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Commentaries

Summary of Design Guideline 2010 of R/C Beam-Column Joint Using Mechanical Anchorages

Kiyoshi MASUO[*1], Toshiyuki KUBOTA[*2]

Keywords: mechanical anchorage, beam-column joint, joint confining reinforcement, ultimate SDA demand, assured SDA capacity

The first version of Design Guideline of RC Beam-Column Joint using Mechanical Anchorages was published in 2006.1, which is intended to be applicable to any headed bar admitted by the technical evaluation committee. Since then, the construction using mechanical anchorage has been extensively applied to from medium to high-rise buildings and explored by rebar fabricators to extend applicable range. However, several problems in the first version are revealed in design practice, such that joint confining reinforcement ratio is excessive at roof level. To settle these problems, Design Guideline 2010 is published to enhance the correspondence to design practice by extending applicable range based on resent experimental results and adjusting to joint design using conventional bend-anchorage. Revised issues on beam-column joint design are summarized below.

(1) Design equation for required joint confining reinforcement ratio, p_{jwh}, is proposed based on demand and capacity as illustrated in Fig.1. Using Eqs.1～3, p_{jwh} is calculated.

$R_{uD} \leqq R_{80min}/\phi_s$ (Eq.1)

R_{uD} is the ultimate story drift angle (SDA) demand provided in Table 1, R_{80min} is the assured SDA capacity given by Eq.2, ϕ_s is the safety factor. α_{wo}, β_w are provided in Table 2.

$R_{80min}=R_{80a}\cdot\alpha_w$ (Eq.2)

$\alpha_w=\alpha_{wo}+\beta_w\cdot(p_{jwh}\cdot\sigma_{wy}/F_c)$ (Eq.3)

If orthogonal beams are attached at both sides of the joint, p_{jwh} is approximately 0.2% for interstory exterior joint, when the capacity ratio of joint to beam, λ_p, is the lower-bound value of 1.1 and design criteria II in Table 1 is applied. Also, for roof interior and exterior joints, p_{jwh} is 0.3% when λ_p is 1.0 and design criteria II is applied.

(2) Beam, column reinforcement anchorage design is modified based on recent experimental data.

(3) Other joint types, including sub-beam to main-beam, foundation to column, are added.

(4) SRC beam-column joint design is modified to include roof interior and exterior joints.

(5) Design procedure corresponding to joint design using conventional bend-anchorage is added.

(6) Design using high-strength material is included. Here, ordinal strength is defined as concrete with design strength F_c of 60N/mm^2 or below and reinforcement of SD295 to SD490. High strength is defined as concrete with F_c of 45N/mm^2 to 120N/mm^2 and reinforcement with nominal f_y of 590N/mm^2 to 685N/mm^2.

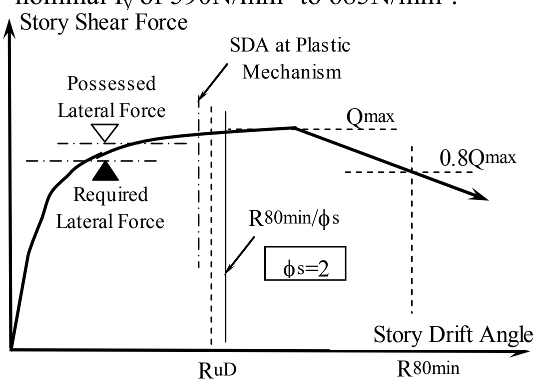

Fig.1 Definition of Ultimate SDA Demand, R_{uD}, and Assured SDA Capacity, R_{80min}

Table 1 Ultimate SDA Demand, R_{uD}

Joint Type	Design Criteria I	Design Criteria II
Interstory Exterior	1/75	1/50
Roof Exterior (L)	1/75	1/50
Roof Interior (T)	1/100	1/67
	(Potential Hinge)	(Plastic Hinge)

Table 2 Equations for R_{80a} and α_w

Joint Type	Equation for R_{80a}	α_{wo} Orthogonal Beam: No	One-side	Both-side	β_w
Interstory Exterior	$R_{80a}=0.03\lambda_p$	0.4	0.6	1.0	19
Roof Interior (T)	$R_{80a}=0.024\lambda_p$	0.6	0.7	1.2	4.8
Roof Exterior (L)	$R_{80a}=0.03\lambda_p$	0.6	0.8	1.2	8.9

*1 Consultant, General Building Research Corporation of Japan, Dr.E., JCI Member
*2 Professor, Department of Architecture, Kinki University, Dr.E., JCI Member

(email : masuo@gbrc.or.jp)

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Commentaries

JSCE Standard Specifications for Hybrid Structures-2009

Tadatomo WATANABE[*1], Akinori NAKAJIMA[*2], Tamon UEDA[*3], Shunichi NAKAMURA [*4] and Sachito TANAKA[*5]

Keywords: hybrid structure, standard specifications, performance verifications, composite members, connection

INTRODUCTION

Japan Society of Civil Engineers (JSCE) published “Standard Specifications for Hybrid Structures” in December 2009, which were based on the previous publications (2002 and 2006) of “Guidelines for Performance Verification of Steel-Concrete Hybrid Structures”. This paper briefly introduces the technical main features of the Specifications.

CONCEPTS OF SPECIFICATIONS

The Specifications specify the general principles for the verification and evaluation of the performance of steel-concrete hybrid structures. The Specifications are edited on the basis of the following concepts.

General Principle

In the part of general principal, common rules for hybrid structures are mainly specified. The advanced analyses such as FEM analyses are considered to be applicable to investigate behavior of hybrid structures in detail. The primary features in this part are described below.

Performance requirement and method of verification

The Specifications specify general techniques for checking the target performance of the hybrid structures, which are designed in consideration of natural condition, social condition, constructability, economy, and so on. Basically, the verification is executed by confirming that the verification indexes are always below the corresponding critical values. The limit state for verification is specified. Experimental investigations on real size structure, prototype or scaled model, as well as numerical analysis can be used as tools for verification.

Structural Planning

Structural planning should be executed after setting performance requirements. At the stage of structural planning, it is important to set primary design conditions, such as a type of structure, materials used for structure, a dimension of structure, and so on. Primary design conditions are decided on the basis of many performance requirements such as safety, serviceability, restorability, constructability, maintenance and economy.

Composite Members

In the part of composite members, two methods of verification are indicated to be prepared. A standard method is selected for usual design, or an advanced method can also be applied to complicated structural behavior. This part covers steel-concrete composite members. In future, newly developed hybrid structures, which will be made from new materials such as fiber reinforced plastic (FRP), will be added in the Specifications.

This part covers five types of members as below : Steel-concrete composite beam, Steel-concrete composite slab, Steel-concrete sandwich slab, Steel reinforced concrete (SRC) column, Concrete-filled tubular steel (CFT) column.

The following items for each member are included as a standard method of verification:Scope, Loading before/after composite action, Condition required for verification (shear connectors), Consideration of member stiffness in evaluation of response, Setting or evaluation of critical value, Structural or other details required for method of verification.

Connecting parts between Different Members

Principles of verification to connecting parts between different members are described in this part. The fundamental methods of verification are described corresponding to kinds of members, types and regions and strength of connecting part.

The standard methods of verification are indicated for specified connecting parts listed below : Steel plate girder and reinforced concrete pier, Steel and prestressed concrete girders, Anchor frame of CFT column and concrete footing, Embedment of CFT column and concrete footing, CFT column and socket steel pipe pile.

*1 Vice-President, Hokubu Consultant Corporation, JCI Member
*2 Prof., Faculty of Engineering, Utsunomiya University
*3 Prof., Faculty of Engineering, Hokkaido University, JCI Member
*4 Prof., Faculty of Engineering, Tokai University
*5 Assistant manager, JFE Engineering Corporation Coast & Port Structure Engineering Division

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Technical reports

Convenient Evaluation Method of Adiabatic Temperature Rise using Mortar Sample

Eiji MARUYA[*1], Hidetoshi MISUMI[*2], Toshiyuki TAKAHASHI[*3] and Etsuo SAKAI[*4]

Keywords: adiabatic temperature rise, adiabatic calorimeter, quality test, quality prediction, interstitial phase, calcium sulfate, blast-furnace slag

The evaluating test for adiabatic temperature rise in concrete is not adequate for daily quality test because it requires considerable labor. In this report, we investigated the applicability and the adequate conditions for quality prediction of concrete using an adiabatic calorimeter used for small mortar sample. In addition, the adiabatic temperature rises of cement samples with different C_3A content and SO_3 content were investigated.

Figure 1 depicts the adiabatic calorimeter (made by Tokyo Riko Corp., Ltd.). This equipment uses a 30 ml sample in a film case, used as a sample container. The adiabatic state can be controlled by adjusting the temperature of the air surrounding the adiabatic container to follow that of the sample. This equipment has a maximum control sensitivity of 5×10^{-3} °C.

The adiabaticity and responsiveness of the equipment was tested prior to examining a mortar by checking the adiabatic temperature rise when Joule heat was supplied electrically. Consequently, it was confirmed that this calorimeter had the ability to evaluate the temperature rise with high accuracy.

By using this equipment, clear differences were observed among the mortar samples with different types of cement, and these differences showed the same tendencies as those seen in general concrete data. The temperature histories of mortar prepared with the sand-cement ratio from 2 to 3 showed same level as those of concrete.

We researched the relationship of the adiabatic temperature rising characteristics between mortar and concrete on samples with different types of cement and mix proportion. Curves of adiabatic temperature rise of mortar were found to become similar to those obtained in concrete, by setting a mix proportion of mortar based on the heat balance. It was confirmed that the adiabatic temperature rise of mortar showed a good correlation with that of concrete within the range of testing (Fig. 2). These results suggest that quality test of cement could be practiced reasonably by using this method.

Next, we investigated the influence of interstitial phase composition, SO_3 content and replacement of blast-furnace slag on the adiabatic temperature rise of the cement mortar. Cement clinkers were prepared by using an electric furnace in laboratory. The influence of SO_3 content and replacement of blast-furnace slag on the adiabatic temperature rise differed by interstitial phase composition. It was confirmed that the adiabatic temperature rise of cement containing C_3A of 15 mass% decreased significantly by increasing SO_3 content.

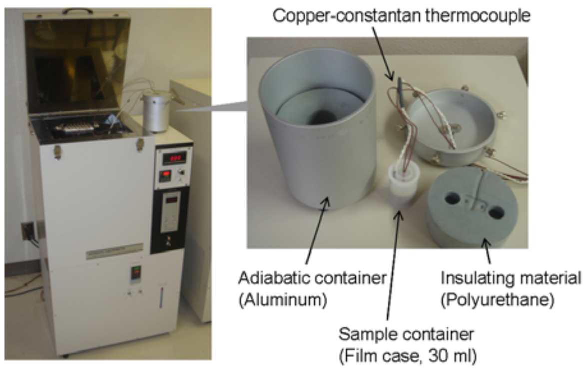

Fig. 1 Adiabatic calorimeter

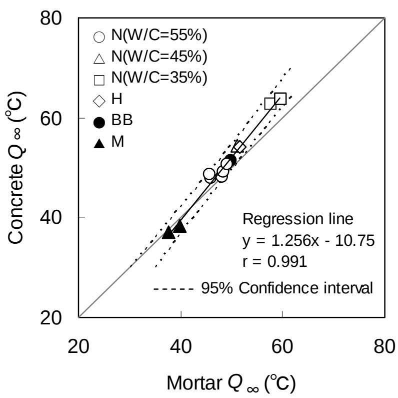

Fig. 2 Correlation between mortar and concrete

*1 Research Scientist, Technical Development Center, UBE Industries, Ltd., Dr. E., JCI Member
*2 Technical Development Center, UBE Industries, Ltd.
*3 Manager, Technical Development Center, UBE Industries, Ltd., Dr. E., JCI Member
*4 Prof., Graduate School of Science and Engineering, Tokyo Institute of Technology, Dr. E., JCI Member

（email：maruya@ube-ind.co.jp）

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Construction records

In-situ Production and Placement of Concrete at Hakata Station New Building Project

Yasuhiro KURODA[*1], Akira NISHIDA[*2], Tatsuro NAGASAWA[*3] and Kunimitsu NAKAGAWA[*4]

Keywords: site mixing, fly ash, mass concrete, high strength concrete, quality control, environment conservation

In the spring of 2011, Japan is going to open a new bullet train route called The Kyusyu Shinkansen. At the same time, the new Hakata station building will be renewed with 10 stories above ground and a further 3 stories underground. The total floor area of the new building is two hundred thousand square meters. The new building will be used as the new entrance of Kyushu as it used to be. It will be one of the biggest projects of the 21st century.

The most characteristic feature of this building is that the structure is planned to surround the train tracks as can be seen in Fig.1. For this reason, construction work beside the railway tracks had to be conducted at night while trains were not running. In addition, to avoid holding-up traffic, we had to restrict vehicles entering and exiting the site during commuting hours. Following those restrictions and considering enviromental aspects, we chose to mix and to place the concrete on site to finish the work on schedule.

The quality of the concrete was kept high, thanks to consistent in-situ production and placement of concrete. Besides, approximately 5000 tons of fly ash were used as a concrete admixture, in order to reduce the hydration heat and improve the workability of the concrete. Using fly ash partially reduced the quantity of Portland cement that was needed, thereby reducing the enbedded CO_2 associated with cement production. Furthermore, in-situ production minimized concrete waste compared with using truck agitator to transport ready-mixed concrete to the site. These points, together with the decision not to transport the ready-mixed concrete by truck agitator, saved a total of 3700 tons of CO_2 emissions.

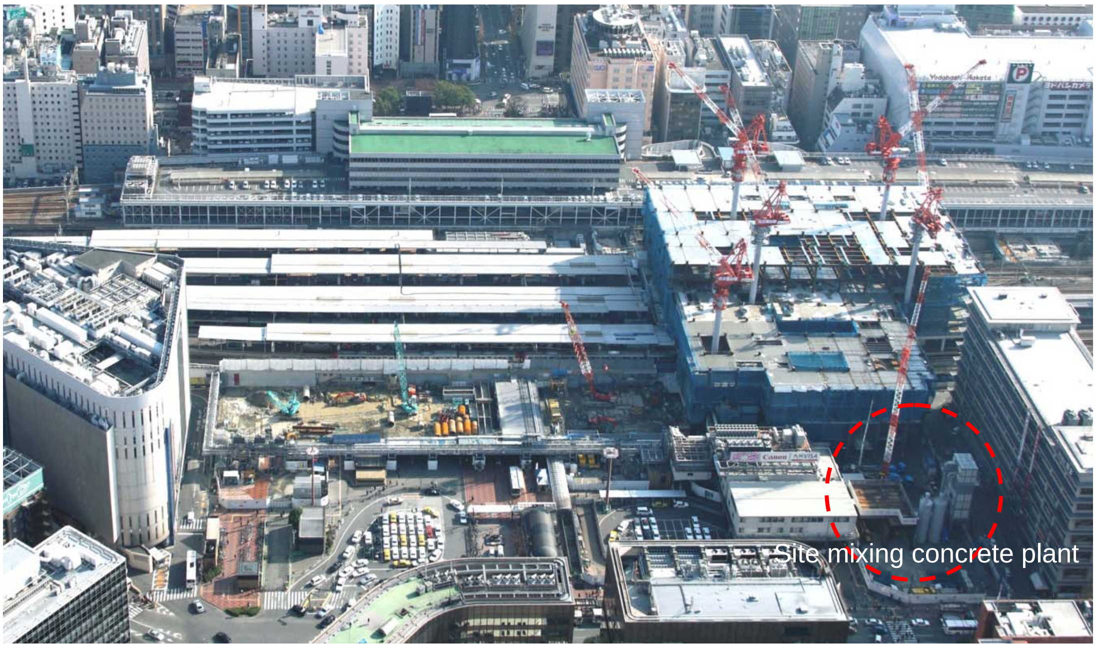

Fig.1 Construction photograph (Hakata new building project)

*1 Institute of Technology, Shimizu Corporation, JCI Member
*2 Institute of Technology, Shimizu Corporation, Dr.E., JCI Member
*3 Civil Engineering Technology Division, Shimizu Corporation
*4 Kyusyu Branch Office, Shimizu Corporation

(email：y.kuroda@shimz.co.jp)

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Construction records

Construction of Warumi Bridge

Norihide SAKUMOTO[*1], Tomohiro MAEKAWA[*2], Yutaka YAMAHANA[*3] and Yoshiki YAMAGUCHI[*4]

Keywords: CLCA method, Cable erection method, composite structure, mass concrete

Warumi Bridge was built as a strait crossing road that across the main island of Okinawa and the Yagaji island. This bridge was planned as fixed concrete arch deck bridge, to harmonize with the ambient surrounding and secure the sea route of the ship.

The arch rib was constructed by concrete lapping method with pre-erected composite arch (CLCA method) in the safety and economy. The arch span length of this bridge is 210m, and it is the longest length of Japan in the bridge constructed by the CLCA method.

In this construction, we measured the stress of the arch rib, to confirm the safety of construction and the stress fluctuation of the arch rib. This paper presents the construction records and stress measurement results of the arch rib.

PROJECT OUTLINE	
Project Name	Warumi Bridge Superstructure Construction Project
Construction Period	December 23,2006-March 25,2010
Owner	Okinawa Prefecture
Contractor	Zenitaka-Takenakadoboku-Kokuba Joint Venture
Total Length	315.0m
Span	26.3m+25.0m+3@20.0m+60.0m+5@24.0m+22.3m
Arch Span	210.0m

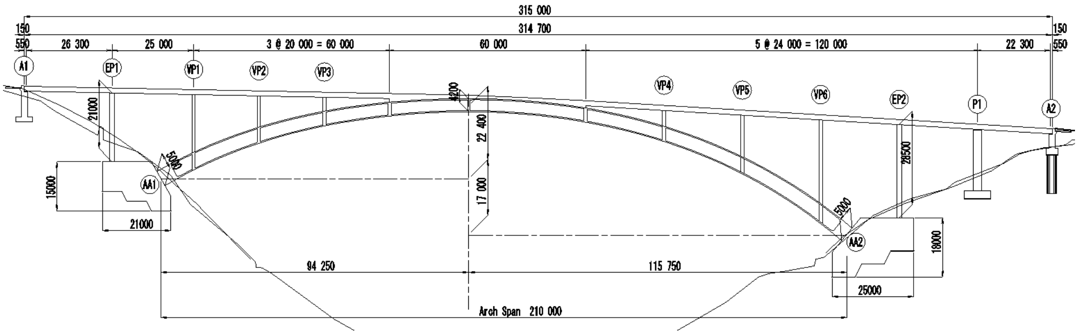

Fig.1 Bridge layout

Photo.1 Construction of Warumi Bridge

Photo.2 Finished photograph

*1 Chubu Regional Public Works Office, Okinawa Prefecture
*2 Hokubu Regional Public Works Office, Okinawa Prefecture
*3 Zenitaka Corporation, JCI Member
*4 Zenitaka Corporation