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A Study on the Quality Control of Concrete Production in Dhaka City

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Abstract: *The quality control of concrete is the most important issue in achieving its desired strength and durability.The principal aim of the study was to investigate the existing practices on the quality control of concrete production in Dhaka city. In doing so the key factors involved quality control of concrete production were identified. Various questions on the factors that affect quality control of concrete production were prepared for the purpose of this study. A total of forty five construction sites were visited at different location in Dhaka city and relevant data were collected. During the survey the necessary information was collected by eye observation, asking question to the site engineer and from written documents kept in the site. The survey results have shown that in Dhaka city most of the concrete production companies are neither aware of the key factors nor following the quality control of concrete. Eventually, an inferior quality of concrete is being achieved in Dhaka city which can affect both the strength and the durability of the most of structures those are being constructed currently.*

Keywords: *Concrete, Strength, Aggregate, Quality Control and Durability*

I. Introduction

Concrete is a major component of most of our infrastructural facilities today in the 21st century because of its versatility in use. Concrete is used more than any other man-made material in the world [1-6].Concrete is generally produced in batches at the site with the locally available materials of variable characteristics. It is, therefore, likely to be variable from one batch to another. The magnitude of this variation depends upon several factors, such as (a) variation in the quality of constituent materials; (b) variation in mix proportions due to batching process; (c) variation in the quality of batching and mixing equipment available; (d) the quality of overall workmanship and (e) supervision at the site [1-3]. Moreover, concrete undergoes a number of operations, such as transportation, placing, compacting and curing [1]. During these operations considerable variations occur partly due to quality of plant available and partly due to differences in the efficiency of techniques used. Thus there are no unique attributes to define the quality of concrete entirely. Under such a situation concrete is generally referred to as being of good, fair or poor quality. This interpretation is subjective. It is, therefore, necessary to define the quality in terms of desired performance characteristics, economics, aesthetics, safety and other factors. Due to the large number of variables influencing the performance of concrete, quality control is an involved task.

Therefore, the aim of quality control is to reduce the above variations and produce uniform material providing the characteristics desirable for the job envisaged. Thus quality control is a corporate, dynamic program to assure that all aspects of materials, equipment and workmanship arc well looked after. The tasks and goals in these areas are properly set and defined in the specifications and control requirements. The specifications have to state clearly and explicitly the steps and requirements, adherence to which would result in a construction of acceptable quality. Except for compressive strength and appearance there is no early measure of construction performance. Each step in construction procedure is therefore to be specified. The probability based specifications containing allowable tolerances on its attributes is more rational and is preferred. Quality control is thus conformity to the specifications, not more not less. The most practical method of effective quality control is to check what is done in totality to conform to the specifications. An owner will have no right to expect anything more than what is in the specifications. The builder, on the other hand, knows that anything less than what is in the specifications will not be acceptable to the owner. The main objective of the study is to evaluate the present practices for the quality control of concrete production in Dhaka city.

1.1 Methodology

The working methodology of the study was followed as given below:

(i) Identification of key factors involved quality control of concrete production.
(ii) Preparation of various questions on the factors that affect quality control of concrete production.
(iii) Collection of data from under construction project in Dhaka city on the quality control of concrete production.

(iv) Analyzing field data.
(v) Conclusion on the analysis and necessary recommendation.

1.2 Scope of the study

This study was focused on examining the existing practices for quality control of concrete at project sites in Dhaka city. The reason behind choosing concrete is its greatest significance to be used in a structural member.

II. QUALITY OF CONCRETE

Quality means excellence. It is thus a philosophy rather than a mere feature. The difference between two objects is judged by their qualities. We set some standards those can determine the level of acceptability. In most industries especially in manufacturing and processing, the concept of quality control is old and used extensively.

Nowadays, application of quality control is not only becoming popular but also mandatory in construction industry. Just knowing some quality control methods or procedures will not do any good. We must have to adopt and implement the quality control methods and tools that are available to us. The concept and its practice must be tuned in harmoniously. Quality control in construction activities guides the implementation of correct structural design, specifications and proper materials ensuring that the quality of workmanship by the contractor /sub-contractor is achieved.

2.1 Factors affecting in the quality of concrete

In view of the different processes involved in the manufacture of concrete, the problems of quality control are diversified and their solution elaborated. The factors involved are the personnel, the materials and equipment, the workmanship in all stages of concreting, i.e. batching of materials, mixing, transportation, placing, compaction, curing, and finally testing and inspection. It is therefore necessary to analyze the different factors causing variations in the quality and the manner in which they can be controlled.

2.1.1 Materials

For a uniform quality of concrete, the ingredients (particularly the cement) shall preferably be used from a single source. When ingredients from different sources are used, the strength and other characteristics of the materials are likely to change and, therefore, they should only be used after proper evaluation and testing.

2.1.1.1 Cement

Cement is any material that hardens and becomes strong adhesive after application in plastic form. Cement is the binding constituent of concrete. Similar types of cement from different sources and at different times from the same source exhibit variations in properties of concrete, especially in compressive strength. This variation in the strength of cement is related to the composition of raw materials as well as variations in the manufacturing process. The cement shall be tested initially once from each source of supply and, subsequently, at every two months interval. Adequate storage under cover is necessary for protection from moisture. Set cement with hard lumps is to be rejected.

2.1.1.2 Aggregates

In any concrete, aggregates (fine sand and Coarse) usually occupies about 70-75% and between 60 – 80% of the total volume of the concrete mass. The aggregates have to be graded so the whole mass of concrete acts as a relatively solid, homogeneous, dense combination with the smallest particles acting as inert filler for the voids that exist between the larger particles. This therefore suggests that the selection and proportioning of aggregates shall be given due attention as it not only affects the strength, but the durability and structural performance of the concrete also. Further, the aggregate is cheaper than cement and thus it is cheaper to use as much quantity of aggregate and as little of cement as possible. Aggregates provide better strength, stability and durability to the structure made out of cement concrete than cement paste alone. Aggregate is not truly inert because its physical, thermal and chemical properties influence the performance of concrete. While selecting aggregate for a particular concrete, the economy of the mixture, the strength of the hardened mass and durability of the structure must first be considered. Grading, maximum size, shape, and moisture content of the aggregate are the major source of variability. Aggregate shall be separately stock piled in single sizes. The graded aggregate should not be allowed to segregate.

2.1.1.3 Water

The water used for mixing concrete shall be free from silt, organic matter, alkali, and suspended impurities. Sulphates and chlorides in water should not exceed the permissible limits. Generally, water fit for drinking may be used for mixing concrete.

2.1.2 Personnel

The basic requirement for the success of any quality control plan is the availability of experienced, knowledgeable and trained personnel at all levels. The designer and the specification-writer should have the knowledge of construction operations as well. The site engineer shall be able to comprehend the specification stipulation .Everything in quality control cannot be codified or specified and much depends upon the attitude and orientation of people involved. In fact, quality must be a discipline imbibed in the mind and there shall be strong motivation to do everything right the first time.

2.1.3 Equipment

The equipment used for batching, mixing and vibration shall be of the right capacity. Weigh-batchers shall be frequently checked for their accuracy.

2.1.4 Workmanship

The activities involved in the workmanship in all stages of concreting, i.e. batching of materials, mixing, transportation, placing, compaction, curing and finally testing and inspection.

2.1.4.1 Ready mixed concrete

If instead of being batched and mixed on site, concrete is delivered for placing from a central plant, it is referred to as ready-mixed or pre-mixed concrete. This is used for large batches with lorry transporters up to $6m^3$ capacity. It has the advantage of eliminating site storage of materials and mixing plant, with the guarantee of concrete manufactured to quality-controlled standards. Placement is usually direct from the lorry therefore site-handling facilities must be co-ordinate with deliveries.

Advantages of Ready-Mix Concrete:

(a) Close quality control of batching which reduces the variability of the desired properties of the hardened concrete.
(b) Use on congested sites or in highway construction where there is little space for a mixing plant and aggregate stockpiles.
(c) Use of agitator trucks to ensure care in transportation, thus preventing segregation and maintaining workability
(d) Convenience when small quantity of concrete or intermittent placing is required.

The disadvantage of ready-mix concrete is that it is costlier by about 10 – 15% than concrete mixed at project site. But this is often off-set by savings in site organization, in supervisory staff, and in cement content.

2.1.4.2 Concrete mix ratio

When making concrete it's important to use the correct concrete mixing ratios to produce a strong, durable concrete mix. Mixing water with the cement, sand, and stone will form a paste that will bind the materials together until the mix hardens. The strength properties of the concrete are inversely proportional to the water/cement ratio. Basically this means the more water you use to mix the concrete (very fluid) the weaker the concrete mix. The less water you use to mix the concrete (somewhat dry but workable) the stronger the concrete mix. Accurate concrete mixing ratios can be achieved by measuring the dry materials using buckets or some other kind of measuring device. By measuring the mixing ratios you will have a consistent concrete mix throughout your entire project.

2.1.4.3 Batching of concrete

The correct measurement of the various materials used in the concrete mix is called batching. Errors in batching are partly responsible for the variation in the quality of concrete.

Concrete can be batched in two ways: -

(I) By Volume batching and
(II) By Mass (weight) batching.

Weigh-batching of materials is always preferred than volume batching. When weigh-batching is not possible and the aggregates are batched by volume, such volume measures to be regularly checked for the weight-volume ratio.

2.1.4.4 Mixing of concrete

This is the practical means of producing fresh concrete and placing it in the form so that it can harden into the structural or building material referred to as concrete'. The sequence of operation is that the correct quantities of cement, aggregates and water, possibly also admixture are batched and mixed in a concrete mixer which produces fresh concrete. This is transported from the mixer to its final location. The fresh concrete is then placed in the forms, and compacted so as to achieve a dense mass which is allowed and helped, to harden. The objective of mixing of concrete is to coat the surface of all aggregate particles with cement paste and to blend all ingredients of concrete into a uniform mass. Mixing of concrete is done either by hand or by machine.

Mixers performances shall be checked for conformity to the requirements of the relevant standards. Concrete shall be mixed for the required time; both under-mixing and over-mixing shall be avoided.

2.1.4.5 Transportation

After mixing, concrete shall be transported and placed at site as quickly as possible without segregation, drying, etc. as soon as concrete is discharged from the mixer, internal as well as external forces starts acting to separate the dissimilar constituents. If over-weight concrete is confined in restricting forms, the coarser and heavier particles tend to settle and finer and lighter materials tend to rise. If concrete is to be transported for some distance over rough ground the runs shall be kept as short as possible since vibrations of this nature can cause segregation of the materials in the mix. For the same reason concrete should not be dropped from a height of more than 1m. If this is unavoidable a chute shall be used.

The green concrete shall be handled, transported and placed in such a manner that it does not get segregated. The time interval between mixing and placing the concrete shall be reduced to the minimum possible.

2.1.4.5 Placing

The formwork and position of reinforcement shall be checked before placing concrete to make sure that they are clean and free of any detritus, such as ends of tying wire. The fresh concrete shall be deposited as close as possible to its ultimate position. Care need to be taken when discharging concrete from skips to avoid dislodging the reinforcement or over filling the formwork. When filling columns and walls, care shall be taken that the concrete does not strike the face of the formwork, which might affect the surface finish of the hardened concrete. For deep sections the concrete shall be placed in uniform layers, typically not more than about 500 mm thick, each layer being fully compacted.

2.1.4.6 Compaction

Compaction of concrete is the process adopted for expelling the entrapped air form the concrete. In the process of placing and mixing of concrete, air is likely to get entrapped in the concrete. If this air is not detrained out fully, the concrete losses strength considerably.

Anticipated targets of strength, impermeability and durability of concrete can be achieved only by thorough and adequate compaction. One per cent of the air voids left in concrete due to incomplete compaction can lower the compressive strength by nearly five percent (Gambhir, 2004).

2.1.4.7 Curing

Curing of concrete is the process of maintaining satisfactory moisture content and a favorable temperature in concrete during the period immediately after the placement of concrete so that hydration of cement may continue till the desired properties are developed sufficiently to meet the requirements of service. The reasons for curing concrete are to keep the concrete saturated or as nearly saturated as possible, until the originally water filled space in the fresh cement paste has been filled to the desired extent by the product of hydration of cement, to prevent the loss of water by evaporation and to maintain the process of hydration, to reduce the shrinkage of concrete and to preserve the properties of concrete.

Adequate curing is essential for the handling and development of strength of concrete. The curing period depends upon the shape and size of member, ambient temperature and humidity conditions, type of cement, and the mix proportions. Nevertheless, the first week or ten days arc the most critical, as any drying out during this young age can cause irreparable loss in the quality of concrete. Generally, the long-term compressive strength of concrete moist cured for only 3 days or 7 days will be about 60 per cent and 80 per cent, respectively, of the one moist cured for 28 days or more (Gambhir, 2004).

2.1.5 Formwork

Formwork is a structure, usually temporary, used to contain poured concrete and to mould it to the required dimensions and support until it is able to support itself. It consists primarily of the face contact material and the bearers that directly support the face contact material. Proper removal of formwork is an important factor to achieve good quality of concrete during the service life.

2.1.6 Inspection & testing

Inspection and testing play a vital role in the overall quality control process. Inspection could be of two types, quality control inspection and acceptance inspection. For repeated operations early inspection is vital, and once the plant has stabilized, occasional checks may be sufficient to ensure continued satisfactory results. The operations which are not of repetitive type would require, on the other hand, more constant scrutiny.

Apart from the tests on concrete materials, concrete can be tested both in the fresh and hardened states. The tests on fresh concrete offer some opportunity for necessary corrective actions to be taken before it is finally placed. These include tests on workability, unit weight or air content (if air-entrained concrete is used), etc.

III. Field Survey

The study aims to notice the existing practices which are used to quality control of concrete production in Dhaka city on project sites. A questionnaire is developed and accordingly data is collected from different project sites in Dhaka city. In the current case Uttara, Badda, Banani, Mirpur, Mohakhali, Bosuundhora, Dhanmondi, Kalabagan, Pallabi, Tejgaon, Banasree, Khilkhet and Puran Dhaka regionsare selected.A total number of forty five (45) on- going construction project sites producing concrete were surveyed and relevant data were collected according to questionnaire. The building projects were 6 to 10 storied in addition basement.

3.1 Survey techniques

The study was carried out by either physical observation or questioning the site engineer of the processes involved in the production of concrete from project sites along with some written documents. Site operations is observed by including the methods employed by site concrete workers at project sites in batching and mixing of concrete, handling of the concrete, placing, compaction, finishing and curing. Other investigations have been conducted on project sites were the inspection of cement stores and their storage system, a check on sections where concrete raw materials are deposited before utilization i.e. where aggregates are stockpiled, formwork, the nature and sources of water being used for the works as well as the level of supervision and workmanship.

IV. Results

Quality of concrete depends on the constituent materials, their proportions, mixing, transporting, placing, compaction and curing of concrete. The concrete with proper mix proportion has the needed workability and develops the targeted compressive strength. Efficient concrete mixers are needed to mix the ingredients and to produce a cohesive and workable concrete. Once the concrete is placed and consolidated by compaction in the formwork, protected and cured properly, it shall be a good quality concrete and is expected to perform satisfactorily in the service life. Forty five (45) sites are visited to collect relevant information in this study. The findings of the field investigation works on the quality control of concrete production in Dhaka city are presented in the coming sections.

4.1 Result and analysis

The survey results have been presented in table and discussed under different parameters. The parameters are materials, personnel, equipment, workmanship and formwork.

4.1.1 Materials

The main ingredients of concrete are cement, fine aggregate, coarse aggregate and water. The results were obtained from the sites for all the ingredients are given below:

Survey result of cement is given in Table 1.

Table 1: Survey result of cement

Type of cement		Source of cement collection		Type of source of cement collection		Test of cement		Test performed for each lot of Cement		Test performed for long time storing		Storing of cement at site	
PCC (%)	OPC (%)	Factory (%)	Agent (%)	Same (%)	Different (%)	Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	No (%)	Stored properly (%)	Not Stored properly (%)
100	00	77	23	88	12	00	100	00	100	00	100	71	29

From the above table it is evident that no construction company or building owner has been tested their cement, even some cases it is found that they did not store properly. Storing of cement at field is presented in Fig. 1.

Figure 1: Typical storing of cement at site.

There are mainly two types of sand available in Dhaka city to produce concrete. It is found that 64% of the total has been using Sylhet sand, 7% using local sand and the rest percent using a mix of local and Sylhet sand. However, none has been found conducting any laboratory test for fine aggregate. It is seen that in 82% cases screening has not been conducting and 97% cases washing before use in concreting is ignored. Survey result of fine aggregate is presented in Table 2. Fig. 2 represents the on field storing of fine aggregate.

Table 2: Survey result of fine aggregate

Type of fine aggregate			Type of source of fine aggregate collection		Test of fine aggregate		Test performed for each lot of fine aggregate		Screening before use		Washing before use	
Sylhet sand (%)	Local sand (%)	Mixed of these two (%)	Same (%)	Different (%)	Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	No (%)
64	7	29	16	84	00	100	00	100	18	82	3	97

(a) Sylhet sand (b) Local sand

Figure 2: Typical storing of fine aggregate at site

It has been found that most company used stone chips as coarse aggregate. However, similar practice has been noticed than the earlier materials, i.e. no laboratory test is being conducted. Moreover, the practice for storage is improper. Typical on field storing of coarse aggregate is shown in Fig. 3. Survey result of coarse aggregate is presented in Table 3.

Table 3: Survey result of coarse aggregate

Type of coarse aggregate			Source of coarse aggregate collection		Test of coarse aggregate								Screening before use		Washing before use		Storing of coarse aggregate at site	
					Unit wt.		Absorption		Grading		Maximum size							
Stone chips (%)	Brick chips (%)	*Mixed (%)	From dealer (%)	At site (%)	Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	No (%)	Stored properly (%)	Not Stored properly (%)
60	17	23	91	9	00	100	00	100	16	84	00	100	14	86	56	44	7	93

* Few members were cast with stone chips and few members were cast with brick chips.

(a) Stone chips (b) Brick chips

Figure 3: Typical storing of coarse aggregate at site

WASA supply water is being used in all construction projects in the survey area. But they no test has been done for water. It is to mention that a few construction project sites used rain water which fell during construction work illustrated in the figure 4. Survey result of water is presented in Table 4.

Table 4: Survey result of water

Source of water		Test of water	
WASA (%)	Others (%)	Yes (%)	No (%)
100	00	00	100

Figure 4: Water used for concreting

4.1.2 Personnel

From the survey it is found that no supervisor from land owner, no technician and even most cases the labor have been non-skilled for concreting works. During the survey period the skill of labor was observed by the sincerity of works, the techniques adopted by themselves for concrete work and their works. Survey result of personnel is presented in Table 5.

Table 5: Survey result of personnel

Structure Designer				Site engineer			Supervisor from land owner		Technician		Machine Operator		Labor	
P. Engr (%)	B.Sc Engr.(%)	M.Sc Engr.(%)	Diploma Engr.(%)	B.Sc Engr.(%)	Diploma Engr.(%)	No Engr.(%)	Yes (%)	No (%)	Yes (%)	No (%)	Trained (%)	Untrained (%)	Skilled (%)	Unskilled (%)
30	66	2	2	9	77	14	5	95	00	100	00	100	71	29

4.1.3 Equipment

For quality control of concrete production, the equipment is being used for batching; mixing and compaction shall be of the right capacity. Survey results were conducted on equipment is given in Table 6.

Table 6: Survey results of equipments used in concreting

Aggregate crushing at site		Batching			Mixing		Transportation		Compaction	
By hammer (%)	By machine (%)	Steel pan (%)	Tukri (%)	Wooden Ferra (%)	By hand (%)	By machine (%)	By labor (%)	By machine (%)	By manual (%)	By machine (%)
00	100	77	16	7	00	100	71	29	00	100

4.1.4 Workmanship

A mixed concrete of ready mix and on site produced concrete has been used in 60% of the study sites, where on site concrete production is studied in 40% cases. They were mainly used ready mixed for slab and beam, in situ concrete for column. The batching procedure was found commonly volume batching. But an important factor w/c ratio was maintained by the experience of mixer. Curing process of the cast concrete has also been studied where about 80% is found improper. Survey result of workmanship is given in Table 7.

Table 7: Survey result of workmanship

Concrete production type			Test performed to check the strength of ready mixed concrete		Batching type		W/C ratio		Specimen for final testing			Proper curing	
Ready mixed (%)	At site (%)	Mixed of these two (%)	Yes (%)	No (%)	Volume (%)	Weight (%)	By experience (%)	By accurate measure (%)	One test for each floor (%)	One test for whole structure (%)	2 or 3 floor interval (%)	Yes (%)	No (%)
00	40	60	100	00	100	00	100	00	5	83	12	20	80

It is seen that ready mix concrete has been extensively used to cast slab and beam. However, the way of placing and handling of fresh concrete is completely erroneous as shown in Fig. 5.

Figure 5: Slab casting by ready mixed concrete

The quality of in situ concrete was studied during the survey period and the workmanship included in casting column, beam and even slab were observed. The workmanship of in situ concrete is given in Fig. 6.

Figure 6: Slab casting by in situ concrete

The provisions of final testing differ from company to company which is given in Table 7. The specimen was kept for testing mainly cylinder is given in Fig. 7.

Figure 7: Specimen for testing

4.1.5 Formwork

Steel and wooden formwork has been found in the survey project sites as shown in Fig. 8. It is observed that there had no options in each of project that could make the formwork water tight. Removal of the formwork has been done in an improper manner.

Table 8: Survey result of formwork

Type of formwork			Level check		Maintain column in vertical position		Water proofing done		Proper removal of formwork	
Steel (%)	Wooden (%)	Mixed of these two (%)	Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	No (%)
40	31	29	100	00	100	00	5	95	12	88

(a) Wooden Formwork (b) Steel formwork

Figure 8: Typical formwork used at site

V. Conclusion

This study gives understanding of the existing practices for quality control of concrete production in Dhaka city. From the limited scope of present study the following conclusion can be drawn.

(i) No test report for any of the construction materials has been found at any of the project sites visited. Even the construction materials were not stored properly at the project site.

(ii) Few structural design-drawings have been found as designed by Diploma Engineer. Even some of the projects have no site engineer. In most of the projects there is no supervisor from land owner and no concrete technician. Few of the projects were found to have unskilled labor for concreting.

(iii) Almost all of the construction sites maintain their concrete mix ratio by volume batching. The water-cement ratio is maintained from the practical experience of the person concerned. Besides, in most of the projects proper curing of concrete is not followed.

(iv) In most of the project no care is taken for water proofing the formworks for concreting. And early removal of formwork especially those of columns have been found in most of the projects.

VI. Recommendation

The study therefore recommended that:

(i) Concrete Designers/Engineers should specify the concrete materials i.e. water quality, aggregates (grading, shape, maximum size and absorption capacity). In addition important test of cement that is necessary for concrete works.

(ii) The utilization of qualified and experienced personnel right at the top management level to the site manager, supervisors, machine operator, skilled and semi-skilled workers.

(iii) Construction companies should follow relevant standard rules and regulations for concrete works.

(iv) Government at all levels including private sector operators should urgently enforce the implementation of the provisions of the National Building Code (BNBC).

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References

[1]. M.L. Ghambhir. Concrete Technology. Third edition. Tata McGraw-Hill Publishing Company Limited, 2004, New Delhi, India.
[2]. M.S. Shetty. Concrete Technology, Theory and Practice. Multicolor illustrative edition. S CHAND & COMPANY LTD, 2005, New Delhi, India.
[3]. A.M. Neville and J.J. Brooks. Concrete Technology. Third Indian reprint. Pearson Education Limited, 2003, India.
[4]. M.S. Alazhari and M.M.A, Shebani. Quality of Concrete of Recent Development Projects in Libya. World Academy of Science, Engineering and Technology 58, 2011, 817-821.
[5]. A. Sarkar. Quality management in concrete construction. The Indian Concrete Journal, October 2007, 38-41.
[6]. N.M. Anosike. Parameters for good site concrete production management practice in Nigeria. Ph. D Study, Covenant University, OTA, Nigeria, 2011.