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Commentaries

Rule of Design and Construction for Concrete Structures based on the Performance-creative Design Concept

Shoji IKEDA *1

Keywords: performance, function, performance-based, performance-creative, verification, subjective, objective, design

The author has been proposing a new philosophy of design concept for concrete structures named performance-creative design method. Recently, structural performances have been much more concerned due to the requirements for serviceability, durability, ultimate safety, etc. based on the performance-based concept. In the design calculation, various structural performances should be verified according to the specific design code. This trend has invited the design attitude of the verification of structural performance, say, performance-verification design method. However, the author has felt that the philosophy of design should be more active and creative in manner rather than the verification for a given structural system. Here, the author pointed out the contradiction of the terminology in the coined Japanese words of "subjective" and "objective" which are essential concept to express creativity.

Construction of structures in the society is the construction of artificial environment which becomes the wealth of the society and makes great influence on the psychology and economy of the nation. Therefore, creativity in the design of structural concrete is inevitable to construct and maintain an attractive society. The performance-creative design concept is crucial for the infrastructure design to produce high quality social wealth and civilization at present and in future.

Japan Prestressed Concrete Engineering Association stipulated an entirely new rule for concrete structures based on the performance-creative design concept under the chairmanship of the author and has published it in September 2011. In this rule necessary function of the structure is first determined as a subject and then the structure is realized creatively to get the object. In this context, created performances such as enhancement of social wealth, safety of society against earthquakes and tsunamis, aesthetics, sustainability, long term serviceability, ultimate safety, etc can be definitely expected.

Figure-1 shows an analogy of the concept between the words, subject and object, relating to the optical nature of a lens or a human eye. Here, an object can be recognized in the recognition domain subjectively as a subject and then design can be done objectively under the performance-creative concept.

The definition of the performance is so essential that it was defined such that performance is characteristics and ability in the response of the structure or the structural element subjected to the action. Therefore, the "required performance" as the terminology was replaced by the word "function" since "function" is definitely objective in the design.

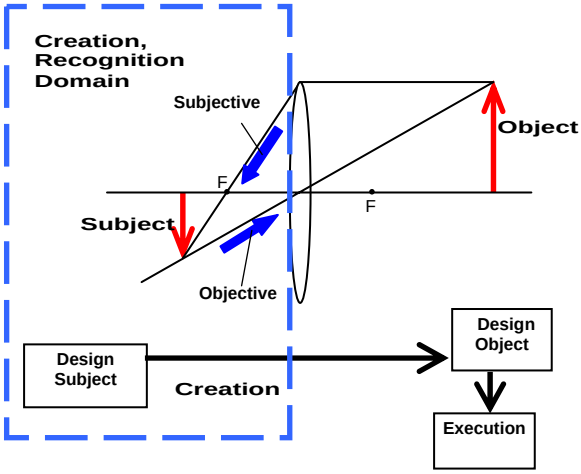

Fig.1 Analogy of Subjective and Objective

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Technical reports

Estimation of Drying Shrinkage Strain of Concrete and Selection of Methods for Shrinkage Crack Control

—Research Committee Report on Shrinkage Crack of Concrete—

Kohji TERANISHI[*1], Ippei MARUYAMA[*2], Kazuhide SAITO[*3], Takashi HIRAIWA[*4] and Kentaro MORI[*5]

Keywords: drying shrinkage, estimation method, aggregate, composite theory, aggregate size, crack control measures, crack pattern

The research committee on shrinkage cracks of concrete organized in ASCoT (NPO) had worked for 3 years until March 2011 to address the following two subjects: a proposal of the method to estimate drying shrinkage strain of concrete and an organization of the shrinkage crack control measures. The results were compiled as the committee report and its contents are shown in Table 1.

With regard to the first subject, it is important to correctly reflect the effect of aggregate in the estimation result of drying shrinkage strain of concrete and the committee aimed to construct the estimation methods focusing on this point. The drying shrinkage strain of concrete is therefore estimated based on the composite theory and the flow shown in Fig. 1.

In order to estimate the drying shrinkage strain of concrete according to the flow shown in Fig. 1, the values of drying shrinkage strain and elastic modulus of aggregate should be obtained. The committee decided to estimate these values from some results of aggregate test which can be conducted as easily as possible. However, such characteristic values or test values (i.e. the evaluation indexes of drying shrinkage strain) have not been found out yet. Consequently, the committee conducted collaborative experiments, and drew a specific surface area, air-dried moisture content of aggregate and direct measurements of drying shrinkage strain of coarse aggregate as evaluation indexes.

The drying shrinkage strain of concrete is estimated from these evaluation indexes, using the prediction equation based on the composite theory shown in AIJ's "Recommendations of Practice of Crack Control in Reinforced Concrete Buildings (Design and Construction)" in Appendix 2.

With regard to the second subject, effectiveness, cost advantages and versatility of various crack control measures were evaluated. The relevant part in the committee report was developed so that readers can gradually understand more detailed information after grasping advantages and disadvantages of each measure shown in the list of evaluation results.

Table 1 Contents of Committee Report

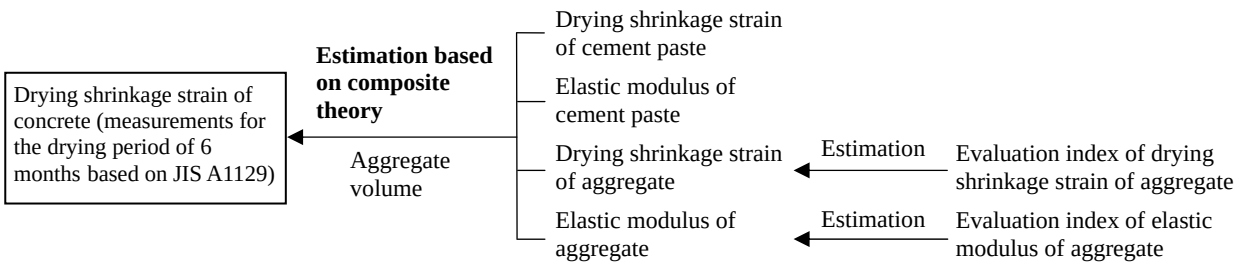

Fig. 1 Estimation Flow of Drying Shrinkage Strain of Concrete

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Technical reports

Case Study of the Redevelopment Rebuilding Construction of the Housing Development with the Concrete using the Recycled Aggregate which prepared it than a Local Outbreak Concrete Lump

—Report of study on reproduction exploitation of resources Committee of the disposal concrete—

Tooru YOSHIKANE[*1], Terumi URUTA[*2], Shinobu UCHIDA[*3] and Takayuki KIMURA[*4]

Keywords: disposal concrete, recycled concrete, reproduction in construction spot, cost, quantity of CO_2 discharge, energy reduction

The supply in the market of the normal ready-mixed concrete can afford to be enough under the present conditions, and therefore recycled concrete does not come to spread.

Therefore this study compared the influence that the use of the recycled concrete gave to economy, quantity of CO_2 outbreak, energy consumption by a case study based on a model of the reconstruction project of the apartment complex. In addition, this study used the recycled aggregate of the M class for recycled concrete. The reason depends on there being little disposal amount of resources to occur secondarily in production of the recycled aggregate.

The case study made the trial calculation about following three cases.

Case I: It produces recycled aggregate and the recycled concrete with the disposal concrete that occurred in the construction spot.

Case II: The disposal concrete carries it to the recycled materials production plant out of the spot. Recycled aggregate and the recycled concrete are manufactured from the plant and use it for reconstruction.

Case III: All the disposal concrete throws it away in the disposal facility place and use the concrete which is all new for a reconstruction.

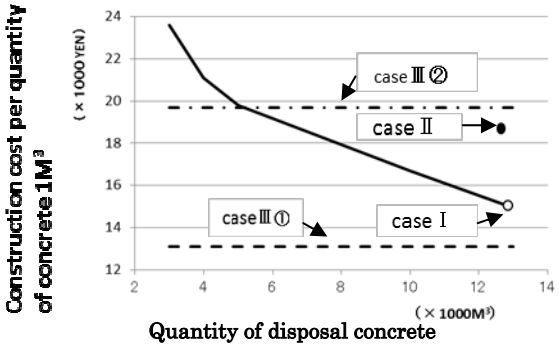
In this case study, quantity of disposal concrete intended for a scale of 12,000m^3 as a model in an actual housing development. In addition, the deficit when total quantity of the concrete of the reconstruction project exceeds quantity of recycled concrete, is supplemented with new concrete.

When quantity of the disposal concrete surpasses approximately 5,000m^3 in the example of Case III ② which is high in cost of new concrete, Case I is cost down in comparison with Case III by the figure of the calculation result. However, a cost merit does not appear when the quantity does not exceed 20,000m^3 in Case III ① having low value of the new concrete.

Discharge (C conversion value) of the CO_2 and the energy consumption calculated total quantity of the whole construction as the condition that was common by Portland blast-furnace slug cement B class use.

... In the CO_2 discharge, Case I decreased by 74% in comparison with Case III, and Case II decreased to 84%. In addition, with the quantity of energy reduction, each became 76% and 90%..

As for these reductions, it is not cut down the cost of construction. It is evaluated as a social merit under the present conditions. It is a future examination problem.



Case Ⅲ①: (a cost of construction that increased cost of new concrete and dismantling concrete disposal cost in the case of 15,100 yen /m^3):
Case Ⅲ②: (a cost of construction that increased cost of new concrete and dismantling concrete disposal cost in the case of 19,700 yen /m^3):

FIg : Relations with a dismantling scale and the cost

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Technical reports

Questionnaire survey concerning securing cover thickness of RC buildings

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Keywords: durability, bar arrangement, cover thickness, questionnaire survey, JASS 5, non-destructive inspection, construction management

According to the reason for such as close bar arrangement and the use of fat diameter bar, it is necessary to consider it more than the past for securing cover thickness. Then, authors executed the questionnaire survey to understand the actual situation of construction and to examine the effective countermeasures and the note in design for securing cover thickness in the reinforced concrete work.

The questionnaire survey executed to the construction sites of general contractors that belonged to the Japan Federation of Construction Contractors (JFCC) in November, 2010, and the answer was obtained from 135 sites.

Fig. 1 shows the factor of harmful influence to the cover thickness securing. The largest factor to influence the cover thickness securing harmfully is that the bar arrangement is overcrowded. Additionally, the problems concerning skill and knowledge of the bar placing engineer etc. have been enumerated. The overcrowded of the bar arrangement might be inevitable problem from both viewpoints of securing the structural safety and the economy in the future.

Fig. 2 shows the part of adjustments at bar arrangement inspection. There are a lot of adjustments in column, beam, wall, joint of column and beam, etc. that part depend on assembling sequence and spacer etc., oppositely a little in slab handrail etc. assembled to be suitable for them. Neither the handrail nor cantilevered slab, etc. cause the problem at the stage of the bar arrangement inspection, and the possibility that the bar move at the time of a concrete placing that is the post-processing is guessed.

Fig. 3 shows the targeted value of the formwork accuracy (street accuracy at top of formwork). As the targeted value of the street accuracy, 2.0-3.9mm is the mode values. Construction management tends to become severe, considering the answers of 4.0-5.9mm was mode values in a similar questionnaire survey that did in 1986.

Additionally, the result of the matter concerning the matter concerning the cover thickness inspection, the matter concerning the design, and the construction accuracy etc. is described in the manuscript.

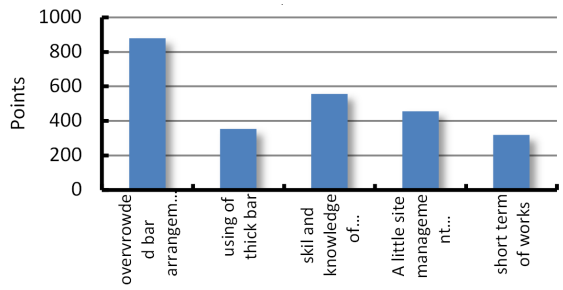

Fig.1 Factor of harmful influence

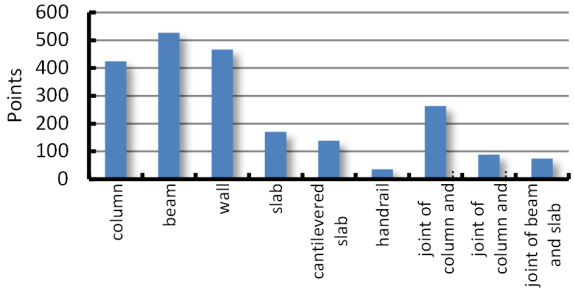

Fig.2 Part of adjustment at bar arrangement inspection

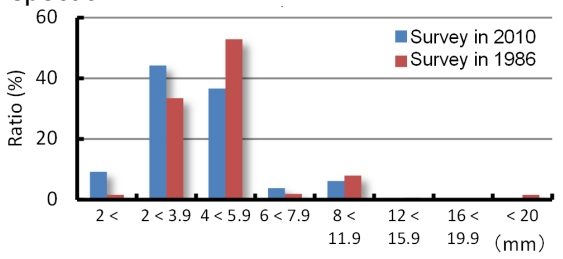

Fig.3 Target value of formwork (street accuracy at the top of formwork)

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Construction records

Structural Design and Construction of High-rise Intermediate Story Seismic Isolation Building Using Branched CFT Columns
—Mita Bellju Building—

Kazuhiro IWAMA[*1], Kazuhiko WADA[*2], Izumi KOBAYAKAWA[*3] and Hiroshi WAKABAYASHI[*4]

Keywords: Branched columns, concrete-filled-tube (CFT), concrete injection, intermediate story seismic isolation

The structural framing work was completed this autumn for the construction of the Mita Bellju Building near JR Tamachi Station, and the whole building was transformed. In particular, the external columns directly below the high-rise part of the building branch from the 2nd floor for a height of two floors, to give the external façade design a strong expression. In this article the concrete injection construction for these branched CFT columns is described.

1. Outline of the Design

The building is a multi-purpose, multi-layered high-rise building, with a self-drive car park, shops, offices, and rental apartments. The offices have a 39.0m×39.0m regular shape in plan, arranged as column-free spaces with 550mm square columns at 3.6m centers on the periphery. The residential part is provided on the higher floors for a better view, set back so as to open up the south side to obtain a comfortable living environment.

Fig.1 Perspective of the Building

An intermediate story seismic isolation structure with a seismic isolation layer provided in the boundary between the offices and apartments was adopted as the structural solution in response to two conditions that arose from the architectural requirements, (1) layering of the different functions, and (2) the irregular shape of the higher stories, and consequently vibration control was adopted for the building as a whole. In addition, a steel structure was adopted for the office area where large spaces were required, and an RC structure was adopted for the residential area where living comfort was required, and the structure type and column spans were changed at the seismic isolation layer. The seismic isolation layer was provided below the 25th floor, and contained 23 seismic isolation bearings and 12 viscous dampers.

2. Branched Concrete Filled Columns

This building is a multi-purpose, multi-layered building, and each function has a different optimum span. Therefore the basic module was taken to be 3.6m, and the underground car park was planned @10.8m, the office floors @3.6m, and the residential floors @7.2m. Between the residential and office areas the spans and structure type were switched at the seismic isolation layer, and between the office and car park branched columns were provided having the height of 2 floors.

The branched columns were designed as exposed structural steel, as they were one of the important architectural features. Therefore it was not possible to provide concrete injection holes in the branches at the 2nd floor level. On the other hand the inclined columns were the height of 2 floors, so it was not possible to drop the concrete using the tremie pipe method. Therefore, pressure injecting from the 1st floor directly below the branches was adopted.

The greatest concern in pressure injecting the concrete into the branched columns was whether it was possible to uniformly inject the filling concrete upwards from the floor below into the center columns which were in a straight line and into the inclined columns. Therefore the following measures were adopted.

- Concrete filling holes were also provided in the panel zone vertical rib plates, so that the concrete would flow into the inclined columns at the branches.
- The concrete filling holes in the diaphragms were made smaller in the center columns (200ϕ) than for the inclined columns (260ϕ).
- Concrete confirmation holes (20ϕ) were provided in the sides of the columns at 1.0m pitch in the height direction.

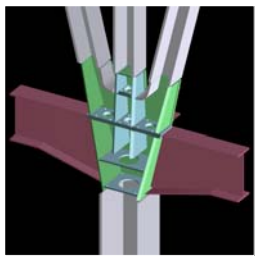

Fig. 2 CG of branched column

After confirming the effectiveness of these measures in a test construction, 63.2m^3 of concrete was placed in eight 2-branch columns (7.9m^3 each), and 75.2m^3 of concrete was placed in eight 3-branch columns (9.4m^3 each).

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