bleeding ratio and the cement type is shown in **Figure 5**[6]. As the surface area of the cement increases, the setting time becomes shorter, which leads to a decrease in the bleeding ratio. As the former is supposed to be related to an increase in the constrained amount of free water, and the latter is related to the suppression of movement of free water, the suppression method itself is different. Specifically, the bleeding rate decreases in high early-strength portland cement, and increases in low-heat Portland cement.

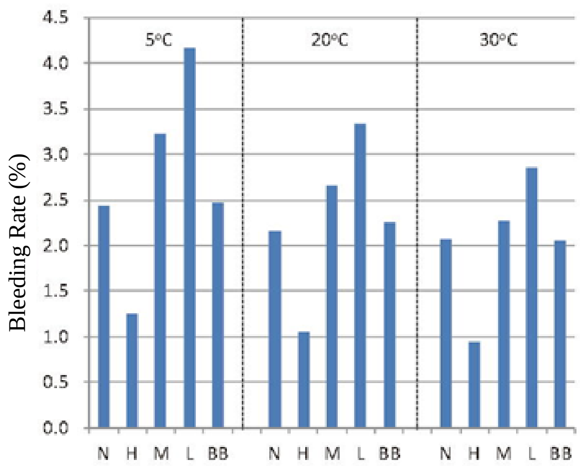

Figure 5 － Relationship Between Bleeding Ratio and Cement Type[6]

We can consider that the aggregate has a large position as a constraint of free water. Therefore, we can consider that the size of the surface area and the ease of restraint of water on the aggregate surface are effective in suppressing the bleeding amount. **Figure 6** shows the relationship between the bleeding amount and the total fine particle content contained in fine aggregate[7]. An increase in the total amount of fine particles contained in the fine aggregate is extremely effective for suppressing the bleeding amount.

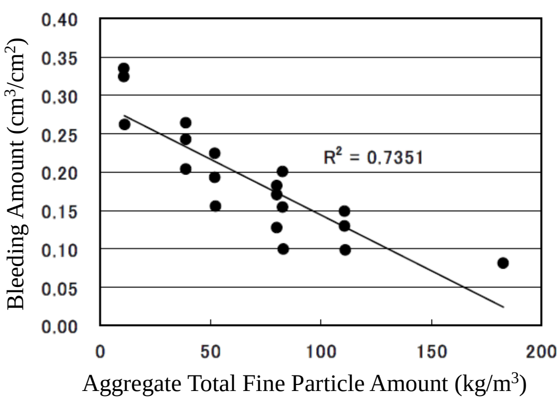

Figure 6 － Relationship Between Bleeding Amount and Total Fine Particle Amount

in Fine Aggregate[7)]

Chemical admixture influence bleeding in various ways. For example, the water reducing performance of a chemical admixture contributes to the reduction of free water by suppressing the unit water amount of concrete. Additionally, the accelerator and retarder influence the free movement time of free water for the control of the setting time of fresh concrete. Furthermore, we can consider that the segregation reducing agent, (thickener), acts on the reduction of the bleeding amount because it restrains free water in fresh concrete. For example, in the reference document[8)], it is considered that the hydrophilic functional group of the linear cellulose ether molecule in the thickener is generated by trapping water molecules (see **Figure 7**).

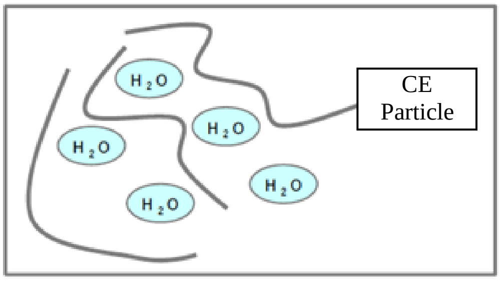

Figure 7 - Conceptual diagram of Bleeding Reduction Mechanism by Cellulose Ether Thickening Agent[8)]

5.2 Influence of Mixture proportion on Bleeding

From the mechanism of bleeding, the mixture proportion of concrete have a somewhat complicated relationship with the suppression of bleeding water. For example, suppressing the unit water content leads to a reduction in the free water and cement content , however, at the same time the weight of aggregate that will become a constraint increases. As shown in **Figure 8**, when generally plotting the relationship between the unit water content and bleeding rate, there is a tendency to explain that a reduction in unit content leads to a reduction in the bleeding rate[9)]. However, the reality as shown in **Table 3** is that since upon suppressing the unit content , the weight of aggregate that becomes the restricting body increases, it becomes a mixture proportion where the already small-amount of free water is further restricted by more aggregate for easy bleeding control[9)]. Also, from Figure 8, we can read trends when making changes to the water cement ratio,changing the unit cement content with a fixed of unit water content. As can be seen from the Figure, the lower the water cement ratio is, the lower the bleeding ratio tends to be. This is presumably due to the fact that the amount of cement and aggregate that constrain water is increased, and that the composition of fresh concrete itself is in a dense state in which it is difficult for water to move.

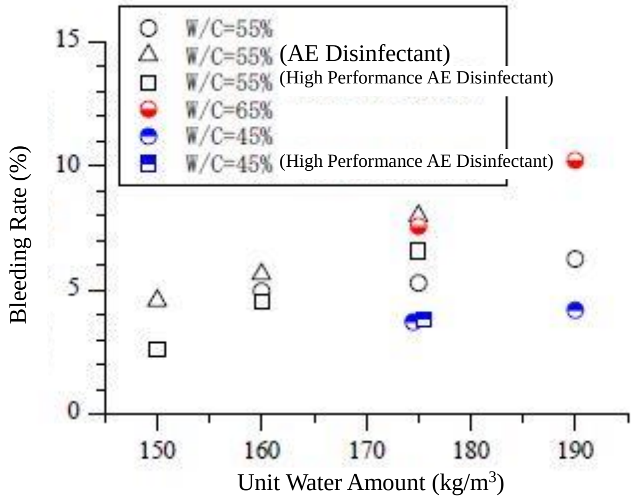

Figure 8 -Relationship Between Unit Water Amount & Bleeding Ratio[9)]

Table 3 - Figure 8 - Concrete Mixture (preparation) [9)]

Distri-bution	W/C (%)	Unit Amount (kg/m³)				Admixture (% vs C)			Sl (cm)	Air (%)	σ 28 (MPa)
		W	C	S	G	WR	SP	AE			
1	55	175	318	803	979	—	—	0.006	12.5	4.8	39.3
2		190	345	775	945			0.01	18.5	5.4	37.1
3		160	291	831	1013			0.008	7.5	4.8	35.5
4		175	318	803	979	0.25		0.001	20.5	3.7	42.2
5		190	345	775	945			0.002	22.0	3.3	34.0
6		160	291	831	1013			0.004	10.5	5.8	37.5
7		150	273	849	1036			0.003	4.0	4.3	40.7
8		175	318	803	979	—	1.0	0.004	22.5	5.4	35.7
9		160	291	831	1013			0.002	21.0	5.7	39.1
10		150	273	849	1036			0.002	11.0	6.0	40.7
11		150	273	849	1036		4.0	0.005	18.5	2.3	27.4
12	65	175	269	821	1001		—	0.006	11.5	4.5	26.3
13		190	292	795	969			0.006	20.0	4.0	28.3
14	45	175	389	776	947			0.008	8.0	5.5	45.4
15		190	422	746	910			0.008	13.5	5.8	46.0
16		175	389	776	947		1.0	0.002	25.5	5.5	49.5
17		190	422	746	910			0.002	25.5	3.0	44.6

5.3 Influence of Construction Conditions on Bleeding

Construction conditions also have an influence on bleeding. For example, if the outside temperature decreases, the cement hydration is delayed leading to an increase in the bleeding amount. Also, as the concrete placing height becomes bigger, the amount of moving water also increases, leading to an increase in the bleeding water that stays on the top surface. For example, in reference document 10), a wall test sample is placed as shown in **Figure 9**, and the bleeding amount at the top surface is measured. As a result, it is reported that the bleeding amount increases in accordance with the placement height, as shown in **Figure 10**. The vertical axis represents the bleeding amount per unit area, however it does not increase by a factor of 5 even if the placement height increases by a factor of 5. In other words, when considering the bleeding ratio, the bleeding ratio tends to decrease as the placement height increases (see **Table 4**). Therefore, when suppressing bleeding from the construction conditions, it is necessary to correctly consider the viewpoint from which reductions are desired – the bleeding ratio, and the bleeding amount.

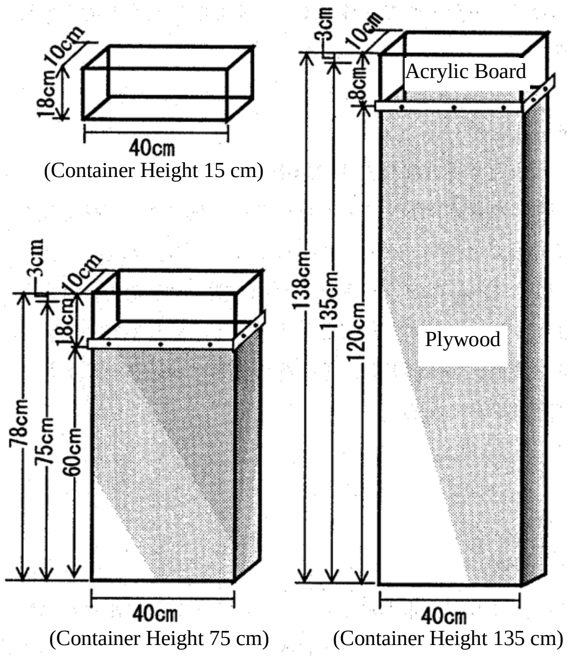

Figure 9 – Wall Test Specimen[10)]

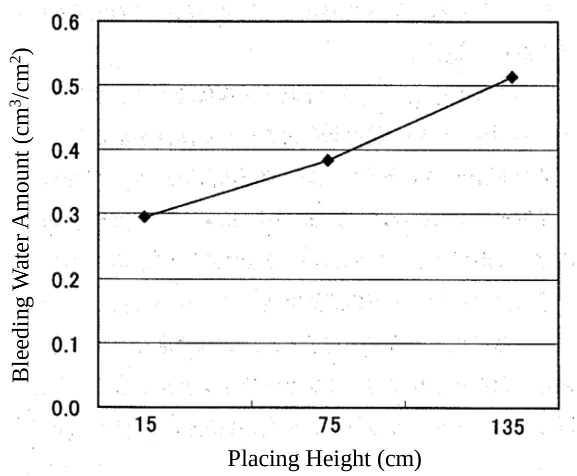

Figure 10 – Placing Height and Bleeding Amount[10)]

Table 4 – Relationship Between Placement Height and Bleeding Ratio/Amount

Placing Height	Bleeding Ratio	Bleeding Amount
Large	Small	Large
Small	Large	Small

5.4 Bleeding Suppression

In terms of materials used, it is important to select materials that don't result in a delay of the concrete. Also, using thickening agents, etc. are effective in constraining free water.

In terms of mixture proportion, it is effective to increase the amounts of cement and aggregate, which serve as constraints, while suppressing the amount of free water. Additionally, we can consider that by setting a low water cement ratio, this prevents the movement of water within concrete, which reduces bleeding water. Specifically, bleeding countermeasures that are commonly practiced, such as suppression of the unit water content , reduction in water cement ratio, and an increase in the fine aggregate ratio, are effective.

In terms of construction conditions, it is necessary to pay attention to the fact that as the outside temperature decreases and the cement hydration is delayed, the bleeding amount increases. Additionally, it will be necessary to consider the appropriate response after carefully considering things like the shape of the placement part, the required items, etc.

6. Questionnaire Survey on Bleeding

In order to understand the actual situation regarding the operation of the bleeding test, and the practitioner's awareness, we conducted a questionnaire survey aimed at looking into points of improvement. The survey summarized 1) the actual implementation conditions of the bleeding test, 2) status of inquiries and cooperative requests regarding bleeding at the fresh concrete factory, 3) actual condition of the work and the test method for the bleeding test, and 4) the practitioner's awareness and recognition regarding bleeding.

6.1 Outline of the Questionnaire Survey

The questionnaire survey was conducted from October 2015 to January 2016. The survey subjects were ready-mixed concrete factories, construction companies, cement makers, chemical admixture manufacturers, and test institutions related to concrete. As the survey covered a lot of items, this report will show the results of certain extracted items.

A breakdown of the questionnaire distribution and collection is shown in **Table 5**. Here, excluding the ready-mixed concrete factory, the collection rate is shown as the number of organizations collected from against those distributed to.

Table 5 – Questionnaire Distribution and Collection Breakdown

Target Respondents		No. Distributed (Factory/Company)	No. of Answers		Collection Rate (%)
			No. of Answers (Factory/Company)	No. of Answers (Cases)	
Fresh Cement Factories		2641	1819	1819	68.9
Construction Companies		23	20	63	87.0
Makers	Cement	18	9	74	50.0
	Chemical Admixture	14	12	16	85.7
Testing Agencies		89	39	78	43.8

6.2 Bleeding Test Performance Results

The presence or absence of a bleeding test is shown in **Figure 11**, and the presence or absence of a bleeding test per ready-mixed concrete factory region is shown in **Figure 12**. Hereinafter, the number n in the figure shows the number of respondents.

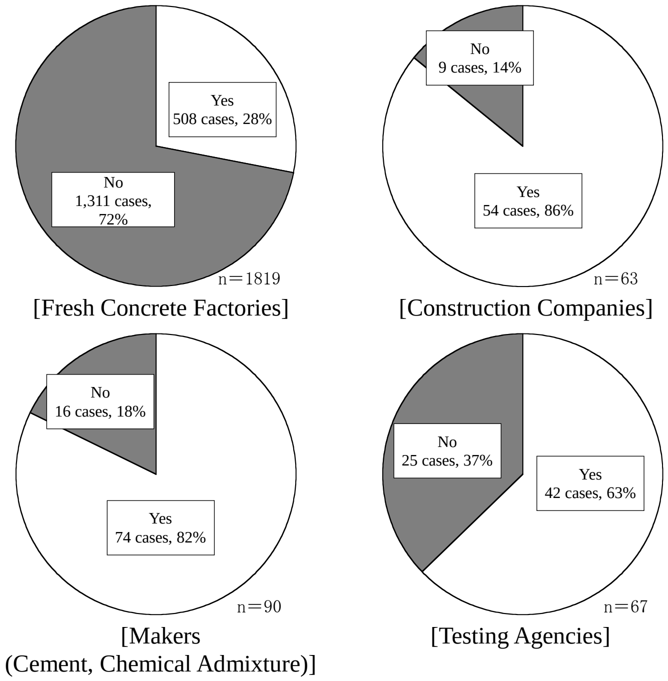

Figure 11 － Bleeding Testing Experience

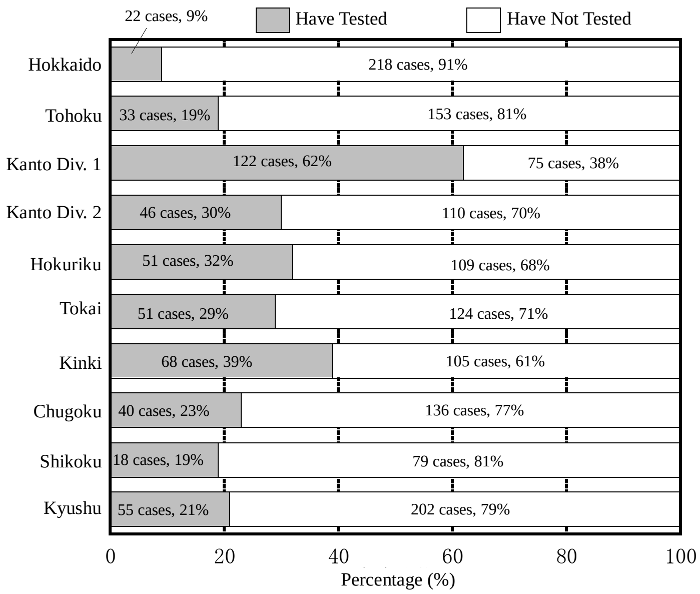

Figure 12 － Bleeding Testing Experience at Fresh Concrete Factories by Region

For places that have carried out the test, ready-mixed concrete factories were less than 30%, but test agencies were 60%, and construction companies and makers exceeded 80%. From this, we can say that the frequency for checking for bleeding at ready-mixed concrete factories is not so high, however as shown in Figure 12, this differs greatly depending on the location of the factory. The Kanto Div. 1 was the most prominent in having responded in the affirmative for implementation, with the Kinki region coming in second. There were large regional differences in the construction that needed to confirm bleeding, mostly concentrated in large metropolitan cities.

Figure 13 shows the response results for concrete usage places having received an enquiry or request for cooperation from designers and contractors at ready-mixed concrete factories. For places, the location where indentation such as reverse construction and CFT were the largest, and building construction work also took a large share. For the other survey items, large metropolitan areas were the regions with the most inquiries and cooperation requests regarding bleeding, and for types of construction, building construction tended to be the most frequent. We can consider this as a reflection of the fact that the upper limits for the bleeding and sedimentation amounts[12)] are shown in the "Technical Standard of Concrete-Filled Steel Tube."of Association of New Urban Housing Technology

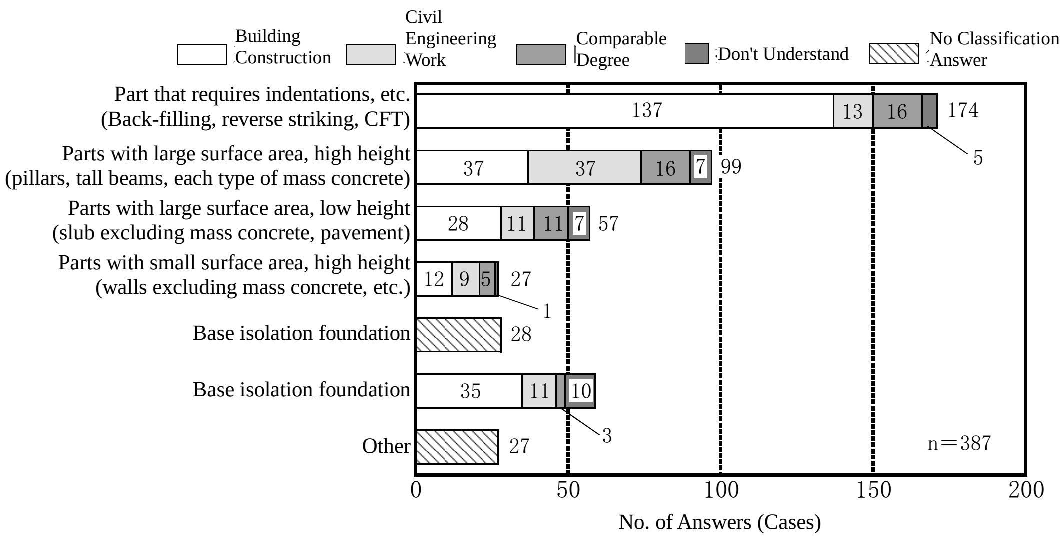

Figure 13 - Concrete Usage Locations with Inquiries or Cooperation Requests

6.3 Bleeding Test Method and Work

Whether or not a test was conducted that does not conform (or cannot conform, hereinafter "non-compliant method") to JIS A 1123 "Method of test for bleeding of concrete" (hereinafter, JIS standard) is shown in **Figure 14**. The percentage of respondents who responded that there were cases where the test was implemented in a non-compliant method to the JIS standard was relatively low at 26% at ready-mixed concrete factories and 27% at testing agencies, but the percentage was over half at construction companies at 57%, and makers of cement,and chemical admixture at 58%. **Figure 15** shows the results of multiple item responses (test conditions) that do not conform to the JIS standard. For items (test conditions) that do not conform to the JIS standard, the responses for "test room temperature," test room humidity," and "concrete temperature" were more than half, and the responses for "samples were collected in two parts" at ready-mixed concrete factories were quite numerous at 53%. We can assume that this due to cases where the test is implemented at a location where temperature and humidity control facilities are not in place, and when testing fresh concrete samples that are collected at the construction site, which means that the JIS standards for temperature ,humidity and the test location of the concrete could not be conformed to. This appears to be consistent with the fact that the percentage of tests that were implemented in a non-compliant method to the JIS standard were lower at the ready-mixed concrete factories (where concrete is often created in the testing room) and testing agencies. We can consider the reason why “samples were collected in two parts” was not frequent at fresh concrete factories as the possession status of bleeding test containers. In other words, though it depends on the survey results of other items, even though the fresh ready-mixed concrete factories who have bleeding test containers are few at 10% of the whole, even if they do have containers, they only have 1-2 containers at most, so when conducting multiple tests, samples are collected one at a time for one test.

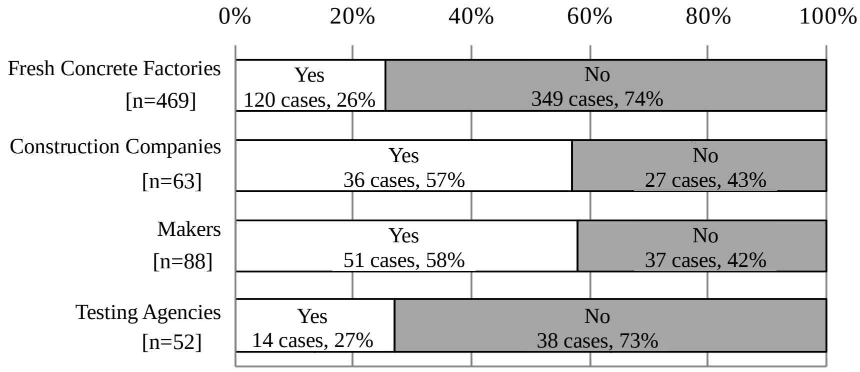

Figure 14 - Existence of Tests That Do Not Conform to the JIS Standard

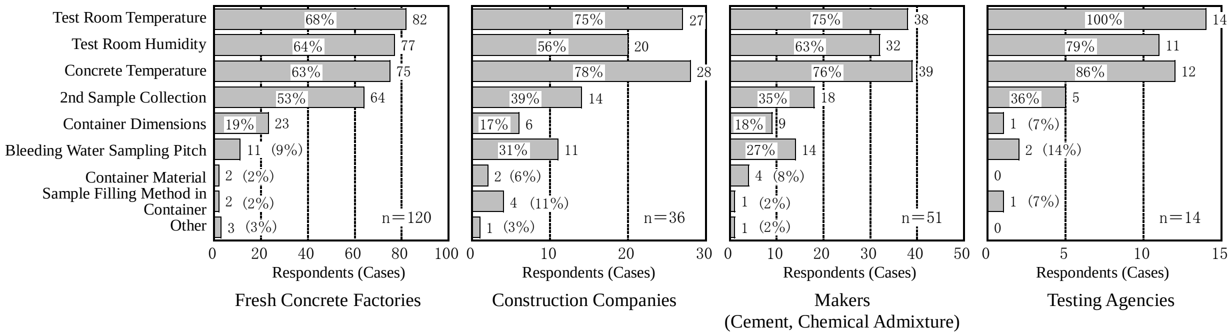

Figure 15 - Items (Test Conditions) That Do Not Conform to the JIS Standard (Multiple Responses)

The weight impression of the container filled with the test sample is shown in **Figure 16**, and the impression of the work for removing the sample after the test is shown in **Figure 17**. For the impression of the weight of the sample-filled container, most respondents responded with “extremely heavy,” with “heavy” coming in second, and both responses making up over 90% of the responses. We can consider that this is because the total mass of the JIS specification container and the test sample is around 40 kg. As a policy from the Ministry of

Health, Labor, and Welfare, male workers who are at least 18 years old should handle items whose weight is 40 kg and below – items above that weight should be handled by two or more persons[13].

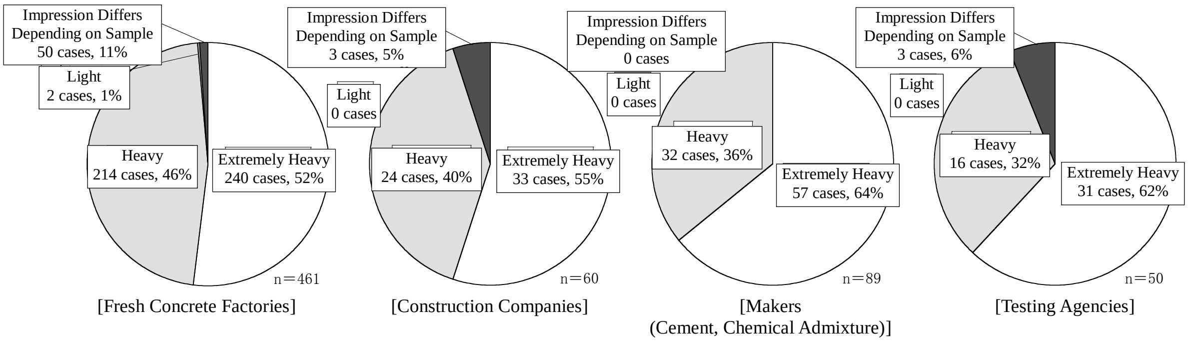

Figure 16 － Impressions of the Weight of the Sample-Filled Container

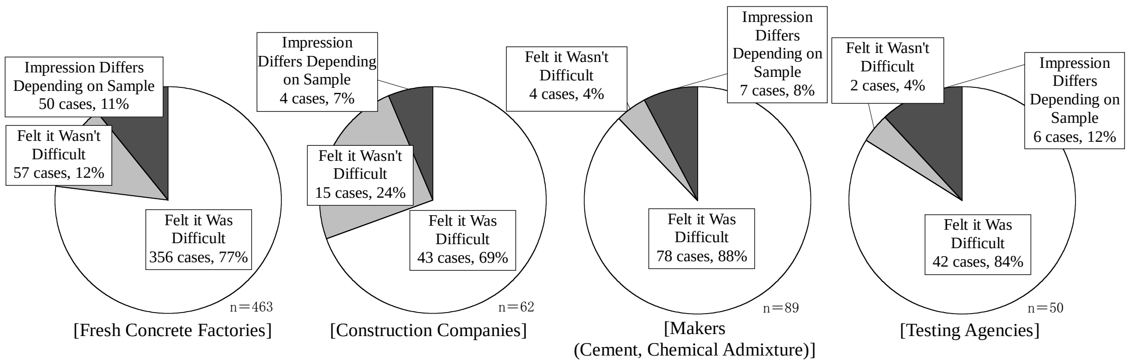

Figure 17 － Impressions of the Work to Remove the Sample After Testing

The impression for the work of removing the sample after the test was “Felt it Was Difficult,” frequent among all the respondents, accounting for around 70-80%. This is because the weight of the container and the sample combined is around 40 kg, which is difficult to handle, and additionally, after the test there is no fluidity, and sometimes setting has begun, resulting in effort needed in order to handle the concrete.

7. Considerations Regarding the Bleeding Test Method

Based on the results of the examination and the questionnaire survey regarding testing method standards for bleeding both domestically and overseas, we considered improving the bleeding testing methods, and formulated the “Concrete Bleeding Simple Test Method (Draft)” as a result.

7.1 Domestic and International Bleeding Test Method Standards

JIS A 1123 exists in regards to domestic bleeding test methods. It was established in 1957, and revised four times – in 1975, 1997, 2003, and in 2012, to its current form. On the other hand, the overseas testing methods ASTM C 232: 2004 “Standard Test Method for Bleeding of Concrete” and BS EN 480-4: 2005 “Admixtures for Concrete, Mortar and Grout-Test

Methods- Part 4: Determination of Bleeding of Concrete" are representative testing methods. The primary differences between these and JIS A 1123 are the materials and dimensions of the test container, the environment of the test room (temperature and humidity), sample height, and the bleeding water sampling interval time. However, as these differences are not significantly different, they are generally the same testing method.

7.2 Concrete Bleeding Simple Test Method (Draft) Proposal

In order to improve the difficulties that practitioners are having in regards to JIS A 1123, as made clear by the questionnaire survey, together with a comprehensive understanding of the implemented test results from the test method WG, we have proposed the concrete bleeding simple test method (draft).

The primary differences between this test method proposal and JIS A 1123 are as follows.

- Three types of container measurements: φ250 x 285 mm (JIS container), φ125 x 250 mm, and φ150 x 300mm
- The container material does not have to be made of metal, so long as it does not have a chemical reaction with Portland cement or other hydraulic cements.
- The testing location is not limited, any level location that is not exposed to direct sunlight or wind is fine.
- No standards are made from the testing location and the test sample temperature.
- The sampling interval for bleeding water is uniformly set to 30 minutes regardless of collection time.

8. Afterword

This report summarizes the results of the committee's activities over a two-year period. First, in order to have a common consciousness regarding bleeding, we organized the mechanism and defined the terms. Next, the results of the investigations and considerations on relationship bleeding amount or rate and the properties of concrete were organized, and based on the results, we showed the thought processes for setting bleeding target values to realize the performance of concrete. And we also organized the control method of the set target value. The testing method is also important in controlling bleeding, so through an understanding of the situation gained from the questionnaire survey, we proposed a bleeding simple test method that is suitable for practical use.

Based on the results of this committee's activities, we can consider that it's possible to show how to control bleeding for the performance improvement of concrete structures. However, there are still many issues, such as not being able to quantify the influence that bleeding has on the concrete characteristics, and specific displays of bleeding target values is insufficient. For future considerations, we hope to see the establishment of bleeding control technologies, that will lead to the improvement of performance of concrete structures.

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