QUALITY CONTROL OF RC ELEMENT FOR EARTHQUAKE DESIGN

Javier Yukio Yamamoto Munoz[1]
MEE07149

Supervisor: Dr. Goto Tetsuro[2]
Dr. Taiki Saito[3]

ABSTRACT

Recently the RC structure has been increasing adopted in Dominican Republic; however, quality of the buildings in the rural area is poor. For this reasons my study is focused on the quality control of the structural elements to secure a better performance when an earthquake happen. By visiting several constructions site in Japan, the construction method, technology and the quality controls of their concrete work. By means of Comparing them with the methods used in the Dominican Republic and a proposal is prepared to improve the construction process and the quality of the structural elements in my country. Also studied how the honeycombs affect the concrete strength in the structural elements and a seismic capacity of high quality RC member. Based on the study result, methodology for better RC elements is proposed in this paper.

INTRODUCTION

A possibility is high that in a relatively near future the Dominican Republic is going to be affected by a strong seismic shock, since the last strong earthquake in 1946, 62 years has already passed. Despite the high seismic risk of our territory and despite the proximity of an important seismic event, the country is not prepared for an earthquake of considerable Magnitude. Since most of the population did not experience the last great earthquake of the August 4, 1946, the seismic risk in the Dominican Republic tends to be underestimated. This underestimation of the seismic risk allows construction of building in most inappropriate zones and quality of the buildings in the rural area is poorer. The informal construction of houses occupies 80% in all the country, this construction are done by the own owners or by neighbors of the place who do not count on any professional engineering formation. These types of buildings would be of the first to collapse at the time of an earthquake.

In the morning of September 22, 2003 the north zone of the Dominican Republic was hit by an earthquake of magnitude 6.5, the epicenter was located 15 kilometer from Puerto Plata city and 20 kilometer from Santiago de los Caballeros city. This earthquake damaged important buildings in Puerto Plata city, including schools and hospitals, and some buildings collapsed. After the earthquake, it was found that quality of these collapsed buildings were poor in terms of constructions materials and constructions works.

---

[1] Engineer, private company in Dominican Republic (**EPSA-LABCO S.A.**)
[2] Senior Researcher of National Institute for Land and Infrastructure Management (NILIM),
[3] Chief Research Engineer of Building Research Institute (BRI)

QUALITY OF RC CONSTRUCTION IN JAPAN

Constructions Practice

In the Dominican Republic concrete is most commonly utilized material for the constructions; the strength depends on several variables like characteristic of the materials, production method, transport, placement and cured. For these reasons part of this paper involves observing the construction process in Japan and exposing the problems of quality control that we have in the Dominican Republic.

Table 1 List of construction site visited in Japan

Location	Named	Detail
1	Mitakadai, TOKYO (UR Mitakadai complex)	8 story RC apartment building, Under Construction.
2	Oumigison, OKINAWA prefecture (Oumigison town office)	Reinforce Concrete office building, Constructed in 1925, under partial rehabilitation.
3	Miyakojima, OKINAWA prefecture (Irabu-oohashi)	RC bridge, Under Construction
4	Concrete Factory in Miyakojima	Automatic system to manufacture concrete severe quality control by computer monitoring

Important Factor for Construction Quality

Formwork System

The formwork is very important when we make out a structural element of reinforced concrete, since this form the required element. In both Japan and Dominican Republic wooden formwork is used.

The formwork system used in Japan is simpler and has better quality than in Dominican Republic. The wood used in Japan is processed and prepared to accomplish this function, which is more resistance and can be used more repeatedly. In order to join the formwork's woods in Japan steel separator is used to maintain the shape not to open while concrete is casted. In Dominican Republic use wooden lot is used but, is not resistant as the steel separator.

Manufacture of Concrete

Not all the concrete factories in Dominican Republic have high technology as the concrete factories in Japan, and the majority of these factories wit high technology concentrate in the capital or in major cities of Dominican Republic. Because in these places the most important projects are implemented and the volume of the consume concrete is more. In the rural area the concrete is made by the construction workers without any concrete design.

In Japan the concrete mixing is totally automatic, and the mixture is homogeneous wit all the production. In the Dominican Republic it is not guaranteed that concrete mixture, brought to the construction site is homogeneous. In many cases delivery concrete is delayed and for these reasons the driver of the truck adds additional water or additive to the concrete mixture before placing the concrete. For this reason it is necessary to make the concrete slump test to each concrete truck.

Qualified Staff

At Dominican Republic, the laborers do not have technical trainings and the majorities are Haitian immigrants, and in many instances they are not aware of what they are doing. For that reason they always go on with the same procedure of work and are very difficult to learn new techniques. To improve the quality in the construction site, capacitate the staff is important in order to increase quality and make a more fast work.

HONEYCOMB CONCRETE EFFECT TO THE CONCRETE STRENGTH

The specimens of concrete were given load and determine the Shear Stress to with and without honeycomb. The concrete strength is 21 N/mm², slump 18 cm and maximum coarse aggregate site is 20mm; the specimens were cast on July 2, 2008 and the actual test was carried out on August 5, 2008.

Shear Strength Test

Portable Structural Testing Equipment (PSTE)

Measuring instrument used is Data logger: TDS-303 b y Tokyo Sokki, Japan

Transducer: CDP50 by Tokyo Sokki, Japan.

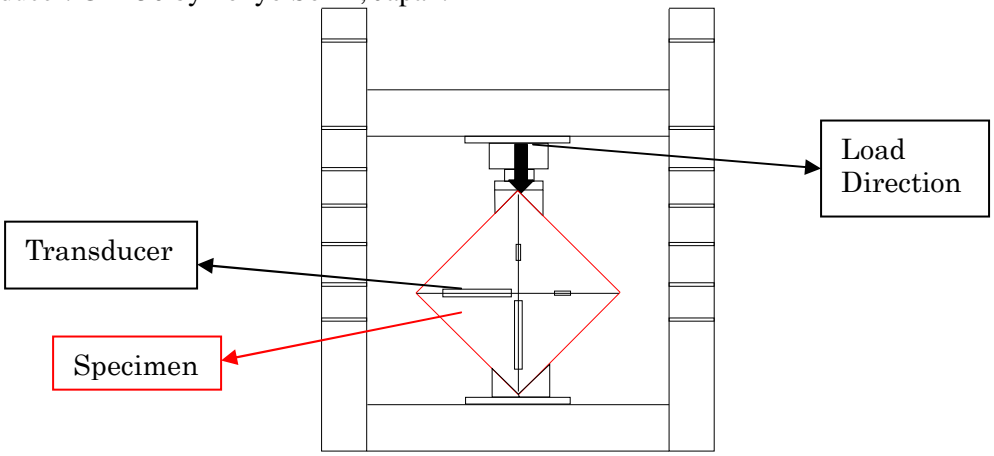

Figure 1 (PSTE) Developed by Dr. Goto Tetsuro of NILIM, Japan.

Specimens

The dimensions of the concrete specimen are 70cms x 70cms with 10cms of thickness. 2 type's specimens without honeycomb and with honeycomb concrete were prepared. The variable of this test is the honeycomb concrete area. Are tree type PH-1, PH-2 and PH-3.

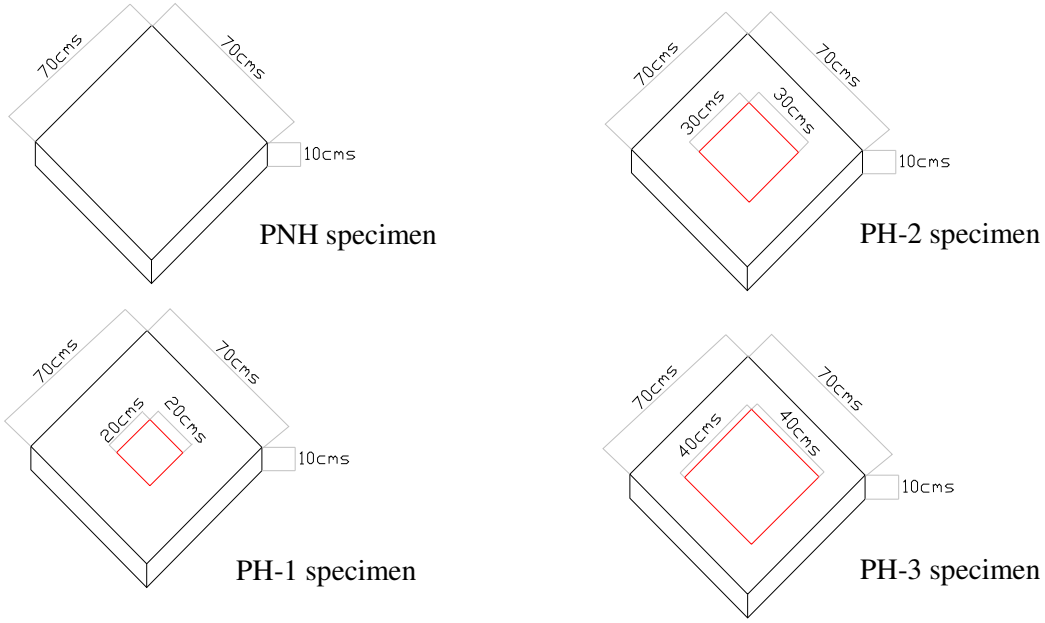

Figure 2 Specimen of Honeycomb

In order to create the honeycomb, sifter of 20mm is used to select large size aggregates. It results reduction of the quantity of mortar in the mixture.

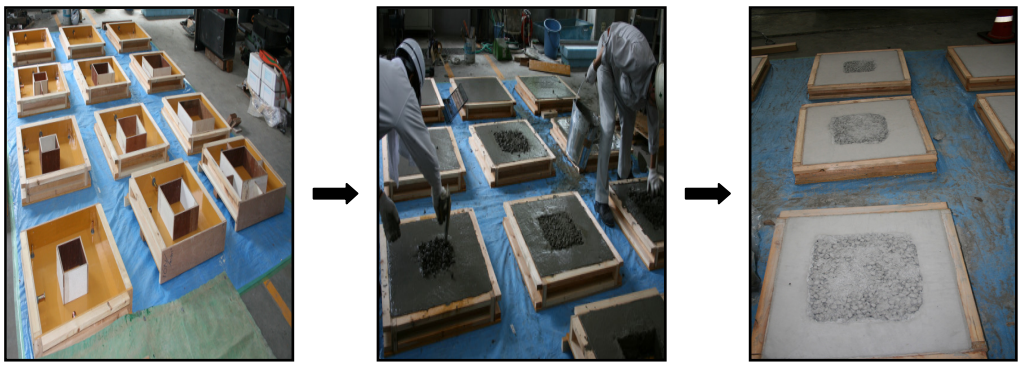

Figure 3 Construction Process of specimens

Material test

Table 2 Quality control of concrete

Material	Cylinder Test		Specimens
	Compression	Tensile	Pulse Velocity
Concrete	24.62 N/mm²	2.15N/mm²	0.38 Km/sec

Compression Test

From the test results, the compressive strength and Young's Modulus of the concrete are listed in Table 2. The compressive strength is obtained by using the ratio of damage load *fc* and section area of the sample, and the Young's Modulus is calculated by using the secant value of 0.5**fc*. The compressive strength and Young's Modulus are about 25MPa and 40kMPa respectively as shown in Table 1

Splitting Test

The splitting test is about 2.15 N/mm² respectively as shown in Table 2.

$$\sigma t = \frac{2P}{\pi dl}$$

σt: Tensile strength
P: Maximum load
d: Diameter of cylinder
l: Length of cylinder

PUDINT Test

In order to check the homogeneity of the concrete in non honeycomb concrete area, an Ultrasonic non-destructive integrity testing (PUDINT) are used. This test is applied to all Concrete plate but not in the concrete honeycomb concrete area.

As velocities, showing in the Table 2, do not have drastic change in the tested areas. That means the concrete preserve the uniformity in all the concrete area except for the honeycomb area.

Shear Test Results

Figure 4 shows the relationship between vertical deformation and load obtained from shear stress test for 4 specimens.

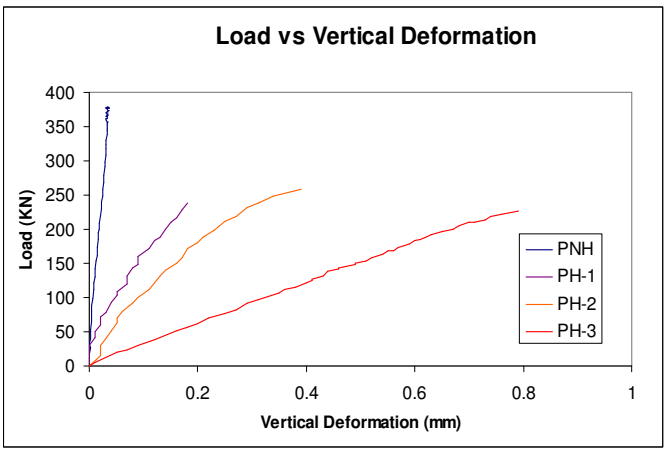

Figure 4

Table 3 result of shear stress test

Specimen	Load (KN)	Qu (KN)	Area (mm^2)	Shear Strength (N/mm^2)	Vertical Deformation (mm)
PNH	379.5	268.35	70000	3.83	0.03
PH-1	238.37	168.55		2.41	0.18
PH-2	259	183.14		2.62	0.39
PH-3	226.75	160.34		2.29	0.79

From figure 4 it is observed that vertical deformation of specimen with honeycomb become large compared with specimen without honeycomb. The specimen whit large honeycomb area, PH-3, gives the largest vertical deformation.

Figure 5 shows the graph of shear strength of the specimens.

From this graph, the ratios of shear force reduction are 1.43 for PH-1, 1.21 for PH-2 and 1.54 for PH-3 in average, the honeycomb reduce 36.4%.

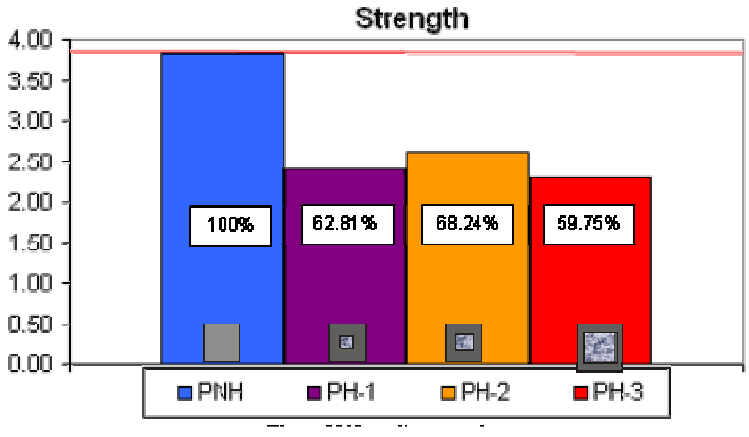

Figure 5

When comparing the results between them with honeycomb specimen and without honeycomb specimen. The load capacity of PNH is higher than the PH-1, PH2 and PH-3. The Vertical Deformation of the PH-1, PH2 and PH-3 specimen is proportional to the honeycomb area.

The honeycomb affected the concrete the shear strength of de concrete and de vertical deformation of the specimens

CONCLUSION

From this study, it is conclude the honeycombs in the structural element affect the strength of the concrete. The honeycomb area is an important factor in this aspect. However, it is ideal to test specimens of structural elements with steel bars as adopted in the actual structural body. Therefore, the challenge for the future would be testing structural elements with the same honeycomb to examine the effects of honeycomb to the structural elements. Also step from this study is to verify the repair methods used for honeycomb, and conventional repair methods should be tested to verify their effectiveness. In this study specimens used are not structural elements. When comparing the construction methods of the Dominican Republic with those of Japan, the problems at the construction site in the Dominican Republic are clearly observed as follows.

- Absence of quality control
- Ignorance of regulation for quality control.
- Expansion of buildings often made ignoring original structural design.
- Absence of qualified staff.

These problems can be minimized with proposals of quality control on the construction site. The proposal includes training and education to the construction workers in term of quality control.

Following recommendations are presented:

- Educate the workers, designers and constructors in fulfilling the standards established by the construction code.
- The government has to introduce programs capacitating the workers.
- Investing to new technologies, which help to secure the concrete quality such as assembling the formwork.

ACKNOWLEDGEMENT

I would like to express my sincere gratitude to Organization of Urban Renaissance Agency (UR), The Morimoto Construction Company, the Oomigi Town Office of Okinawa prefecture government, Miyakojima Branch Office of Okinawa prefecture government, National Registered Architect Association of Miyakojima Branch of Okinawa prefecture and Daiyomi Construction Company.

REFERENCE

Ing. Héctor E. O'Reilly Pérez, Reglamento Sísmico Dominicano, BOLETIN DE LA SOCIEDAD DOMINICANA DE SISMOLOGIA E INGENIERIA SISMICA (SODOSISMICA)

Ramón A. Delanoy, Aspectos de Sismología Dominicana, 1995

R. Osiris de León, RIESGO SÍSMICO EN LA REPUBLICA DOMINICANA

Tadashi Maki, SENIOR VOLUNTEER, JICA ADVISER (ABTI-EARTHQUEAKE) ,SEISMICITY in the Dominican Republic- For Measurement of Anti- Earthquake-2004.