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Concreting Workmanship in Indonesia Study Case: Padang City, West Sumatra, Indonesia

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***Abstract*—This research gives information about the practice of concreting work in Reinforced Concrete (RC) building project in Indonesia. The study area is Padang City, which has suffered severe damages due to September 2009 Earthquake. The target interviewee is 100 builders who are constructing RC buildings. This interview together with observation was conducted by directly visiting the construction sites. While collecting information about the main factors which contribute to RC building quality, e.g., concrete mixing, compaction, concrete placing and curing, the information about the profile of the builders have been collected. The results show that the workers dominate the profile of builders in productive age with 30 years experiences on average. However, 90% of the builders yet experience any construction workshop. The concreting work, which is conducted by the builders, yet reaches the required standard. More than 50% of the builders produced concrete with the higher water-cement ratio, and almost 65% admitted that they add more water after concrete`s setting time is finished. There are 3common methods of concrete compaction which is used. 6% of the builders use a vibrator, 43% use the rodding method, 28% use hummer, and 8% choose to add more water to placed concrete to increase concrete workability. Meanwhile, more than 60% of the builders do not cure the placed concrete. The results show that construction practice that is conducted by the local builders is needed to be improved. The mistakes seem to be repeated over a generation since the source of learning of the builders is mainly from their senior builder (77.25%) and self-learning (2.5%). Only 7.5% that admitted they had experienced on construction workshop.**

***Keywords*— concreting workmanship; builder; reinforced concrete building.**

I. INTRODUCTION

Concrete is the most robust construction material available and has obtained a favorite position in construction. Concrete is the most widely used construction materials [1], [2]. Hence, it becomes a disaster when a large urban dwelling made from concrete material constructed poorly [1]. The quality and performance of concrete is not known but assumed at the design stage and that the actual quality and performance characteristics are determined through the actual execution process. This is the unique situation for concrete structures compared to structures made from other building material and emphasizes the special needs verify the actual quality of concrete execution in the field by investigating the concreting workmanship of construction worker/ labor [3], [4].

The occurrence of concrete defects such us honeycomb, cold joint and improper concrete cover can lead to the decreasing of its durability, low compression strength and increase concrete vulnerability due to a severe environmental condition such us corrosion and delamination of reinforcement bars if concrete is applied for Reinforced Concrete (RC) building. Padang City is the capital city of West Sumatra (Sumatera Barat) province, Indonesia, located on the western coast of Sumatra island [5], [6]. As the center of economic, education, health and governmental, the population growth in Padang City keeps increasing by the year, as shown on the population growth graph in Fig. 1 [7].

Earthquake damage records in Indonesia also show the number of houses damaged in West Sumatra, including Padang City, which is the biggest one [7]. Recent researchers highlighted the importance of producing a good quality of concrete which can contribute to reducing the environmental impact of concrete production and achieve green technology on for concrete building [8], [9]. Meanwhile, Juliafad et al. [10] presented the statistical data of concrete strength from existing buildings in Indonesia. By using the log normal distribution, the results show that the concrete strength tends to the left, which mean concrete in Indonesia is weak [10].

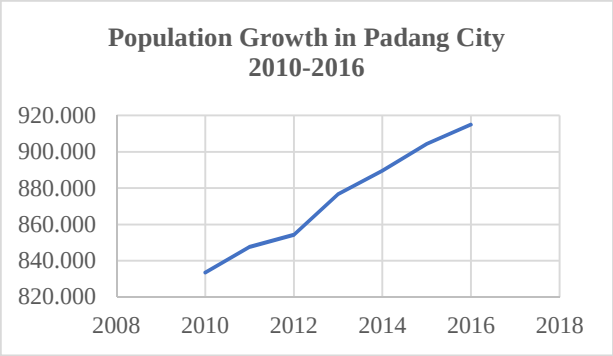

Fig. 1 Population growth in Padang city 2010-2016 [5]

This research considers the concreting workmanship of the builder as one of the components of the environmental system that should be investigated, due to its contribution to the final quality of RC Building performance.

II. MATERIAL AND METHOD

This research used a deep interview method and field observation to collect information about the concreting workmanship of RC building in Padang City.

We interview 100 construction workers including the head of builder and builder. The questions involve items related to the milestone of concrete work. Since the number of the interviewee is significant, we use a structured interview sheet to keep the timing and the quality of the answers.

This interview and site observation visit was conducted in November 2017 in 60-construction site in Padang City, West Sumatra, Indonesia. The interviewee works in RC building projects from low to mid-rise buildings. We categorized the questions into three categories, which are:

- Builder profile, aiming to understand the profile of the builder in Padang City. The information can be gathered including their educational background, experience, type of buildings they used to build, and their recent knowledge of building construction
- Concrete mixing practice. This part emphasizes the practice of concrete mixing in the construction site.
- Concreting workmanship. This category is aimed to find the problem mostly occurs during the construction process in the field and the probability of concrete and construction defect that might occur due to that practice.
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The questions and sub-questions regards to the aim of the interview are explained in Table 1.

TABLE I
THE LIST OF INTERVIEW QUESTIONS

Questions	No	Sub-questions
A. Builders Profile	1	Name
	2	Position (head of the builder, builder, labor)
	3	Education background
	4	Construction work experience
	5	Seminar or construction training has been joined
B. Concreting mixing	1	Concrete workability (dilution)
	2	Do you measure slump
	3	How do you learn to mix the concrete
	4	How do you measure water to cement ratio
C. Concreting Workman-ship	1	Compaction practice
	2	Curing Methods
	3	Compaction methods
	4	Construction joint treatment

III. RESULT AND DISCUSSION

A. Builder Profile

There are three builder positions in construction field excluding the position which mainly occupied by a professional engineer, e.g., supervisor, project manager or designer. The three positions are head of builder, builders, and labor.

1) Age Distribution of The Builder: Fig. 2 shows the distribution of age of construction workers over 16 to 75 years old for three positions; head of the builder, builder, and labor. The figures are given as the percentage of the population.

Overall, the construction workers are at a productive age which is from 26 to 55 years old. Head of the builder dominate the age 36-45 years old and over. On the other hand, younger age is occupied by builder positions, which make sense since the builder works under the command of the head of the builder. The age of labor position is scattered. Labor usually is unskilled positions, which do not need specific competencies, and mainly works to help builder, e.g., lifting construction materials and construction cleaning in daily.

2) Construction Workshop Experience: Indonesia Law about Construction Sector no.2 year 2017 (UU no.2 2017), regulate all of the construction company must employ the certified builder only. The certified builder is a builder who gets workshop experience under legal/appointed institution [11].

Fig. 3 shows the percentage of interviewed builders who already get workshop opportunity and who have not. 90% builders yet experience any workshop or certified. These results agree with the previous research conducted by Vitri,2018 to the local builders in West Sumatra, which show that almost 85% of a construction worker (builder) yet been certified based on data from 2014 till October 2017 [12].

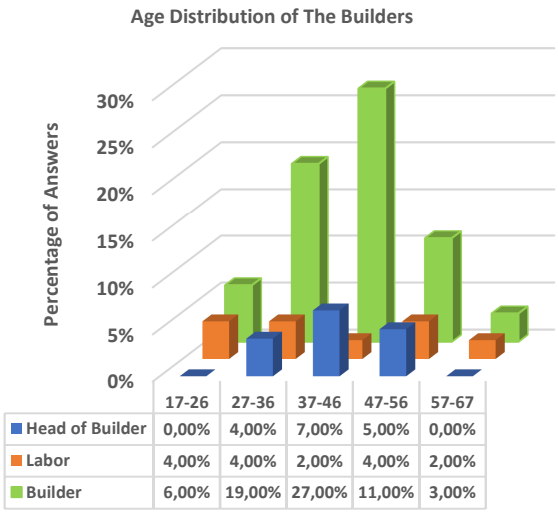

Fig. 2 Age distribution of the builders in RC building projects

The slight difference in percentage probably due to the difference in the source of data, where Vitri, 2018 use data from the builder who registered legally as West Sumatra resident. Meanwhile, this research did not require the legal status of the builders who have been interviewed.

3) Work Experience: Fig. 4 presents the data of builders and Head of the builder experience. Overall, the head of the builder already has 31-40 years of experience, while the builders mostly have 21-30 years' experience.

B. Concrete Mixing Work

Engineering codes of practice and specifications provide guidance and regulation aimed at ensuring the satisfaction of workability and strength criteria of the concrete mix. This specification includes the choice of constituents in the concrete mix, mix design, manufacture of the mix, transport, and placement of the mix and curing of the freshly placed concrete.

Water Cement ratio is one of the critical factors that influence the strength of the concrete and other desirable properties of concrete under job conditions [13]. Propovics 2009 mentioned fundamental assumptions for the strength versus water-cement ratio relationship. He show more comprehensive relation that show (a) the strength of structural concrete is controlled by the strength of the cement paste in it; (b) the strength of a cement paste depends strongly on the porosity in it; and (c) the porosity (capillary) is a function of the water-cement ratio. As the results also show that too much water or too much cement both affect the decreasing of concrete strength [14].

Water-cement ratio influences the workability of concrete, which leads the builders in the field to increase the water content to increase concrete mix flow ability/dilution.

Fig. 5 shows the practice of builders who likely to produce high water content in concrete caused by the high workability of placed concrete. The practice to not measuring the slump of concrete mix, weather condition, and inadequate mixing tools also become the reasons for their difficulties in controlling the water content. This research found 87.8% of the builders do not measure the slump. They visually observe their concrete mix workability and adjust it to reach the dilution that they want.

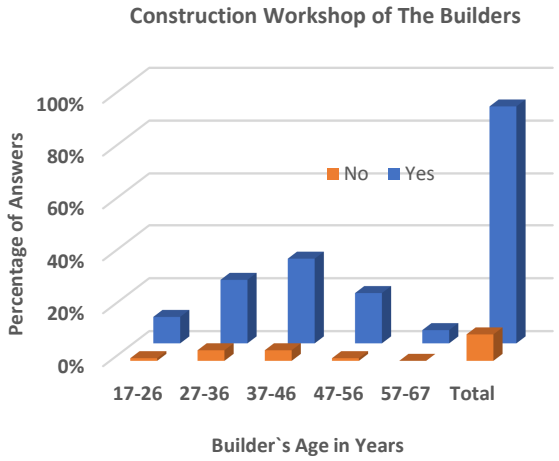

Fig.3 Construction workshop experience of the builders

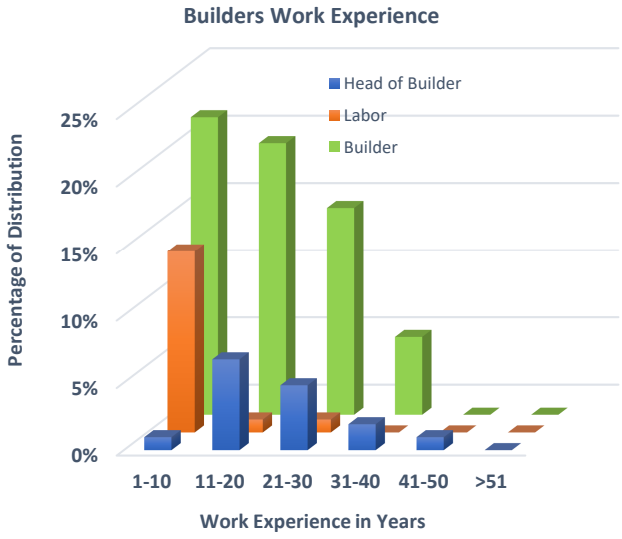

Fig. 4 Work experience of the builders in RC building projects

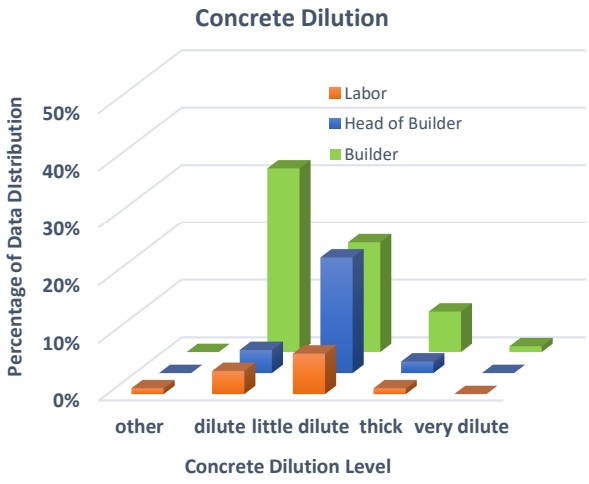

Fig.5 Concrete dilution produced in RC building projects

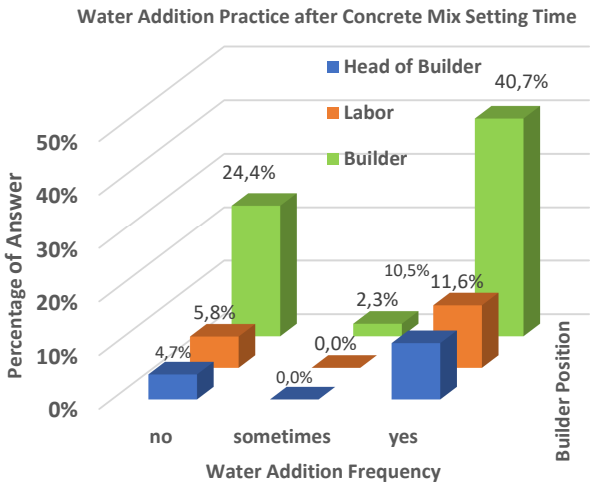

Fig.6 Water addition practice in RC building projects

Fig. 6 presents the finding of water addition practice quantitatively. Water addition is a practice that is conducted by the builders who find their concrete mix has been dry after a couple of time counted since the concrete setting time is finish. Some builders explain that when they add water, they also add cement. However, this practice will result in increasing of un-homogeneity of concrete mix and decreasing of concrete strength.

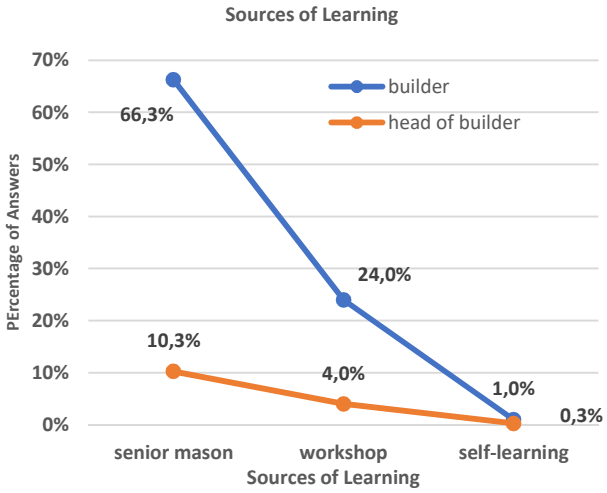

Fig.7 The source of learning of builder

The Source of learning among the builders as shown on Fig.7 mainly is the mentoring from senior builders or the head of the builder. Only 7.5% who learned from construction workshop, which seems to be coincident with the data of workshop experience in Fig. 2.

C. *Concreting Workmanship*

1) Concrete Compaction Practice: The behavior of the concrete`s deformation depends on its compaction, swelling, and creep [15]. Poor concreting workmanship reduced concrete serviceability reliability by reducing the permeability of the concrete. Proper compaction ensures the proper shield around the reinforcement and tendons and helps to achieve the higher ultimate strength, abrasion resistance and improves the bond strength between the reinforcement and concrete[[16], [17].

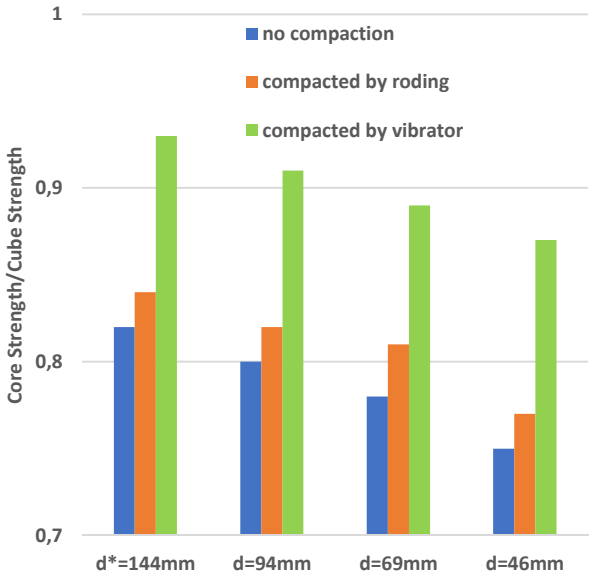

Fig. 8 Effects of compaction [11]

Fig. 8 shows the reduction in cube unit weight that is related to its strength due to different compaction techniques. The specimens have the least weight without compaction and improved if compacted by rodding. Suleiman and Kevern (2003) study the effect of improper compaction on the strength of the concrete as shown in Fig. 9 [18], [19].

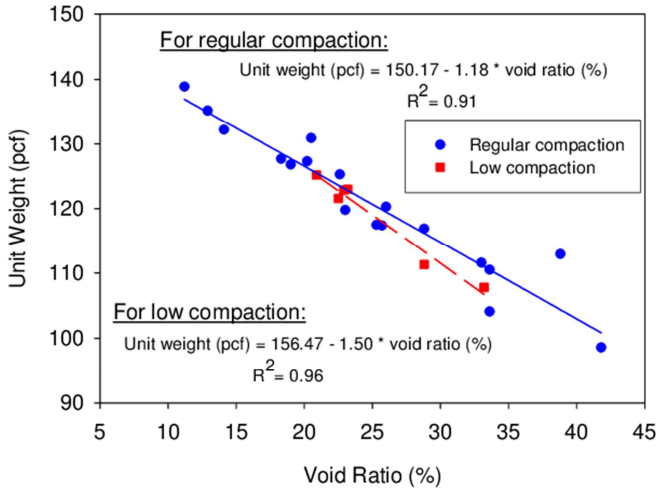

Fig. 9 Effect of improper compaction on concrete weight [19]

This research found the real practice of concrete compaction, which is conducted in the RC construction project in Padang City. Fig. 10 shows that 83% of the builders answered that they conduct concrete compaction, the rest 12% do not compact the concrete.

However while we asked the compaction method they conduct, only 6% answered that they use a vibrator which is on previous research conducted by Tuncan and Suleiman show the best performance of concrete compared to other compaction methods, e.g., rodding.

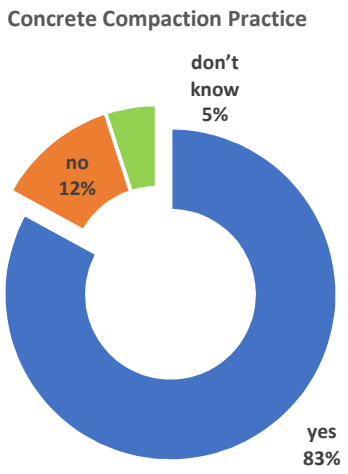

Fig. 10 Concrete compaction practice among the builders

Dominant compaction methods are rodding (43%) and give external vibration by using hummer of stone (28%). Other methods (8%) are by shaking the structural element after concrete placement which aimed at moving the concrete mix downward for column element, or by adding more water directly inside the column element to increase the flow ability of the placed concrete mix (see Fig.11).

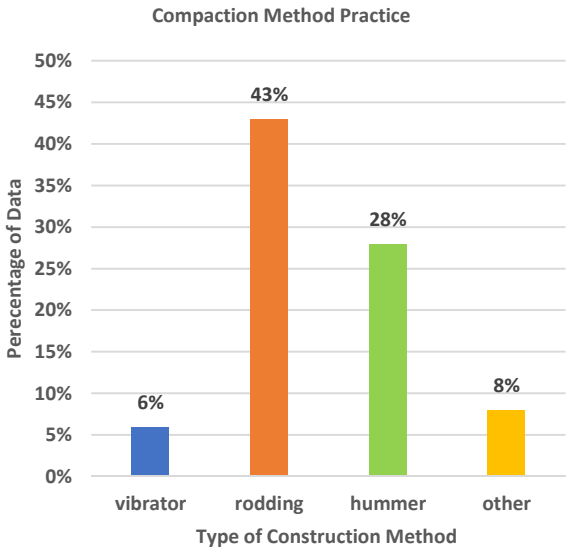

Fig. 11 Concrete compaction method among the builders

Fig. 12 shows one of the builder use hummers to tamp the placed concrete and Fig. 13 shows the observation in the field, which found many defects of concrete defects that could be a sign of improper compaction.

2) Concrete Curing: Improper curing of concrete can have the following effects.

1. Increase the reduction of compressive strength of concrete. Fig. 14 shows an increase in compressive strength with different curing conditions. It shows that the compressive strength of concrete can increase even after 28 days in case of moist curing.
2. Due to less curing, the cracks are formed.
3. The durability of concrete decreases due to improper curing.
4. Improper curing also leads to the reduction of abrasion resistance of concrete as the sand is coated on the surface [20], [21].

Fig. 12 One of the builders used hummer to compact the placed concrete

Fig. 13 Sample of structural defect due to improper compaction

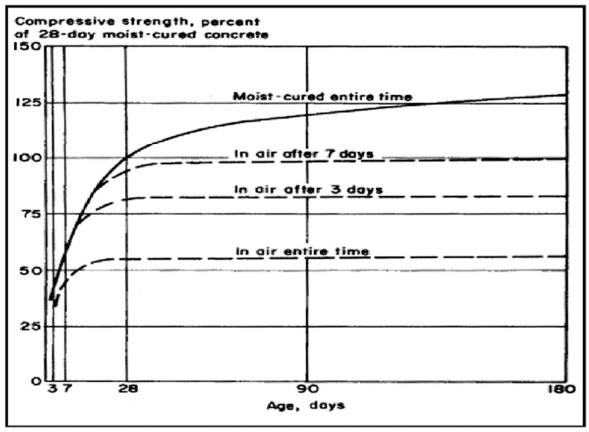

Fig.14 Effects of curing conditions on fc'[21]

Fig. 15 shows the results of interview regards to concrete curing practice in RC building projects in Padang City. Only 34% of the builders who conduct concrete curing. The method that they use is by watering the placed concrete surface for a couple of days or covering it with wet materials. However, 65% of the builders answered that they do not conduct the curing due to the opinion that the concrete does not need to be cured since it will dry by time.

This finding shows the lack of understanding of the builder about the basic knowledge of concrete characteristic and its effects on building performance and durability.

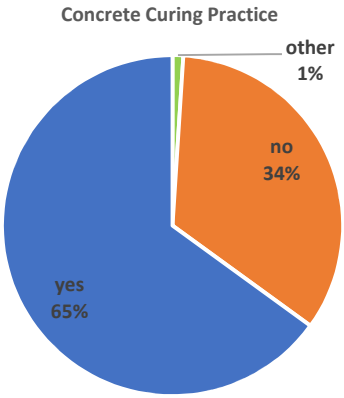

Fig. 15 Concrete curing practice

3) Construction Joint Treatment: Delay in concreting due to various conditions as well as improper casting sequence can result in cold joints. For unusually long delays during concreting, the concrete should be kept alive by periodically re-vibrating it to keep concrete workable [22].

If there are construction joint, it should be roughed, and special glue should be applied to ensure the bonding of two parts of concrete.

Fig. 16 presents the results of the interview and observation, which is more than 70% of builders do not conduct any joint construction treatment. It means that the decreasing of structural elements strength, high probability of spalling and other probable defects. Fig. 17 shows one of the findings of concrete defect due to improper construction joint treatment, where the concrete in the joint surface area is porous.

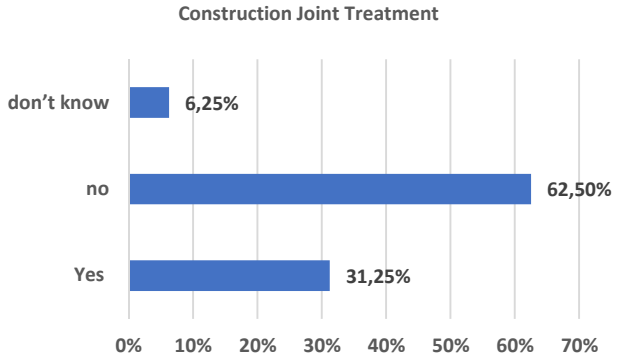

Fig. 16 Construction joint treatment

Fig. 17 Finding on concrete defect due to improper construction joint treatment

IV. Conclusions

The research of performance of builders in Padang City to conduct proper concreting work is needed to improve. The work of concrete mixing, placing, compaction, and the treatment of the construction joint is not adequate. Based on the interview, the low quality of RC building due to cultural work ethic which is indicated by the tend of builders to learn and adopt the same mistakes from their senior is high. Compare to the contribution of knowledge from construction workshop, the influence of previous experience is dominant. It is crucial to pursue intensively the intervention of government and construction experts to increase their knowledge, understanding, and competencies to conduct better concreting.

This research, however, needs to be improved in case of a number of the interviewee, the scope of the area, and maybe detail questions about RC building workmanship. There is also a need to continue the results of this research to understand the effect of each improper practice for RC building quality.

Acknowledgment

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