

# **Manual on Construction Supervision**

The Project on Improvement of Design and Construction  
Quality for Resilience of Private Buildings (DCQR)



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# Preface

This **Construction Supervision Manual** has been prepared to guide engineers, supervisors, contractors, and stakeholders in maintaining high-quality standards during building construction. With increasing awareness of disaster resilience, fire safety and structural integrity proper supervision has become essential to ensure that all works comply with design documents and the **Bangladesh National Building Code (BNBC)**.

The manual outlines the responsibilities of key parties including Owner, Designer, Contractor, Supervisor and RAJUK also emphasizes the importance of **Quality Assurance (QA)** and **Quality Control (QC)** in every stage of construction. It provides practical guidance on supervision procedures, workflow management, record keeping, and inspection with particular focus on **Reinforced Concrete Construction (RCC)** along with disaster prevention systems.

Through checklists, flowcharts and reference procedures, this manual aims to help site personnel understand, implement and monitor construction activities effectively. By applying these principles, stakeholders can achieve safer, more durable and cost-effective buildings.

It is expected that this manual will serve both as a **technical reference** and a **training tool** for engineers and professionals committed to improving construction quality across Bangladesh.

**By Chairman, RAJUK**

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# Chapter 1 General

## 1.1 Social background in construction work

In recent years, there are expectations for increased awareness of construction quality in order to protect human lives from fires, earthquakes, and other disasters. On-site construction involves using many specified materials and assembling those materials (with some processing as necessary) on-site according to the instructions in the design documents. For this reason, the importance of the respective responsibilities of the contractor and construction supervisor regarding what was constructed and how it was constructed is increasing.

## 1.2 Purpose and importance of Manual Book

This manual aims to contribute to improving construction quality by identifying important construction issues related to building quality, explaining the workflow, how to handle and check materials, and construction supervision procedures, as well as clarifying important issues in construction supervision and the importance of construction records, which explanation points below.

- (a) To clear the basic knowledge for Reinforcing Concrete structure (Herein after called RC structure)
- (b) What is Construction Quality
- (c) How to execute site supervision

Furthermore, Basic knowledge on the building construction will be explained for easy understanding of Building quality and it has been also one objection that site-engineer confirm the necessary technical knowledge and the important points of site-construction.

## 1.3 Scope of the Manual

This manual focuses on the structural work (form work, rebar, concrete) and disaster prevention equipment of RC buildings, and provides reference information on pile work, earthwork, and other ancillary equipment work, but does not cover finishing work or other matters.

## 1.4 Definition of Supervision (on construction process)

Construction quality means ensuring that construction is carried out exactly as required by the design documents. Therefore, construction supervision has two important tasks: to confirm that construction is carried out according to the requirements of the design documents and that materials are handled appropriately, and to record that construction has been carried out in accordance with the requirements of the design documents.

### 1.4.1 Checking of construction of the building as required by design documents

The most important thing in construction is to build a building according to the design drawings, but the requirements written in the design drawings include various instructions such as shape,

material designation (grade, etc.), and how to attach the materials. Furthermore, in order for the various materials delivered to the site to perform as designed, they must be stored and handled appropriately. In other words, one of the important elements of construction supervision is to check the situation at the construction site and give instructions for any necessary improvements so that these are carried out reliably.

#### 1.4.2 Records of how construction was carried out during the building construction process

Recording how construction work was carried out during the building construction process is an important means for the contractor and construction supervisor to demonstrate that their respective tasks were carried out appropriately.

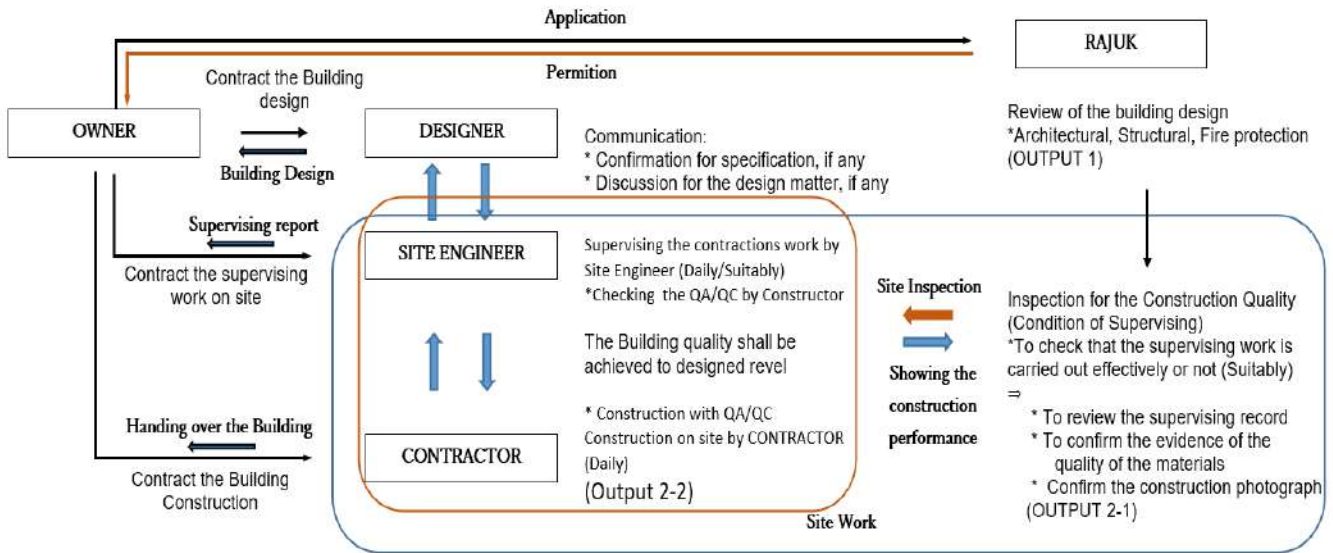
In recent years, not only is there growing awareness of construction quality in order to protect human lives from natural disasters and fires, but when damage occurs in buildings due to disasters, the causes are investigated to prevent such damage from happening again. In other words, investigations are conducted to determine whether building disasters (human damage due to collapse due to earthquakes or fires) were caused by inappropriate design or construction not being carried out as instructed in the design documents. As a result, if contractor and/or supervisor have mistaken, the responsibility of the contractor and construction supervisor is pursued.

### 1.5 Duty of Stakeholder for Building Construction

#### 1.5.1 Role of Quality Assurance/Quality Control, Supervising and Inspection

The chart below shows a relation among RAJUK, Owner, Designer/Consultant and Constructor. (BNBC Part2 Chapter2, Chapter3)

Figure 1-1 "Working Relation" illustrates the relationship between the owner who is going to build a building, the architect who is commissioned by the owner to design the building, the construction company and construction supervisor who actually carry out the construction, and RAJUK, which inspects the overall design and construction content from design to construction. The responsibilities of each of these parties are clearly stated in BNBC Part 2, Chapter 2/Chapter 3



### 1.5.2 Duty on each party for Building Quality

- Duty of Constructor contracted by owner
  - Quality Assurance (Q/A): Methodology for construction with required quality.
  - Quality Control (Q/C): To check construction work following the planned method.
- Duty of Designer and/or Consultant contracted by owner/Supervising
  - To check constructor's activities on site and confirm the construction work followed design document such as drawings, specification and any other designer's instructions and/or construction rules.
- Duty of RAJUK/ Inspection
  - To check the construction work, which going on following applicate design and any other requirements and/or construction rules

**Table 1-1 Object of Inspection by**

**Object of Inspection**

Requester	Executer	Duty	Method/Tool	Report Distination
Owner	Professional body Designer	Design/ Requirement	Checklist/ Measuring	Owner (Instruct to Supervisor)
	Supervisor	Site Supervison/ Checking	Checklist/ Measuring	Owner/Designer (Instruct to Constructor)
	Constructor	QA/QC Concrtuction	Checklist/ Measuring	Owner Supervisor

Especially, Supervising work and construction work are very closely related in each other to achieve a building quality, and it is very important that supervisors cooperate with RAJUK inspector for construction quality as double checking.

	Constructor	Consultant/ Supervisor	RAJUK
Subject/Duty	*Leading of Building construction to complete the construction work with required condition by design document ,and construction rules, regulations, and stipulations.	*Checking of important points on the Building Construction-process *Giving suitable instruction to complete the Building as designed condition, if necessary if any.	*Confirming of the Construction-process and completed condition of The Building, which shall match with the permitted condition.(Controlled by owner)
	Residential Total checking (100%)	Residential/ Periodical Random Checking (Partial)	Suitably Suitably Confirming

Figure 1-1 Duty on each party

## 1.6 Site supervising work

### 1.6.1 Flow-chart of Supervision (including contractor activities)

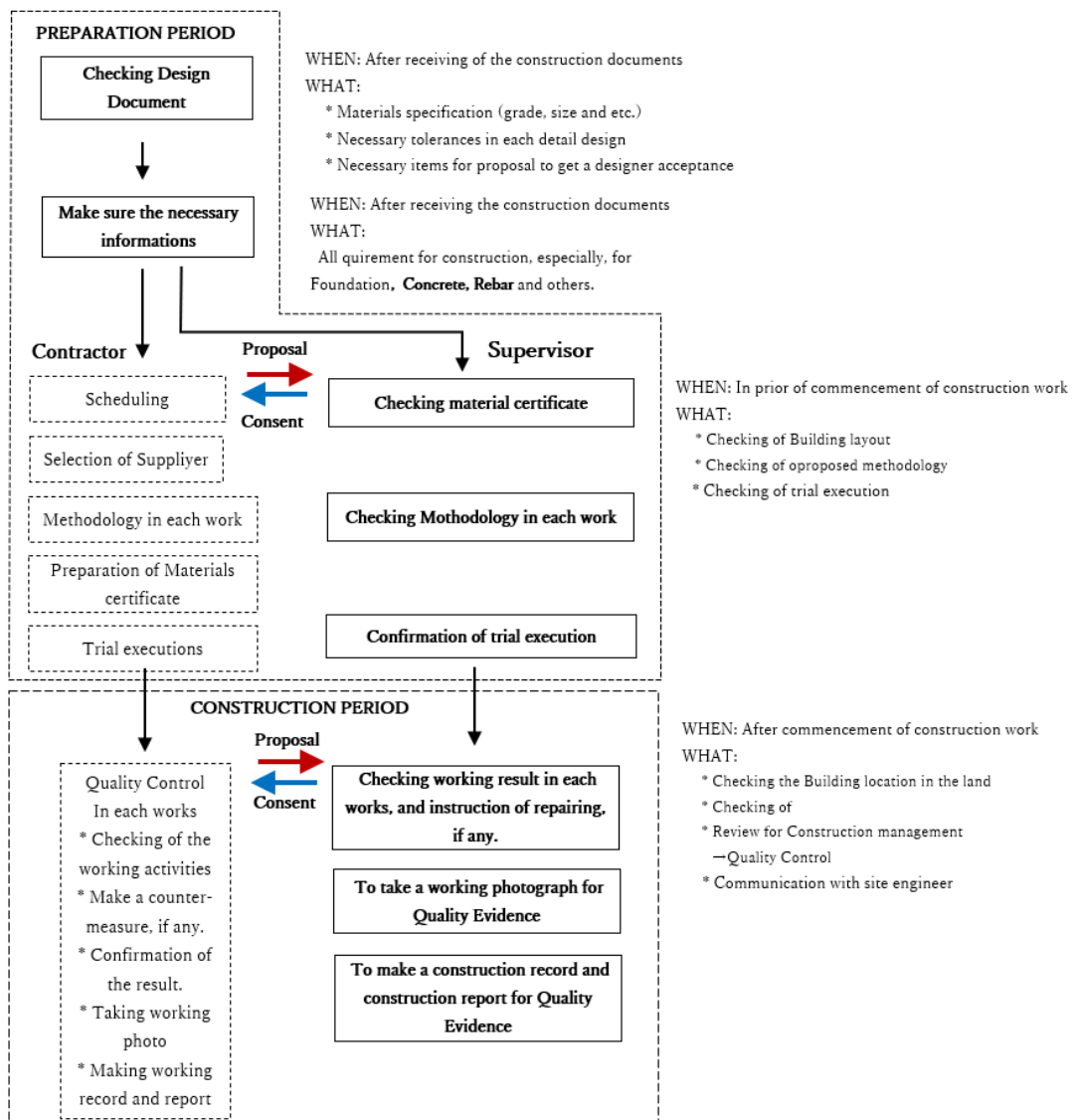


Figure 1-2 Flow-chart for Site Inspection

## 1.6.2 Contents on working flow-chart for supervisor

Supervision will be carried out during construction period on site shown as the above Flow-chart, and that each step will be explained as follows.

### 1.6.2.1 Preparation period

The supervisor will check the issued design document to confirm the required points that need to achieve the required building quality, which points are shown below.

#### 1) Checking design documents

The following information has been described in design documents so that all information shall be confirmed prior to commencement of construction work.

- a) Required specifications of material: Reber grade, Rebar size in each part, Concrete strength, Allowable chemical additives, Water-cement ratio, Maximum aggregate size, Water quality for mixing concrete and other required points.
- b) Required value, and Allowable range of construction errors (Tolerance): Rebar anchorage length, Raber lapping position and length, Deviation and bent in each part, and others.
- c) Items to be get permission: Standard axis, Setback position, Concrete mixing ration and others

#### 2) Ensuring the necessary information for construction

All special requirements by design documents shall be checked prior to commencement of construction, some of which are below.

- a) Depth of bearing layer and capacity: it is very important information for foundation works.
- b) Country of origin of rebar: when rebar is imported or purchased imported material, it shall be checked, which shall be get a permission from designer to designer.
- c) Sampling lot for rebar tensile test, concrete compressive test and any other required test: Which sampling lot for rebar tensile test, concrete compressive test and any other required test shall be conformed to designer prior to commencement of construction.
- d) Required documents to be submitted: Test report, material certificate, construction photograph and report and any other necessary document shall confirm to designer in prior to commencement of construction.

#### 3) Checking material certificate

The construction materials shall be confirmed to match the design required, and that the material certificate and/or equivalent documents shall be submitted to the designer. The main items are below.

- a) Rebar: mile sheet and/or tensile test report
- b) Cement for concrete
- c) Ready mixed concrete

- d) Aggregate, sand and backfilling materials
  - e) Other materials shipping certificate, delivery slip and others
- 4) Checking methodology in each work
- In prior construction work, methodology in each work shall be planned and supervisor check it and then had better to give consent to carry out construction work correctly as Quality Assurance. The items for the working procedure needed to prepare are shown below.
- a) Piling work (Method, arrangement of piling area, piling sequence and others)
  - b) Earth work (Working sequence, excavated depth, compaction method, and so on)
  - c) Rebar work (Bending and assembling)
  - d) Form-work (Shuttering design, shoring plan)
  - e) Casting concrete (Arrangement of concrete pump, casting route, method of vibrating and tamping, sampling test piece and so on)

5) Confirmation of test execution

Test execution for construction work will be carried out to check the planned procedure which will be suitable and/or unsuitable. The popular test executions are below.

- a) Test piling: Test piling will be carried out to check the exact piling length and bearing capacity.
- b) Concrete mixing test: Concrete test mixing will be carried out to check that it has been able to achieve designed concrete strength by the planned mixing ratio, which mixed concrete would be tested the compressive strength after 28 days later at the test mixing, therefore it shall be carried out with plenty of time to apace for actual concrete work.

And it is suitable to keep construction quality that test execution for other works would be also carried out to conform the workability, especially, compacting method for backfilling soil and filling soil, and gravelling work for sub-base are very reasonable to keep construction quality.

#### 1.6.2.2 Construction Period

During construction time, the contractor shall check every construction behavior and the result as Quality Control. And if the result of the construction work does not match the required conditions by design document, the procedure should be replanned to get a correct condition. In the other hand, Supervisor shall check that the quality control by the contractor has been effective or ineffective and give instruction to contractor timely. Furthermore, the Supervisor had better to request the contractor to make a construction report and to submit it to confirm the constructed condition totally.

1) Checking the working result in each work, and of repairing, if any

The contractor should check that the constructed result has matched the required points by design documents and make a record. And the supervisor would confirm the record, and that some items shall be rechecked by the supervisor at random. When the supervisor has found

the unsuitable result, Instruction of the repair and/or any countermeasure will be issued. The major checking items are below.

- a) Actual position of standard axis line for building set-back
  - b) Re-bar work: Rebar size and number/pitch at each part, Concrete cover size, Space of between rebars, Splicing position and length, Anchorage position and length, bending style and hook, setting condition of rebar (in level and straightness), and so on.
  - c) Form-work: Strength of shoring system, Strength of form-work system (shuttering panel and support materials), Position of form-work system, Setting level for form-work system, Bending of form-work system, straightness of beam form-work, Plumbing of column form-work, Dimension of form-work in each position, and so on.
  - d) Concreting: Casting sequence, casting condition, Method of vibrating and tamping, Concreting time after mixing concrete Curing style, and so on.
- 2) To take a working photograph of Quality Evidence
- Constructed conditions, especially for structural bodies such as rebar arrangement, concrete cover size and/or concrete casting action, cannot check after concreting, therefore, **those important construction activities had better be taken photographs to prove later** that they had been carried out suitably. The important construction activities are shown below.
- a) Rebar arrangement such as size, number, pitch and others
  - b) Rebar setting conditions such as bent, twist and others
  - c) Splicing and anchorage position and those length
  - d) Concrete coverage size
- 3) To make a construction record and construction report for Quality Evidence
- Contractors should make a construction report to show their construction work suitable, which would prove their correct quality control and achievement of required condition by design documents, and the supervisor would confirm the report. The contents of the report are as follows.
- a) Each dimension in the structure
  - b) Material certificates such as mill sheets, shipping certificates, ingredients, and others.
  - c) Test reports such as Concrete mixing plan, concrete test on site (flow, slump, and air content), and Concrete crushing test, rebar tensile test, and any other tests required by designer.
  - d) Construction photographs
  - e) Site checking/measuring report such as set-back distance, each dimension of column, beams and others, installed rebar pitch, number and size, and others

### 1.6.2.3 Importance of supervisor

Despite the social background regarding buildings mentioned at the beginning of the book, except for some forward-thinking owners and contractors, there are still many areas to be

improved in the construction quality of buildings in Dhaka city. Even if the designer designs the building appropriately, if the contractor does not reliably materialize it, the performance intended by the designer will not be realized. Therefore, the role of the construction supervisor is becoming more important. The construction supervisor needs to cooperate with the contractor as well as the RAJUK inspector to improve the construction quality of the building. The tasks that the construction supervisor needs to carry out are wide-ranging, but the representative tasks are as follows, the details of which will be described later chapter.

- a) Making sure requirements by design-documents
- b) Support for Quality Assurance and Quality Control
- c) Attending daily activity (Checking and Instructions, if any)
- d) Confirmation of construction tests
- e) Making Supervising report

In any case, it is essential that the owner, including the contractor, fully understands the content and that the construction inspection is carried out in close cooperation with RAJUK. The key point for improving the construction quality of all buildings is to correctly recognize that by ensuring appropriate construction quality, the owner can ensure that the value of the building is commensurate with the construction costs.

## 1.7 Suitable building quality and Owner's gain

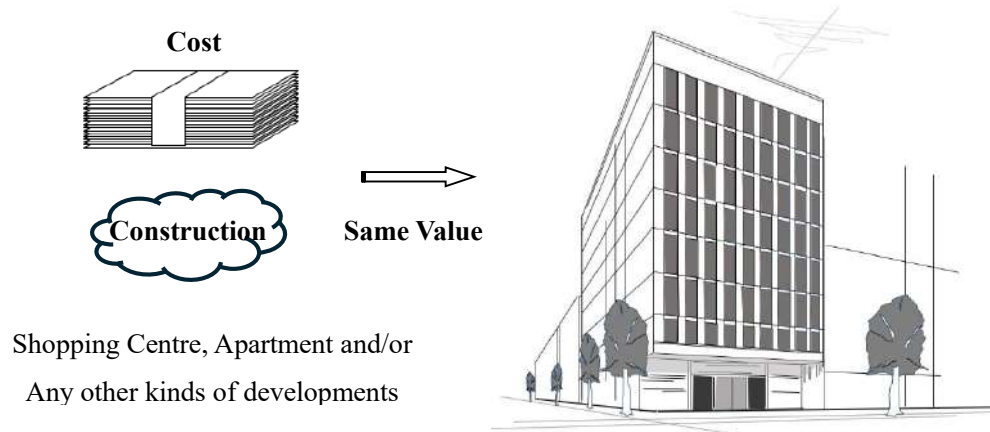
### 1.7.1 The importance of appointing a construction supervisor and selecting an appropriate contractor

If an owner builds a building of the quality intended by the designer based on the BNBC regulations, he or she must entrust the construction to a contractor who can understand the design documents and ensure appropriate construction quality and must directly hire a construction supervisor and/or enter into a contract to entrust supervision to a construction supervision company. This is, of course, the basis of the actual construction, but even today there are many cases which deduct the cost of such appropriate supervision in reduced costs, resulting in the construction of low-quality buildings that do not achieve the planned quality. The owner cannot check the building after completion, even if the builder did not understand the important points of the architectural design. The role of the construction supervisor is to check and instruct the builder to ensure that the items required in the design documents are carried out at each stage of construction to prevent quality deterioration due to mistakes or carelessness during construction.

Furthermore, the building builder needs to understand that he is expected to improve his own technical knowledge, fully understand the designer's intentions, and construct the building as required in the design documents.

### 1.7.2 Contribution for Owner's gain as construction supervisor

Needless to say, it takes a lot of money and time for an owner to construct a building. It is important to complete a building of a quality that is commensurate with the time and money spent on construction without wasting these expenses and time. To achieve this goal, it is essential to select a contractor with excellent construction techniques and appoint a construction supervision engineer, and there are many benefits when considering the cost-effectiveness.



#### 1.7.2.1 Same value/ Cost-effectiveness

Buildings designed by design engineers and permitted by RAJUK would be guaranteed to be durable and safe against fires and other disasters. In other words, a building can function only when it is constructed as designed. The cost of constructing a building is calculated based on the design documents and the construction management costs, but if the building is not constructed according to the design documents and has a shorter service life than the design conditions, or is more vulnerable to fires and earthquakes than it was designed to be, the quality of the building cannot be said to be worth the construction costs. Even if a building is ordered at a cost calculated based on the design documents, if proper construction management is not performed, there is a concern that the building will not be worth the construction costs. To avoid such a result, owners need to include construction management costs in the construction costs. Construction managers play an important role in this type of construction quality.

#### 1.7.2.2 Construction situations that affect building quality

The design documents specify the shape of the building, the size and number of rebars required, detailed structural information such as tensile strength, and specifications for building materials (for example, the specified strength of concrete to be used and the type of foundation piles). Of course, construction must be carried out in accordance with these design requirements, but the quality of the building constructed also depends on the handling of materials and construction methods at the construction site in addition to the matters

specified in the design documents.

The on-site tasks that have the greatest impact on quality are as follows:

- a) Concrete mixing (Especially site mixing): Measuring method for the materials), mixing time and to refrain from any contaminations
- b) Stock condition of concrete materials such as cement, aggregates, and fine aggregates (chemical additives, if any)
- c) Handling of rebar: To refrain from rust, muddy dirt, oil adhesion, bend, twist and any other damages
- d) Condition of form-work materials: sufficient strength, free from damage such as peel, twist, scratch, and others
- e) Arrangements of rebar: Size, number, pitch, anchorage and lapping position and length, concrete coverage, and to refrain from bent twist and curve
- f) Condition of constructed form-work: Each dimension, straightness, flatness, in level, sufficient strength of shuttering panel, sufficient strength of shoring system to refrain from dirt
- g) Concreting: concrete sequence, concreting times, pouring condition of concrete, tamping and vibration method, treatment for construction joints, and so on.
- h) Curing conditions: To refrain from impact in initial, suitable period when formwork remains in place, and to keep wet condition.

The above point is shown on concrete work, rebar work and form-work only, so that there are many important points in the other work.

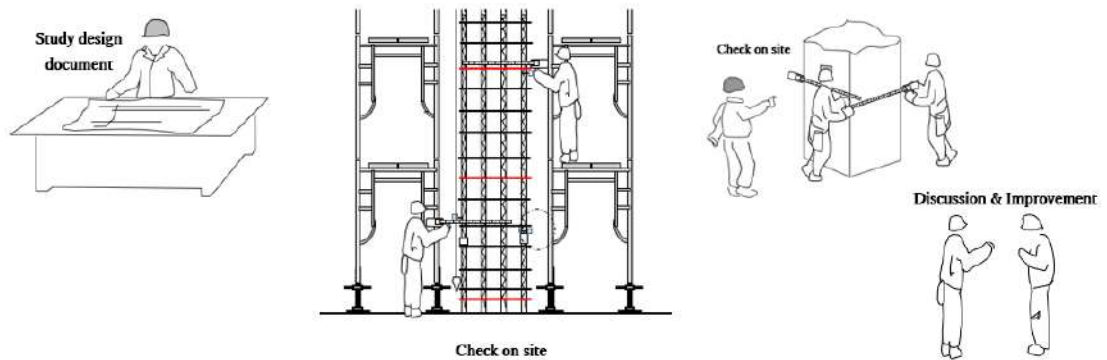
Contractors shall execute construction works considering the above points to keep a building quality, thus supervisor has to check the working progress and issue some instructions to lead the work to suitable working result.

#### 1.7.2.3 Working duties of construction supervisors at construction sites

The duty of the supervisor is to check on site the materials and/or working activities instead of the owner, and issue instruction, if any, to the contractor to avoid any loss of construction quality.

if any, which is quite reasonable for Owner to keep a good cost-effectiveness and construction terms. The important checking points are shown below.

- a) Checking construction procedure
- b) Checking daily activities on site
- c) Construction result on site
- d) Join and check some required tests by design documents
- e) Checking construction report.
- f) Making supervision report



Furthermore, the construction supervision is as the above, those points are quite important Construction quality, and those points seriously impact structural safety. and also, mistakes would seriously impact construction time, which give damage to owner.

Especially, supervision reports are quite important to prove suitable construction work for contractors, supervisors, and owners.

## Chapter 2 BASIC POINT ON BUILDING QUALITY

When supervisor is carried out their duties to achieve the required quality, the basic knowledge for building construction is very important to judge the construction condition, to instruct the contractor, and to communicate with inspector. Therefore, the point of basic technical points herein would be explained.

### 2.1 Basic point of Reinforced Concrete Structure

Reinforced concrete structure (hereinafter referred to as RC structure) nowadays is highly versatile construction style, which reasons why RC structure is a standard structural style for which materials are easy to obtain and can be easily processed on site. And there are some basic technical matters of RC structure, and understanding these points is useful for understanding the factors that affect the quality of construction. We will explain these points here.

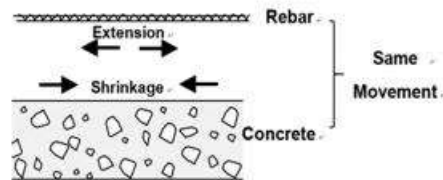
#### 2.1.1 High-processible

RC structures are constructed on-site by assembling the forms for columns, beams, slabs, and other components, arranging rebars of the size and quantity confirmed by structural analysis, and pouring ready-mixed concrete into the framework. For this reason, the condition of the rebars arranged inside the framework and condition of pouring concrete are important.

### 2.1.2 A structure made of two types of materials.

RC structures are made up of two types of materials, reinforcing bars (herein called later “rebar”) and concrete, which have similar linear expansion coefficients under normal conditions, so they can move together in response to temperature changes and do not behave separately. This is why they can function as a single component.

Those two kinds of materials have their own duty, which concrete is shared to bear compression, and reinforced bar share the tensile force.



**Figure 2-1 Linear Expansion Coefficient**

### 2.1.3 Considerations of construction quality based on basics of RC construction

Based on the basic RC construction format described above, in addition to ensuring the size and quantity of rebar as per the design drawings, it is important to pay attention to the construction point of ensuring the adhesion between the rebar and concrete. However, construction work on site has several situations to disturb the bonding strength between concrete and rebars. There are various factors that hinder the adhesion between steel and concrete, and supervisors shall recognize surely the factor and supervise on site. In each point will be explained later.

## 2.2 Concrete and Steel bar

### 2.2.1 Concrete

#### 2.2.1.1 Raw materials for concrete

Concrete consists of aggregate, fine aggregate (sand) and cement, and some chemical additives are added to improve the performance to match its use condition.

It is basic point that concrete would be produced by hydrating cement reaction, therefore, the mixing ratio of the composition such as cement, fine aggregate, aggregate, water and some chemical additives is very important. Concrete materials have been stipulated on BNBC Part 5 chapter 2/Building Materials, clause 2.3 “Cement and Concrete” as the below.

## **2.3 Cement and Concrete**

### **2.3.1 General**

Materials used to produce concrete, and admixtures used for concrete shall comply with the requirements of this Section and those of Chapter 5 Part 6 of this Code.

### **2.3.2 Aggregates**

Concrete aggregates shall conform to the following standards:

BDS 243: 1963, Coarse and Fine Aggregates from Natural Sources for Concrete; ASTM C33/C33M Concrete Aggregates; ASTM C330/C330M Lightweight Aggregates for Structural Concrete; ASTM C637 Aggregates for Radiation-Shielding Concrete; ASTM C332 Lightweight Aggregate for Insulating Concrete; IS: 9142 Artificial lightweight aggregates for concrete masonry units.

#### **2.3.2.1 Special tests**

Aggregates failing to meet the specifications listed in Sec 2.4.2 shall not be used unless it is shown by special test or actual service experience to produce concrete of adequate strength and durability and approved by the Building Official.

#### **2.3.2.2 Nominal size**

Nominal maximum size of coarse aggregate shall not be larger than:

- (a) One-fifth of the narrowest dimension between sides of forms; or
- (b) One-third the depth of slabs; or
- (c) Three fourths the minimum clear spacing between individual reinforcing bars or wires, bundles of bars, or pre-stressing tendons or ducts.

Exception:

The above limitations regarding size of coarse aggregate may be waived if, in the judgment of the Engineer, workability and methods of consolidation are such that concrete can be placed without honeycomb or voids.

### **2.3.3 Cement**

Cement shall conform to the following standards: BDS EN 197-1:2003 Cement Part-1 Composition, specifications and conformity criteria for common cements, BDS 612 Sulphate resisting Portland cement-type A, ASTM C150/C150M Standard Specification for Portland Cement, BDS 232 Portland cement, ASTM C595/C595M Blended Hydraulic Cements, and to other such cements listed in ACI 318.

### **2.3.4 Water**

Water used in mixing concrete shall be clean and free from injurious amounts of oils, alkalis salts, organic materials or other substances that may be deleterious to concrete or reinforcement. Water shall conform to the following standards: BDS ISO 12439:2011 Mixing water for concrete.

#### **2.3.4.1 Chloride ions**

Mixing water for pre-stressed concrete or for concrete that will contain aluminium embedment, including the portion of mixing water contributed in the form of free moisture on aggregates shall not contain deleterious amounts of chloride ion. The maximum water-soluble chloride ion concentration in concrete shall not exceed the limitations specified in Sec 5.5.3 Part 6.

#### **2.3.4.2 Potability**

Nonpotable water shall not be used in concrete unless the following are satisfied:

- (a) Selection of concrete proportions shall be based on concrete mixes using water from such source.
- (b) Mortar test cubes made with non-potable mixing water shall have 7 days and 28 days strengths equal to at least 90 percent of strengths of similar specimens made with potable water.

In addition to the above description, BNBC has stipulated the admixtures such as Chloride, Standards, Pozzolans, Blast furnace slag and Pigment for colored concrete.

Basically, these points have been considered by design terms, therefore the required materials grade has been checked at site.

Again, The Public Works Department (PWD), which is mainly responsible for public buildings in Bangladesh, has established “Book of Specifications”, which has described for concrete materials as shown in the table below (For reference).

**Book of Specifications (Compiled by PWD) Part 2,  
Table 2.1 Composition of cement**

Main types	Notations	Composition (Percentage by mass)										
		Main Constituents									Minor additional Constituents	
		Clinker (K)	Blast Furnace slag(s)	Silica Fume	Pozzolana Natural	Pozzolana Natural calcined (Q)	Fly ash siliceous (V)	Fly ash Calcareous (W)	Burnt Shell (T)	Limestone (LL)		
CEN-I, 52.5N	Portland Cement	95-100%	-	-	-	-	-	-	-	-	0-5%	
CEN-II, A-M, 42.5N	Portland Composite Cement	80-94%	←			6-20%					→	0-5%
CEN-II, B-M, 42.5N	Portland Composite Cement	65-79%	←			21-35%					→	0-5%

**Book of Specifications (Compiled by PWD) Part 2,  
Table 2.2 Mechanic and Physical properties given as characteristic**

Strength Class	Compressive Strength (Mpa)			Initial setting time min.	Soundness (Expansion)
	Early strength	Standard strength			
52.5N	≥20	≥52.5	-	≥45	≤10
42.5N	≥10	≥42.5	≤62.5	≥60	≤10

**Book of Specifications (Compiled by PWD) Part 2  
Table 2.3 Grading requirements of fine aggregates as per ASTM C33 and AASHTO M6**

Sieve designation ASTM E11	Percent passing (ASTM C33 Spec.)
No. 4 (4.75mm)	95-100
No. 8 (2.36mm)	80-100
No.16 (1.18mm)	50-85
No.30 (0.60mm)	25-60
No.50 (0.30mm)	5-30 (AASHTO 10-30)
No.100 (0.15mm)	0-10 (AASHTO 2-10)

**Book of Specifications (Compiled by PWD) Part 2**  
**Table 2.4 Grading requirements for sand of FM  $\cong$  1.2**

Sieve designation ASTM E11	Percent finer by weight
No. 4 (4.75mm)	100
No.16 (1.18mm)	95-100
No.50 (0.30mm)	60-80
No.100 (0.15mm)	25-30

**Book of Specifications (Compiled by PWD) Part 2**  
**Table 2.5 Grading requirements for 19 mm downgraded**  
**Coarse aggregate (stone chips) ASTM C33**

Nominal Sizes	Percent passing by weight US standard sieve having square opening							
	1 · 1/2" (37.5mm)	1" (25mm)	3/4" (19mm)	1/2" (12.5mm)	3/8" (9.5mm)	No.4 (4.75mm)	No.8 (2.36mm)	No.16 (1.18mm)
19-4.75mm (3/4"-No.4)	-	100	90-100	-	20-55	0-10	0	-
12.5-4.75mm (1/2"-No.4)	-	100	100	90-100	40-70	0-15	0-5	-
9.5-4.75mm (3/8"-No.4)	-	100	100	100	95-100	10月30日	0-10	0-5

#### 2.2.1.2 Mixing proportion of the compositions

It should be designed carefully following rules, regulations, and structural design. Especially cement-water ratio will influence the mixed concrete such as workability and/or other character, which is as shown on the below table simply.

**Table 2-1 Impact of Proportion of Cement and Water**

Material	Proportion	Character of Produced concrete
Cement	High	<ul style="list-style-type: none"> <li>◆ Strength will be higher</li> <li>◆ Fluidity is going down→Workability for casting will be worse</li> </ul>
Water	High	<ul style="list-style-type: none"> <li>◆ Fluidity is going up→Workability for casting will be better.</li> <li>→Workability for tamping will be worse.</li> <li>◆ Shrinkage factor will be bigger→ Appearance of the shrinkage crack will be easier</li> </ul>

Needless to say, the quality of fine aggregate and aggregate was very important also.

## 2.2.2 Rebar

### 2.2.2.1 Characteristics of Rebar

The form of rebar is thin and long, therefore, if Rebar is affected by compressive force, Rebar will buckle as below sketch.

The compressive force will affect Rebar as bending force, and it will buckle easily, which is caused by slender form.

In the other hand, when the tensile force effects on the bent Rebar, which would become straight easily without resistance, and then rebar would be able to resist against the tensile force after back to original condition. Therefore, the bent rebar does not have any resistance against tensile force.

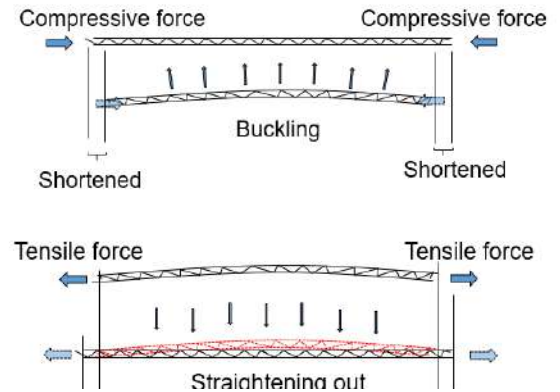


Figure 2-2 Movement of Rebar

### 2.2.2.2 Requirements by BNBC

The material specifications for reinforcing bars and welded steel wire are stated in Part2, BNBC as follows:

#### 2.3.6 Metal Reinforcement

Reinforcement and welding of reinforcement to be placed in concrete shall conform to the requirements of this Section.

- (a) Deformed Reinforcement: Deformed reinforcing bars shall conform to the following Standards; BDS ISO 6935-2:2010, Steel for the reinforcement of concrete-Part-2: Ribbed bars; Reinforcement conforming to the ASTM, Standards: A615/A615M Deformed and Plain Billet-Steel Bars; A616M, Rail-Steel Deformed and Plain Bars; A617M Axle-Steel Deformed and Plain Bars; A706M Low-Alloy Steel Deformed Bars; A767M Zinc Coated Deformed reinforcing bars with a specified yield strength  $f_y$  exceeding 410 MPa may be used, provided  $f_y$  shall be the stress corresponding to a strain of 0.35 percent and the bars otherwise conform to ASTM standards noted above. Fabricated deformed steel bar mats conforming to ASTM A184/A184M and deformed steel wire complying with ASTM A496/A496M may be used. Deformed wire for concrete reinforcement shall not be smaller than size D4 (nominal diameter: 5.72 mm), and for wire with a specified yield strength,  $f_y$  exceeding 410 MPa,  $f_y$  shall be the stress corresponding to a strain of 0.35 percent.

Welded deformed steel wire fabric conforming to ASTM A497/A497M may be used; for a wire with specified yield strength  $f_y$  exceeding 410 MPa,  $f_y$  shall be the stress corresponding to a strain of 0.35 percent. Welded intersections shall not be spaced farther apart than 400 mm in direction of calculated stress, except for wire fabric used as stirrups.

- (b) Plain Reinforcement: Plain reinforcement shall conform to the following BDS and ASTM Standards. BDS ISO 6935-1:2010; ASTM A615/A615M; ASTM A996/A996M and ASTM A996/A996M. Steel welded wire, fabric plain reinforcement conforming to ASTM A185/A185M may be used, except that for wire with specified yield strength  $f_y$  exceeding 410 MPa,  $f_y$  shall be the stress corresponding to a strain of 0.35 percent. Welded intersections shall not be spaced farther apart than 300 mm in direction of calculated stress, except for wire fabric used as stirrups.

Smooth steel wire conforming to ASTM A182/A182M may be used in concrete; except that for a wire with specified yield strength  $f_y$  exceeding 410 MPa,  $f_y$  shall be the stress corresponding to a strain of 0.35 percent.

- (c) Cold-worked Steel Reinforcement: Cold-worked steel high strength bars shall conform to IS 1786 or BS 4461: 1978.
- (d) Pre-stressing Tendons: Wire, strands and bars for tendons in pre-stressed concrete shall conform to BDS: 240 Plain cold drawn steel wire; ASTM A416/A416M Steel Strand Uncoated Seven-Wire Stress Relieved; ASTM A421/A421M: Uncoated Stress Relieved Steel Wire; and ASTM A722/A722M: Uncoated High-Strength Steel Bar.

Wires, strands and bars not specifically listed in the above standards may be used, provided they conform to minimum requirements of these specifications and do not have properties that make them less satisfactory than those listed.

bars in composite compression members meeting the requirements of the Code shall conform to ASTM A36/A36M Structural Steel; ASTM A242/A242M High Strength Low-Alloy Structural Steel; ASTM A572/A572M High-Strength Low-Alloy Columbium-Vanadium Steel; and ASTM A588/A588M High-Strength Low-Alloy Structural Steel.

Steel pipe or tubing for composite compression members composed of a steel-encased concrete core meeting the requirements of this Code shall conform to ASTM A53/A53M Pipe, Steel, Black and Hot Dipped Zinc Coated Welded and Seamless; ASTM A500/A500M Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes; and ASTM A501 Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.

Again, The Public Works Department (PWD), which is mainly responsible for public

buildings in Bangladesh, has established “Book of Specifications”, which has described for reinforcing materials and welded wire as shown in the table below (For reference).

**Book of Specifications (Compiled by PWD) Part 2**  
**Table 2.7 Chemical composition based on cast analysis-**  
**maximum values of mass fraction inpercentage**

Steel Grade	C	Si	Mn	P	S	N <sub>c</sub>	CEV <sub>d</sub>
B300D-R	-	-	-	0.050	0.050	-	-
B300DWR	0.27	0.55	1.50	0.040	0.040	0.012	0.49
B420DWR <sup>a</sup>	0.30	0.55	1.50	0.040	0.040	0.012	0.56
B500DWR	0.32	0.55	1.80	0.040	0.040	0.012	0.61
B500CWR	0.22	0.60	1.60	0.050	0.050	0.012	0.50

<sup>a</sup> Example: B420DWR

B=Steel for reinforcement

420=Specified characteristics value of minimum upper yield strength;

D=Ductility class, value of the ratio of tensile strength to yield strength; here it is 1.25

W="W" means intended for welding, without "W" means not intended for welding. Steel grade B420DWR is Weldable.

R=Ribbed bar

<sup>c</sup> A higher mass fraction of nitrogen may be used if sufficient quantities of nitrogen- binding elements are present.

<sup>d</sup> Other CEV values and formulae may be used by agreement between the manufacturer and purchaser.

**Book of Specifications (Compiled by PWD) Part 2**  
**Table 2.8 Tensile properties of Rebars**

Ductile Class	Steel Grade	Specified Characteristic value of upper yield strength $R_{eH}$ MPa <sup>c</sup>		Specified Characteristic value of $R_m / R_{eH}$	Specified characteristic value of elongation %	
		Minimum	Maximum	Minimum	$A_a$ Minimum	$A_{gt}$ Minimum
C	D500CWR	500		1.15	14	7
D	B300D-R	300	1.30 x $R_{eH}$ (Min)	1.25	10 <sup>b</sup>	8
	B300DWR					
	B400DWR	400				
	B420DWR	420				
	B500DWR	500				
					16 <sup>b</sup>	
					13 <sup>b</sup>	

$R_{eH}$ = Upper yield strength Mpa,  $R_m$ =Tensile Mpa; A= Percentage of elongation after fracture;  $A_{gt}$ = Percentage of total elongation at minimum force.

<sup>a</sup> by agreement between the manufacturer and purchaser, the type of elongation shall be selected between  $A$  and  $A_{gt}$ . If the type of elongation is not specified by agreement,  $A_{gt}$  should be used.

<sup>b</sup> in case of the bars with diameter 32mm or more in ductility class D, the minimum characteristic value for  $A$  may be decreased by 2% for each 3mm increase in diameter. However, the maximum diminution from the minimum specified characteristic value stated in Table 2.8 is limited 4%.

<sup>c</sup> 1Mpa= 1N/mm<sup>2</sup>= 145.038 psi

### 2.2.3 Function of Rebar and Concrete in RC structure

Rebar and Concrete have their own characteristic on RC structure due on its function and that Rebar and Concrete have a merit and demerit as a material for Building structure.

Basically, Steel and concrete have a similar compressive strength in same cross section, however, in the case of the same volume, steel weight is quite heavier than concrete, and it is better not to be heavy for structural material because of deduction of dead loads.

In the other hand, tensile strength of concrete is approximately  $1/10\sim 1/13$  of compressive strength and steel bar has a same strength on tensile and compressive.

In short, Steel bar will be suitable to bear the tensile stress on Building and Concrete will be suitable to bear compressive stress, which is merit for each material.

In the other hand, Rebar is sensitive to rust, which disturb an adhesion and the rebar strength. Furthermore, Concrete is generated by hydration reaction from a cements, waters, aggregates, fine aggregates and other additive materials, therefore Concrete quality depends sensitively on mixing and pouring works. These are demerits of concrete and rebar. Therefore, Supervisor shall check carefully the working conditions on concrete work and rebar work considering the following points.

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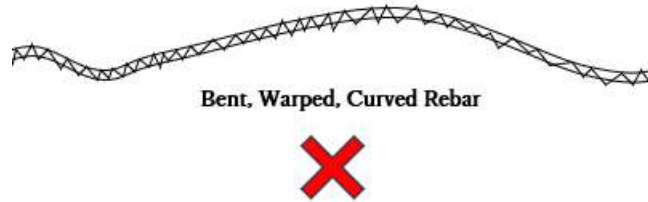
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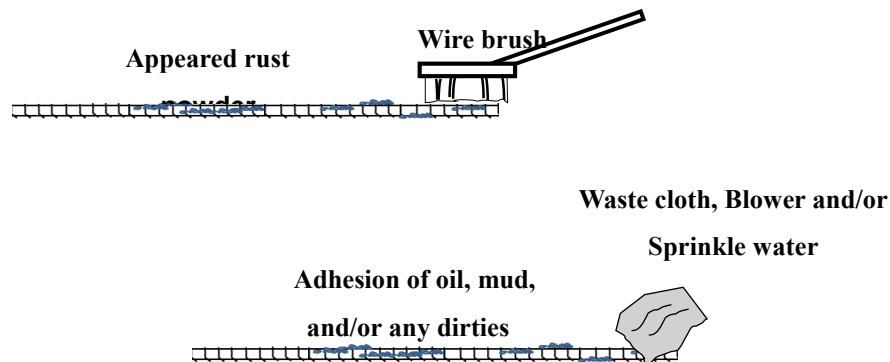
As the previous explanations, Rebar has several characteristics which influenced construction quality as the following points.

- a) Rebar shall be straight to bear the tensile force, which means it shall be stored and handled keeping straight condition avoiding bent, twist and curve.



- b) Rebar of condition to be disturbed suitable adhesion with concrete shall not use such as rust, muddy and oily.

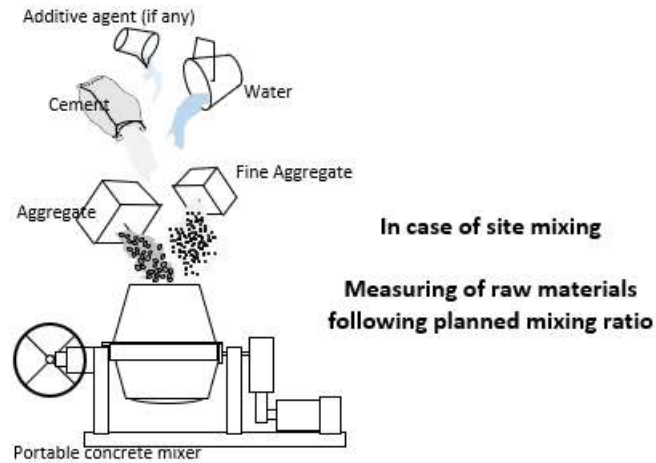
Therefore, Rebar should store refraining from rust, which means rebar should not touch with ground and protect from rainwater and other materials to corrosion such as covering with plastic sheet and others. If rust is found on the reinforcing bars, be sure to remove the rust on the surface of the bars using a wire brush or similar before using them, and clean up the rebar removing adhered muddy, oil, and others.



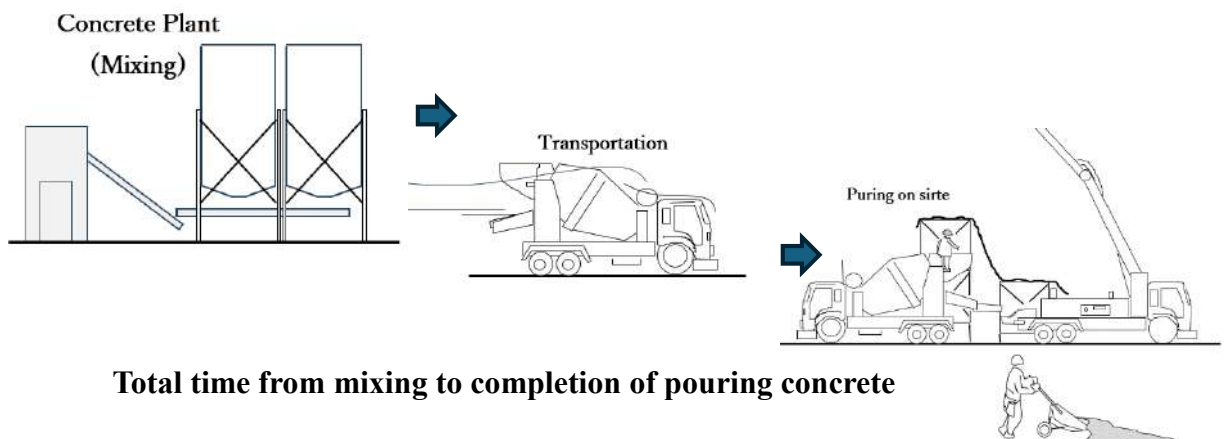
#### 2.2.3.1 Consideration points on concrete work

In the same as rebar materials, Concrete also has a characteristic which influenced construction quality as the following points.

- a) Concrete mixing must be done according to a pre-planned mix plan. Construction supervisors must strictly check the mix records for ready-mixed concrete, and the measuring methods and mixing times for on-site mixed concrete. In particular, the water-cement ratio of concrete has a significant effect on its properties, so it is important never to use more water than planned when mixing at the discretion of the site, or to add additional water to the concrete after mixing.



- b) The hydration reaction of concrete begins in 2 to 5 hours and appears as a hardening of the surface. When pouring two or more layers of concrete, it is said that in order for the upper and lower layers to become one, normally, pouring of the concrete must be completed within 120 minutes of mixing at 25 degrees Celsius, or within 90 minutes of mixing at temperatures above 25 degrees Celsius. To this end, the construction supervisor must confirm with the contractor the pouring plan, including the time required to transport the concrete from the concrete plant to the site, the time required to transport the concrete around the site and the pouring method, so that the concrete pouring can be completed within the appropriate time after mixing is finished, and consider whether the work can be completed within the appropriate time.



### 2.3 Building Quality

The quality of a building depends on constructing it in accordance with the design specifications, material grades, and specifications outlined in the design documents. In addition, the following points are particularly important in construction in terms of protecting the lives and property of the building users:

- Building lifespan
- High Usability (Reasonable Planning, Maintenance Free, Comfortable Space, etc.)
- User's Safety  
Especially, User's Safety is the first priority of Building Quality, because it directly impacts to User's life. And it is classified into two points. Herein the two points will be explained.

### 2.3.1 Quality of Building 1 (Structural Strength)

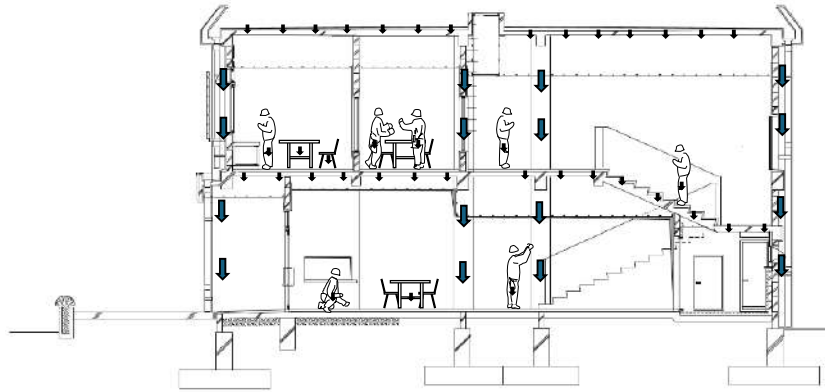
Building shall have an enough strength to keep a user safety, which means that Building will not be damaged by natural phenomenon such as storm and/or earthquake, and also it shall not be any damaged under normal usage of the facility. Therefore, the Safety of the Building structure shall be confirmed the safety against external force such as dead weight/dead load and live load by structural calculation.

Furthermore, the building strength will archive the designed lifetime with reasonable maintenance, and that a performance of construction work on site will influence to the Building strength seriously as previously mentioned, specially Building lifetime, Subject of Supervisor is to support the construction work checking the executed conditions and issue instructions to contractor, if any.

Two forces act on a building, horizontal and vertical, called horizontal and vertical loads. It is important that the building has sufficient resistance to these forces. For this reason, the size and amount of rebar required, as well as the concrete strength required, are confirmed by the structural design and shown in the design drawings, so that it goes without saying that it is important to carry out construction according to the drawings. In the other hand, the forces acting on the building are not evenly distributed on each part of the building, such as the floors, beams, and columns, and depending on the composition of the building, there are some parts that are greatly affected by the forces acting on the building and some parts that are not. There is no doubt that each part is important to the strength of the building, but it is very useful for the Contractor to imagine which parts of the building are particularly affected by the forces in order to carry out construction properly.

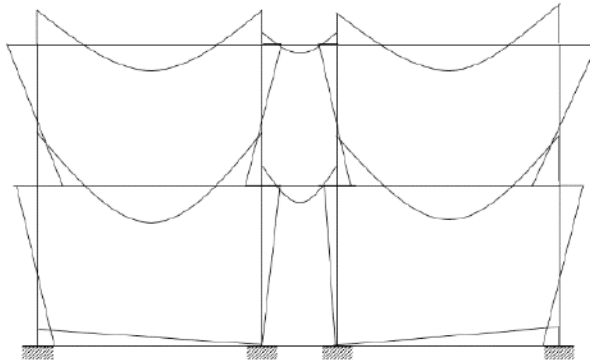
#### 2.3.1.1 Vertical loads on the Building

Dead weight which is such as concrete, rebar, mortar, and any other finishing materials, and live load which means Live load includes the number of people using the building and the weight of equipment installed inside the building when it is in use. have affected the structural frame as vertical force, and these two kinds of loads are always affecting the Building, and that load by snow coverage also shall be considered in the area in Japan where heavy snowfall is. This horizontal load is transmitted from the slab to the foundation via the beams and columns,



**Figure 2-3 Image of Vertical**

At this time the beams and columns are subjected to a force that tries to rotate the components around the fulcrum (the joint between the beam and column). This force is called a rotational moment, and this rotational force causes a force that tries to bend each column and beam. This force is called a bending moment. Figure 2-3 is an image of the bending moment acting on each column and beam.



**Figure 2-4 Bending Moment on the Frame  
(Vertical Loads)**

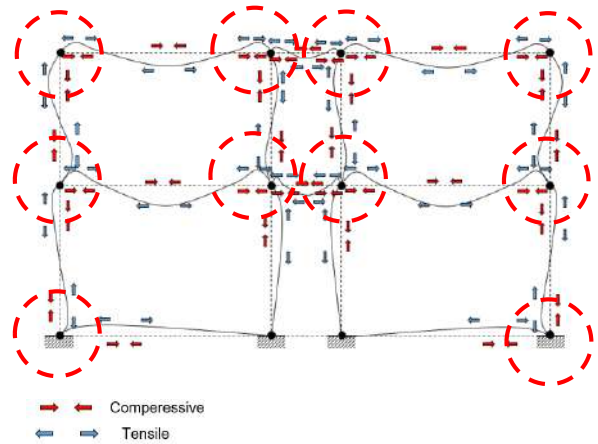
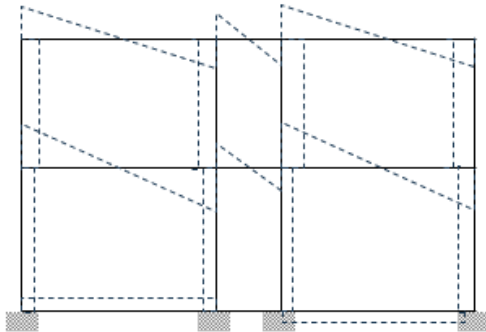
According to the Vertical forces such as a dead load and a live load, Bending Moment will affect the Beams and Columns, and then stresses such as compressive and tensile on and that share force would appear on the Frame due on the impact.

Especially, Moment has concentrated on the connection of Beam and Column showing on the sketch. (A part circled by dot line)

Caused by Bending Moment



The below figure shows as reference illustration



**Figure 2-5** Sharing force on the Frame

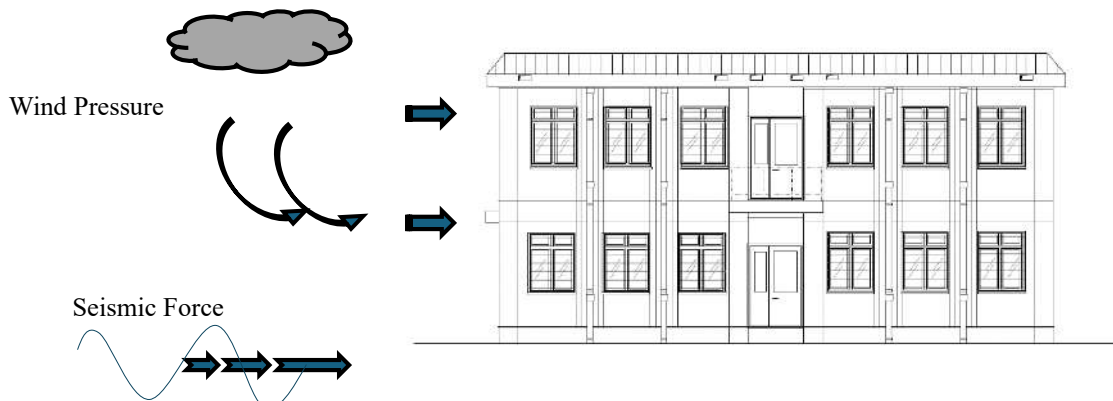
**Figure 2-6** Stress on the Frame

As can be seen from this illustration, each vertical force acts as a tensile force, compressive force, and shear force on each part of the beam or column. The reinforcing bars resist this tensile force, while the concrete resists the compressive and shear forces. In particular, the tensile and compressive forces are concentrated at the intersections of the columns and beams, and it can be seen that large forces are applied to these parts. This means that the construction of the reinforcing bars and concrete in these parts is particularly important.

### 2.3.1.2 Horizontal loads on the Building

On the other hand, the force acting horizontally on a building is called horizontal force, and it is exerted on the exterior walls of the building by strong wind, storm, earthquakes, etc. In the case of basements and buildings built on slopes, the walls in contact with the ground are subjected to pressure from the soil, i.e. earth pressure.

(Refer to Figure 2-7 Image of Horizontal Force)

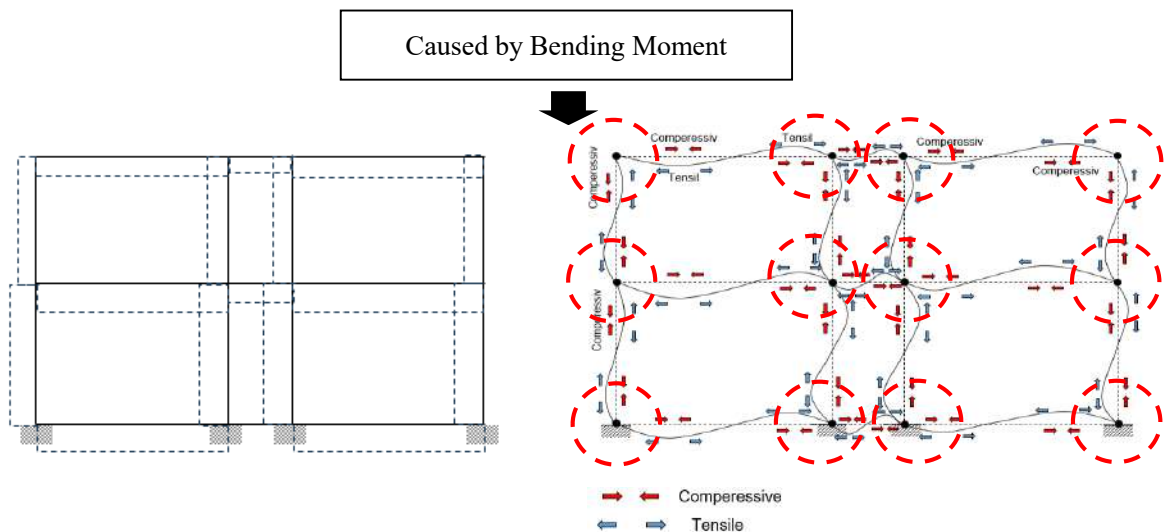


**Figure 2-7** Image of Horizontal Force

Horizontal forces such as strong winds, storms, and earthquakes act on the exterior walls of a building, and this pressure from the outside is transmitted through the walls to the columns supporting those walls, and that the force on those columns is transmitted through the beams to the columns in the next row. At this time, just like with vertical loads, bending moments are generated in the columns and beams that receive the force.

Refer to the below, Figure 2-8

As shown in the diagram above, the generated bending moment generates compressive and tensile forces in various parts of the frame, just as in the case of vertical load, and these are also concentrated at the joints between the beams and columns. In other words, the stress due to the vertical load and the stress due to the horizontal force are concentrated in the joints between the beams and columns, resulting in a large stress (area surrounded by dotted lines).



**Figure 2-8 Share force on Frame  
(By Horizontal force)**

**Figure 2-9 Stress on Frame  
(By Horizontal force)**

In this way, the tensile and compressive forces generated by vertical and horizontal stresses affect seriously at the joints between the columns and beams. This fact is likely to be an important point in construction for the steel bars and concrete that bear these forces.

### 2.3.1.3 Summary of construction points

According to the forces acting on the building, the key points for concrete work and reinforcing bar work (important points for construction supervision) can be summarized as follows:

- 1) Stress on the structure due to both loads
  - In the case of a vertical load, a force (bending moment) that tries to bend the beam born the load is generated, as shown in Figure 2-4. This bending moment acts on the

top of the beam at both ends ( $1/4$  of the beam length from the column) and on the underside of the beam at the center ( $1/2$  of the center of the beam length). As a result, in the column, a bending moment acts on the opposite side of the beam above the turning point of the bending moment (almost the center of the column), and on the beam side below the turning point of bending moment. (Refer to Figure 2-6)

- In the case of a horizontal load, a force (bending moment) that tries to bend the column that receives the load is generated, as shown in Figure 2-8. This bending moment is largest at both ends of the column (where each contacts the upper and bottom floors) and occurs at the top end of the column on the opposite side to where the load is applied, and at the bottom end of the column on the side to which the load is applied. As a result of the influence of this bending moment, a bending moment is generated on the beam at the part of the beam that contacts the column, as a force that balances the bending moment of the column. In this way, the bending moment generated by the horizontal load generates tensile and compressive forces in the columns and beams as well as "Vertical loads", and the reinforcing bars and concrete bear these forces and resist the load. (Refer to Figure 2-10).

## 2) Construction points for Rebar work

The rebars in RC structures bear the tensile forces applied to the building. For this reason, there are strict regulations regarding the quality of the rebar materials, the precision of processing, the position and length of joints, the state of joints of columns and beams, etc., and these are written in the design documents. During on-site construction, it is important that each of these required items is faithfully observed, and this is the key point of construction supervision.

- Reinforcement must be done according to the instructions in the design documents. In other words, the size, number, and joining method of the rebars required for each part of the building, as well as the location and length of the joints, must be strictly controlled. In addition, construction tolerances must be thoroughly discussed with the designer and the construction must be carried out according to the design concept.
- When placing rebars that bear tensile forces, it is important to fabricate using straight materials and to assemble them in such a way that they do not bend or sag.
- Main bar on Columns and Beams, hoops, stirrups, floor rebars, wall rebars, and others have to be arranged in a balanced as designed. And that is purpose the tensile force on those sections will be distributed suitably. Therefore, it is important to secure each arranged rebar firmly with a binding line to keep the position of each reinforcement when arrangement of rebar or when pouring concrete.
- The rebar placed in the formwork must be kept free of dirt, oil, and rust until the concrete pour is complete, so as not to impair the good adhesion of the reinforcement

to the concrete. If any such condition is found, it is important to remove it all before starting the concrete pour.

- Rebar has to be protected from rust to keep a suitable adhere, and insufficient concrete coverage will be roots of concrete crack, which would cause rust. Therefore, it is important that the rebar is placed with an appropriate gap between the formwork and the rebar, using concrete spacers or the like to maintain the required concrete covering thickness.

### 3) Construction points for Concrete work

In the case of RC structures, the compressive force acting on the building is borne by the concrete. For this reason, the compressive strength of the concrete material is a particularly important factor in ensuring the strength of the building. It is necessary to check and strictly adhere to the concrete strength specified in the design documents. and for this reason, the several points shown below must be supervised strictly for both ready mixed concrete and on-site mixed concrete. Furthermore, since concrete is made from the hydration reaction of cement, coarse aggregate, fine aggregate, water and admixtures, its performance is greatly affected by the mixed proportions and how it is poured into the formwork. Therefore, concrete must be mixed with a planned mix and constructed so that it can fully exert the specified strength, which is important supervising points.

- Supervising point of using Ready Mixed Concrete

When contractor has planned to use a ready mixed concrete, supervisor has to check the following points.

- To confirm the design requirement for concrete
- To check the concrete mix plan (Required compressive strength, Cement-Water ratio, Slump, Flow)
- Test practice (Trial mixing and Compressive test for the concrete)
- To confirm the distance from Concrete plant to construction site (necessary time for delivery)
- To check the pouring procedure for the concrete. (necessary time for pouring concrete for one concrete mixer truck)

- Supervising point for using Site Mix Concrete

When the contractor has planned to use a site mix concrete, the supervisor has to check the following points.

- To check the measuring method for raw material such as Cement, Coarse aggregate, Fine aggregate, Water and Admixture
- Mixing time for each batch of the concrete
- Stock volume of raw materials such as Cement, Coarse aggregate and Fine aggregate and its storage condition

➤ Supervising point in Concreting and Curing

In pouring concrete and the curing, the supervisor has to check and confirm the following points to achieve the required quality

- The number of samples for the concrete test to be taken has to be confirmed prior to the pouring concrete.
- Slump test, Concrete flow, Air volume and others have to be executed in prior pouring concrete
- The specimens for concrete compressive test shall be sampled three pieces as one lot.
- In prior pouring concrete, the shuttering panel has to be kept in wet condition to avoid concrete water penetration to the panels
- In pouring concrete, it is necessary to pour it carefully so that it does not separate, and to tamp it thoroughly to ensure that it is dense. In particular, it is necessary to use a vibrator or other tool to thoroughly integrate the poured layers.
- When pouring concrete, vibrators and other tools must be used effectively to create a dense concrete, so that excess air bubbles and impurities mixed in the concrete rise to the surface.
- Once the concrete has been poured, it must not be subjected to any impacts to prevent internal cracks and any other damage.
- After pouring the concrete and the surface dry, it is necessary to keep it moist by sprinkling water on it to prevent shrinkage caused by rapid drying. Also, in places where the temperature drops suddenly, such as in winter, measures must be taken to prevent the moisture inside the concrete from freezing.

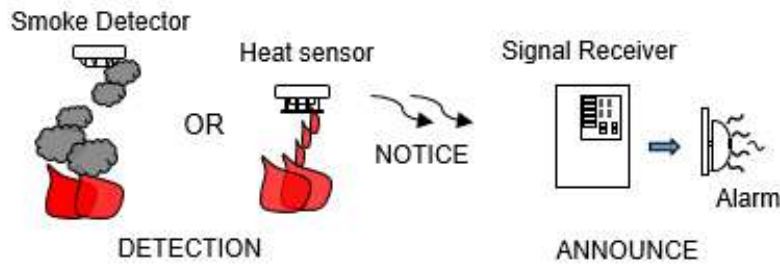
### 2.3.2 Quality of Building 2 (Security for the Building User, especially Fire)

Among other building quality factors, the safety of building occupants is also an important factor in the quality of a building. In the event of natural disasters such as earthquakes, storms, floods, and fires, the safety of building occupants must be ensured. It is important that building occupants can safely evacuate when these disasters occur. While the safety of buildings against earthquakes and storms is ensured primarily by structural design, safety against floods and fires is ensured by architectural design, particularly by measures such as fire prevention and evacuation equipment, as well as fire extinguishing equipment, which will be described here.

#### 2.3.2.1 Fire prevention

At initial stage of Fire, it is not so difficult to extinguish a fire. Therefore, Fire shall be found as earlier as possible. Therefore, Building shall be equipped with a smoke detector, heat sensor,

fire alarm and other fire protection facilities, so that it is quite important that the equipment will suitably function to prevent the disaster.



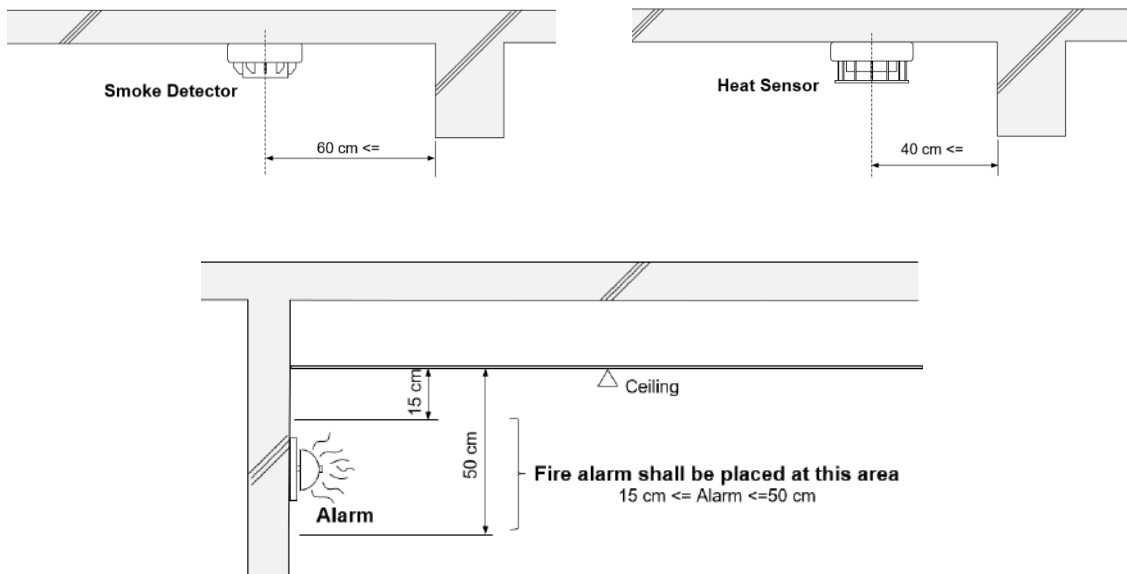
**Figure 2-10 Imagine of Fire Prevention system**

In order for various fire alarm systems to function properly, their installation location and method must be appropriate. It is also very important that the systems are confirmed to operate properly and that their operation is checked regularly, especially, it is a point of site supervision has to check the function.

1) Setting location

Smoke detectors, heat detectors, and gas detectors must be installed in a location where their detection function is not impeded. In other words, they must not be installed near beams or walls, or in places that face the indoor unit or ventilator of an air conditioner, making it difficult to detect heat or smoke. Gas detectors should also be installed near the floor or ceiling depending on whether the gas to be detected is heavier than air or lighter than air.

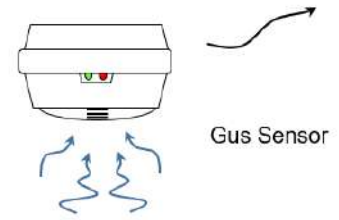
The installation restrictions for each detector and/or fire alarm are as follows:



**Figure 2-12 Installation Restrictions**

Basically, these installation locations are required by the design documents, but if they are unclear, the designer must be confirmed and the installation must be carried out, and the supervisor must check the construction status.

The table below shows “Specific gravity of gas”



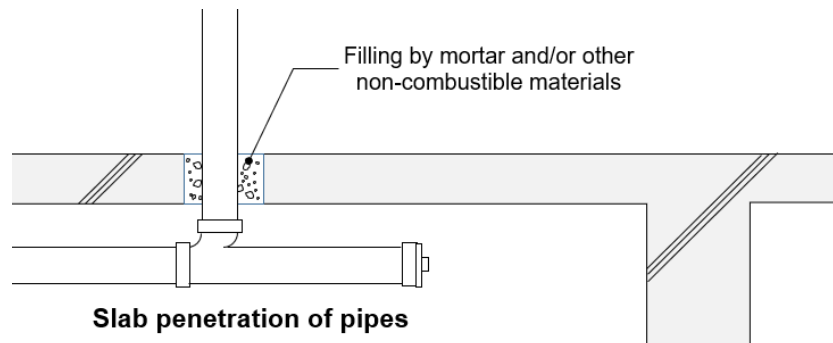
**Table 2-9 Specific Gravity of Gas**

Name	Hydrogen	Helium Gas	Methane Gas	Ammonia	Nitrogen	Air	Hydrogen sulfide	Hydrogen	Propane Gas	Carbon dioxide	Butane Gas	Chlorine
specific gravity	0.07	0.14	0.55	0.59	0.97	1	1.19	1.27	1.5	1.53	2	2.49

2) Method of installation

Fire alarms and other types of alarms must be securely installed so that they are not damaged by earthquakes, etc. Furthermore, fire-resistant materials must be used for electric wires and conduits, and when they penetrate beams, walls, or floors, the penetration points must be securely sealed with non-combustible materials, etc., to prevent the spread of smoke and fire from easily occurring.

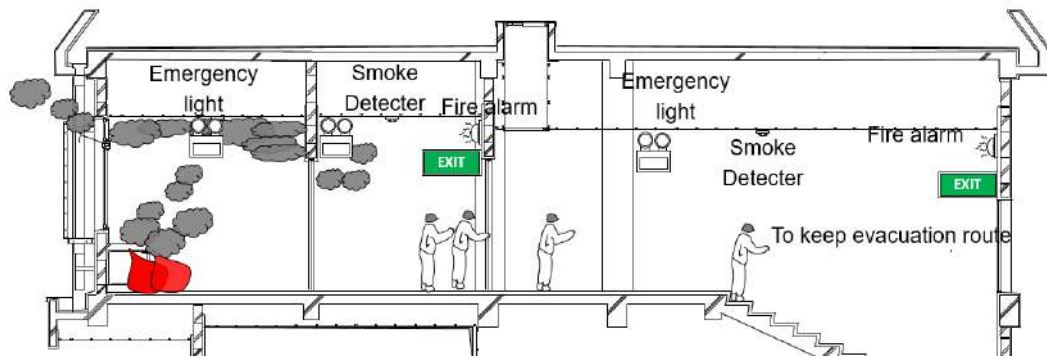
Similarly, piping for water supply and drainage sanitary systems, refrigerant pipes and ducts for air conditioning systems, piping for ventilation systems, and other systems must be constructed with care to prevent the easy spread of fire, smoke, and other harmful gases.



**Figure 2-13 Treatment for pipe penetration in slab**

2.3.2.2 Evacuation from Fire and other disaster

In occurrence of Fire, Building user shall evacuate from the location of Fire safely. Building shall be designed under consideration for User evacuation from fire. Herein the point of fire threat will be introduced.



**Figure 2-14 Device for evacuation from fire**

Since the most important thing for the buildings is to ensure that building occupants do not lose their evacuation routes, the following points are taken into consideration when designing a building.

- Evacuation routes must be secured in at least two directions.
- Emergency lights must be installed to ensure lighting is not lost.
- Emergency exits must be clearly marked.

These safety measures are planned based on a variety of conditions, but they must be constructed in accordance with the plans set out in the design drawings. Therefore, it is important for construction supervisors to fully understand the design intent and provide supervision and construction guidance to contractors so that these facilities can be used reliably in the event of a fire or other disaster.

### 2.3.2.3 Firefighting equipment

Firefighting equipment such as those shown below have been planned on the design documents based on the BNBC and other standards and regulations due to the size and number of floors (height) of the facility.

- Fire water connection piping
- Fire hose box
- Sprinkler system
- Portable fire extinguisher
- Foam fire extinguishing equipment
- Carbon dioxide fire extinguishing equipment

Basically, it goes without saying that fire protection equipment and fire extinguishing equipment are designed by the designer, but the construction supervisor instructs the contractor to install the equipment according to the design documents and checks the installation status.

In order for fire extinguishing equipment to perform its functions, the design documents include important information that must be observed during construction, such as the materials and performance of the equipment used, connection methods, etc. Construction

supervisors must check the important items stipulated in the design documents and ensure that they are installed. The items to be checked for each construction are listed below.

1) Wiring and piping construction

The checking points are below.

- Specifications of materials used, such as piping materials: performance table, quality certificate, delivery note, etc.
- Piping connection method: piping joints, welded joints, flange bolt connections, etc.
- Piping retention method: brackets, hanging, buried, etc.
- Piping and/or wiring route
- Other: requirements for heat insulation treatment, paint color designation, opening and closing valves, air vent valves, solenoid valves, etc.

2) Equipment and device layout

- Fire extinguisher boxes, fire hose storage boxes, water pipe connections, and extinguishing agent outlets for various fire extinguishing systems such as sprinklers and carbon dioxide extinguishing systems must be placed according to the drawings.
- Arrangement of smoke exhaust and the system: location, operation system and enclosure

3) Portable extinguisher

- Evidence for the specifications such as performance table, quality certificate, delivery note, date of manufacture, etc.
- Installed number and size
- Other requirements: sign board, fixing method, etc.

## 2.4 Ensuring the quality of RC construction

As we have seen in the basics, there are many aspects of on-site construction of RC structures that are not expressed in BNBC or other standards or design documents to keep a construction quality. For example, the quality of construction is affected by the storage and handling of materials. In addition, even if something is specified in the design documents, it may be difficult to carry out the work as specified in the drawings, depending on the content, when it is carried out manually on-site, such as assembling formwork or placing rebar. This is called construction error, and it is important to keep it within the allowable range (tolerance).

### 2.4.1 Elimination of defective products

The materials used in construction are delivered by suppliers, but the quality of these materials must be checked by checking documents such as delivery notes and product warranties, and by conducting quality tests as necessary to ensure that they are of the specified specifications and quality. If they are found to be defective, they must be returned or replaced with materials of appropriate quality and used in construction. It is important for the construction supervisor to

instruct the contractor on any measures deemed necessary and to confirm that the materials are of the quality specified in the drawings. If materials are found to be defective, they must be returned or replaced with materials of appropriate quality and used in construction. The items to be confirmed are as follows.

#### 2.4.1.1 Rebar

The strength and product grade of rebar materials are strictly specified in the design documents. As a document to confirm whether the delivered materials meet the ordered specifications, steel mills issue mill sheets containing the material strength and the product ingredients for each product, which allows the quality of the product to be confirmed. However, since mill sheets are created for each production lot, if the quantity purchased (delivered) is small, they may be copies rather than the original documents or may not be issued at all. In such cases, the construction supervisor must take samples for tensile tests from the delivered materials in certain quantities and actually check them with tensile tests.

Refer to Table 2.7 Chemical composition based on cast analysis-maximum values of mass fraction in percentage

#### 2.4.1.2 Concrete Materials (Cement, Coarse aggregate and Fine aggregate)

The main raw materials of concrete, cement, coarse aggregate and fine aggregate, greatly affect the quality of the mixed concrete. The quality of these materials may deteriorate even when stored before delivery, therefore, especially using site mix concrete, it is necessary to take into consideration the quality of these raw materials when accepting materials. In case of using for mortar, the checking point shall be same as well.

##### 1) Cement

Cement materials are materials that harden through hydration reactions when they react with water, so if there are problems with the storage conditions before delivery to the site, the planned strength may not be achieved, and the quality may be significantly affected. For this reason, it is important to thoroughly check the condition of the materials when they are received. Below are some points that should be checked at the time of delivery.

- Type of cement (e.g. Portland cement, blended cement or special cement)
- Manufacturer name and date of manufacture
- Visual inspection and others (damage such as scratches on the cement bag, heat or partial or overall hardening, etc.)

Refer to Table 2-1: Composition of cement

Refer to Table 2-2: Mechanical and Physical properties given as characteristic

##### 2) Coarse aggregate

The strength of concrete is affected by the strength of the coarse aggregate. The use of brick chips as a coarse aggregate is also permitted under the BNBC, but when using them as a coarse aggregate, the strength of the material itself must be given due consideration.

Furthermore, the maximum particle size is regulated when using natural stone, crushed stone, recycled aggregate, or brick chips as raw materials for concrete. For these reasons, it is important to check the following points at the time of acceptance. Basically, the acceptance inspection is carried out visually but crushing tests and sieve tests are also carried out if necessary.

- Impurities (mud and other debris)
- Maximum Granularity
- Types and strength of coarse aggregate

Refer to Table 2.5 Grading requirements for 19 mm downgraded Coarse aggregate (stone chips) ASTM C33

### 3) Fine aggregate

The grain size of the fine aggregate (sand) affects the viscosity of the concrete, and depending on the place of origin, the salt content can have a negative effect on the concrete produced. When using sea sand in particular, careful consideration is required, such as washing it with water. When accepting materials to be used as fine aggregate, it is important to check the following points.

- Impurities (mud and other debris)
- Kinds and origin of fine aggregate
- Maximum particle size and particle size distribution

Refer to Table 2.3 Grading requirements of fine aggregates as per ASTM C33 and AASHTO M6

Refer to Table 2.4 Grading requirements for sand of  $FM \geq 1.2$

#### 2.4.1.3 Water content in concrete

##### 1) Mixing ratio for concrete

As confirmed in 2.2.1.2 "Mixing proportion of the composition", concrete mixes must be carefully planned because they greatly affect workability and concrete strength. In particular, the mixing ratio of water and cement is such that if the mixing ratio of water is too high, the concrete shrinks a lot, which induces cracks and causes problems with the durability of the concrete. For this reason, the BNBC imposes restrictions on the amount of water in the concrete mix. Therefore, when using ready mixed concrete, the on-site engineer (the supervisor) prepares the mix plan after considering the BNBC regulations at the concrete plant, so it can be easily confirmed from the submitted mix plan, but when using on-site mixed concrete, it is necessary to pay particular attention to the amount of water to be mixed.

##### 2) Cement-Rater Ratio

The water-cement ratio indicates the ratio of water to cement in a concrete mix and is used to check the amount of water to be mixed. BNBC also has the following provisions

regarding the water mix in concrete in part 6, Clause 5.6.3.

**[BNBC Part 6]**

**5.6.3 Proportioning by Water Cement Ratio**

5.6.3.1 If the data required in Sec 5.6.2 are not available, concrete proportions shall be based on water cement ratio limits specified in Table 6.5.6 when approved by the engineer.

5.6.3.2 Table 6.5.6 shall be used for concrete to be made with cements meeting strength requirements of “Bangladesh Standard Cement Part-1: Composition, specifications and conformity criteria for common cements” (BDS EN 197-1: 2003), and shall not be applied to concrete containing lightweight aggregates or admixtures other than those for entraining air.

5.6.3.3 Concrete proportioned by water cement ratio limits prescribed in Table 6.5.6 shall also conform to special exposure requirements of Sec 5.5 and to compressive strength test criteria of Sec 5.12.

**5.6.4 Average Strength Reduction**

As data become available during construction, amount by which value of  $f'_c$  must exceed specified value of  $f'_c$  may be reduced, provided:

- (a) 30 or more test results are available and the average of test results exceeds that required by Sec 5.6.2.2(a) using a standard deviation calculated in accordance with Sec 5.6.2.1(a), or
- (b) 15 to 29 test results are available and the average of test results exceeds that required by Sec 5.6.2.2(a) using a standard deviation calculated in accordance with Sec 5.6.2.1(b), and provided further that special exposure requirements of Sec 5.5 are met.

N/mm <sup>2</sup>	entrained	concrete
17	0.66	0.54
20	0.60	0.49
25	0.50	0.39
30	0.40	**
35	**	**

\* 28 day strength. With most materials, water cement ratios shown will provide average strengths greater than that required in Sec 5.6.2.2.

\*\* For strengths above 30 N/mm<sup>2</sup> (25 N/mm<sup>2</sup> for air entrained concrete) concrete proportions shall be established by methods of Sec 5.6.2.

2.4.1.4 Concrete test in prior of pouring in place

Whether ready-mix concrete or on-site mixed concrete is used, the necessary concrete tests must be carried out immediately upon arrival at the site for ready-mix concrete, or after mixing for on-site mixed concrete, to verify the quality of the concrete being used.

1) Ready mix concrete

When ready-mix concrete arrives at the job site, the concrete delivery documents should be checked immediately, and the following tests and sampling for crushing test should be performed:

- Concrete temperature: (\*35°C and less)
- Slump test: Following design specifications (\*Required slump/ 8cm-12cm: +2.5cm, Required slump/ 21cm and more: +1.5cm)
- Concrete flow test: When slump testing is difficult such as highly fluid concrete etc.
- Air volume test: (\*in case normal concrete, 4.5% +1.5%)
- Chloride ion content: (\*less than 0.3%)
- Sampling concrete: It shall confirm to the designer (one sampling lot: each 150m<sup>3</sup>, and every casting time, sampling number in each sampling lot has to be 6 pieces/3 pieces per test at least.)

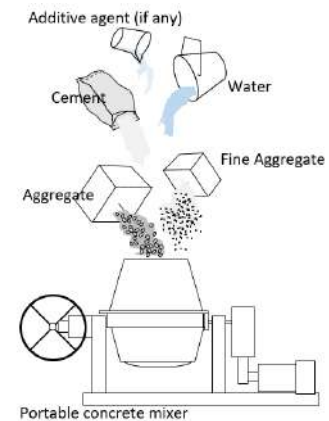
(\*tolerance): it shows a tolerance in JASS (Japanese Architectural Standard specification 5). Basically, all tolerances shall be confirmed to designers.

## 2) On-site mixed concrete

In the case of on-site mixed concrete, it is important to measure the correct amounts of cement, water, coarse aggregate, fine aggregate, and other additives based on a mix plan that has been planned and confirmed in advance and mix suitably. Therefore, it is important to supervise whether it has been mixed according to the mix plan, in addition to checking the condition of the mixed concrete. The checking points are below.

- Slump test Slump test: Following design specifications (\*Required slump/ 8cm-12cm: +2.5cm, Required slump/ 21cm and more: +1.5cm)
- Chloride ion content: (\*less than 0.3%)

- Sampling concrete: In order to confirm that the mixed concrete is manufactured (mixed) uniformly in terms of the planned strength and other properties, it is necessary to test it every time it is mixed with a concrete mixer, but if the pouring quantity is large, the number of test samples will be very large, which is expected to hinder the pouring work on site. For this reason, it is important to ensure the uniformity of the quality of the mixed concrete by strictly controlling the mixture amount of each raw material, the amount of water added, and the



**Figure 2-15 Illustration “Concrete mixing”**

mixing time, therefore, the concrete sampling lot must be decided in sufficient consultation with the designer. In addition, the number of concrete samples in one sampling should be at least 6 (3 per test), and the number of concrete compression tests required should be taken.

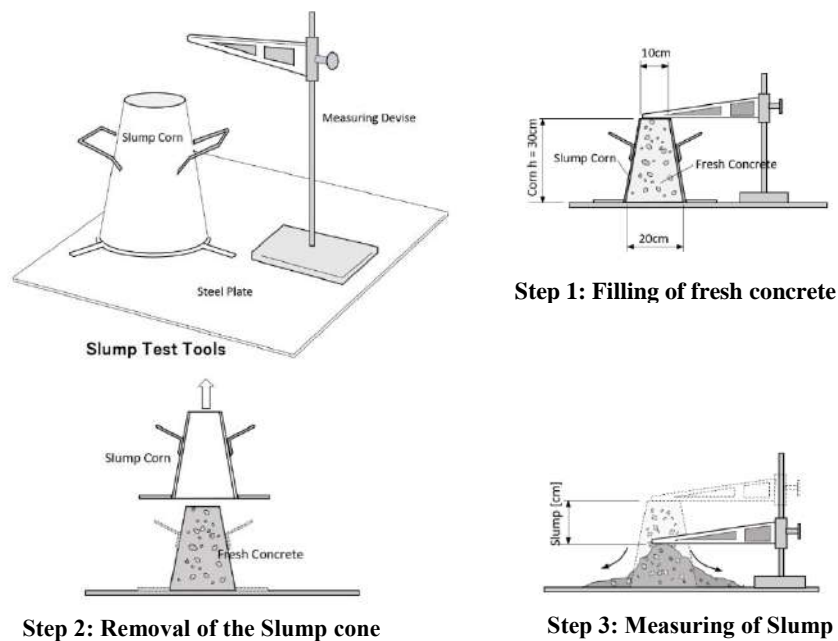
- Control of mixing concrete: Each concrete raw material and water are measured using designated measuring instruments and the mixing time is kept constant to ensure

uniformity. The mixing time should also be the same as that used during test mixing, and it is important to measure accurately using a stopwatch or similar device.

### 3) Concrete slump test

The concrete slump test is a common test performed at the time of acceptance to measure consistency, which is the resistance to flow and deformation, as specified in the BNBC. (ASTEM C143)

- Overview of slump cone and slump flow test  
Outline of each test is shown below.

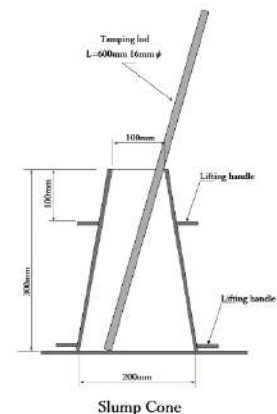


**Figure 2-16 Test devise and method for Slump cone test**

- Points to note using the slump cone test

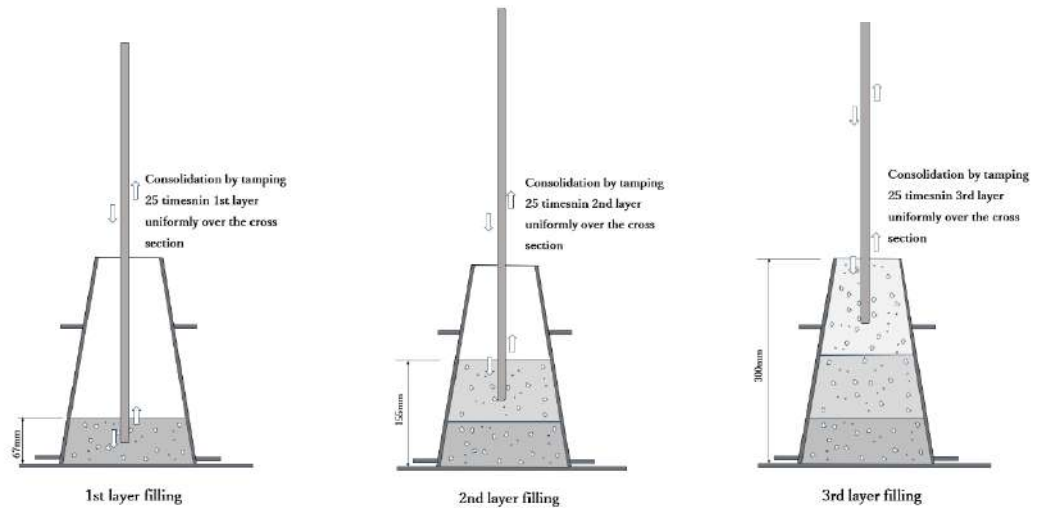
Slump test has to be carried out as specified in ASTEM C143, and some notes for the test are below.

- Slump test shall be executed immediately after being delivered on site (Before starting to harden).
- The steel plate shall be Nonabsorbent, damp, flat, level, moist, rigid surface.
- The test concrete has to be filled with in divided three times.



**Figure 2-17 Slump cone and Tamping rod**

- Removal the mold (slump cone) immediately raising it carefully in a vertical direction. Raise the mold a distance of 300mm in 5 +2 s by a steady upward lift with no lateral or torsional motion.
- Below illustrations show divided 3-times filling of concrete into the cone.

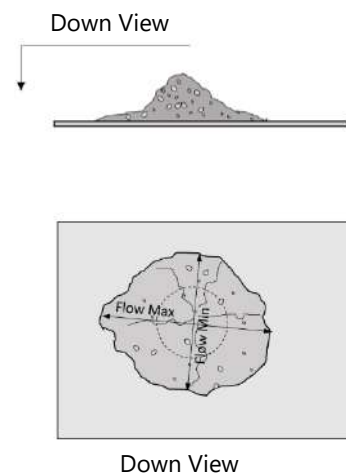


**Figure 2-18 Filling concrete into Slump cone**

➤ Other references

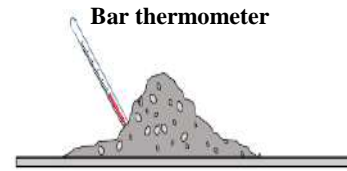
Concrete Slump flow Test: Concrete which is difficult to check the Concrete Slump such as Super Plasticized Concrete shall be checked by Concrete Slump Flow.

- The extent of the concrete after removing of the Slump Corn will be the right-side sketch, so that the extent size is called Concrete Slump Flow. The Flow Max and Flow Min shall be measured. If the difference between Flow Max and Flow Min is more than 50mm, the Slump flow shall be re-tested.



**Figure 2-19 Checking Concrete flow**

- Checking concrete temperature/to measure using a bar thermometer: The temperature of the Fresh Concrete shall be checked, and the temperature shall be 35°C and less. If the concrete temperature is more than 35°C, some countermeasures should be considered, some of which are cooling of the aggregate at Batching Plant and/or covered the agitator to prevent heating up of the concrete. Furthermore, it is necessary to discuss with Concrete plant engineer to use a retarder-type AE agent for additive material.



**Figure 2-20 Checking Concrete Temperature**

## 2.4 Site storing of Rebar and concrete raw materials

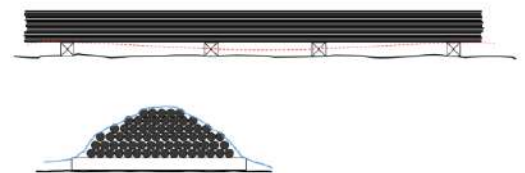
The raw materials for reinforcing bars and concrete are delivered to the site in advance and temporarily stored there until the use. The quality rebar and the raw materials for concrete such as cement, coarse aggregate, and fine aggregate, are greatly affected by their storage conditions, so it is necessary to give careful consideration to the storage method and handling of the materials.

### 2.4.1.1 On-site storage of rebar materials

It is necessary to store rebar in a way that does not cause rust or dirt or oil to adhere to it, preventing it from adhering well to the concrete. It is also important to ensure that the rebar does not bend or twist during storage.

Specifically,

- Do not place them directly on the ground but keep them at least 20cm away (use sleepers).
- Allow good ventilation and cover them with moisture-proof covers to protect them from rainwater, etc.
- Also, secure a storage place and make sure people do not walk on the stored rebar materials.



**Figure 2-21 Storing of Rebar**

#### 2.4.1.2 On-site storage of raw materials for concrete

The main raw materials for concrete - cement, coarse aggregate and fine aggregate - require careful storage for the quality as they are materials to have a characteristic that produce concrete through hydration reactions.

##### 1) On-site storage of Cement

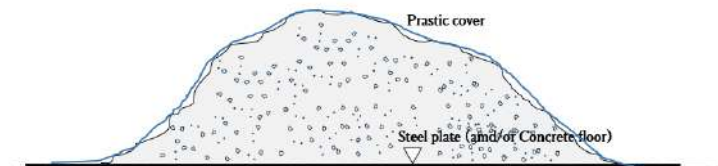
Preventing cement deterioration is extremely important in preventing the deterioration of concrete quality. Cement weathers easily when exposed to air, so it must be stored in a sealed place and humidity must be kept low. Specifically, it must be sealed to prevent drafts and to prevent it from being affected by humidity from the outside air, and the floor must be raised to prevent it from being affected by moisture underground. It is also effective to store the cement bags as tightly as possible.



**Figure 2-22 storing of cement**

##### 2) On-site storage of Coarse aggregate

Coarse aggregate (gravel) requires proper storage methods to prevent drying and separation and deterioration. When storing, it is desirable to stack as densely as possible in a sealed place with poor ventilation (such as a storage warehouse) to prevent extreme drying, but it is effective to consider the following points when storing at the site.



**Figure 2-23 Storing of Coarse aggregate**

- Place a steel plate or something similar in the storage area and do not place it directly on the soil. This is not only effective in not sucking up moisture from the soil, but also to prevent soil and other waste from mixing with the materials.
- Cover the material with a vinyl sheet or the like. This also prevents weathering and drying.
- It is important to measure the moisture content of the coarse aggregate on site and reflect it in the mix design, and coarse aggregate must be used in the condition it was in when the test mix was performed. In particular, in summer and dry areas, the moisture content of the coarse aggregate may be high, so care must be taken. In addition, the water absorption rate of the aggregate and the management of the unit

water content are also important in ensuring the quality of the concrete confirmed by the test mix.

Generally, the water absorption rate of coarse aggregate is 3.0% or less, and the unit water content varies depending on the maximum dimension of the coarse aggregate, but the basic value is 175kg/m<sup>3</sup> for 20-25mm and 165kg/m<sup>3</sup> for 40mm.

### 3) On-site storage of Fine aggregate

Fine aggregate (sand) must be stored properly to avoid mixing or contamination on-site. Specifically, it should be stored in a dry place away from moisture and separated from other materials. It is especially important to store it separately from materials that are vulnerable to moisture, such as cement, and to avoid mixing with them. The careful points are below.

- Dry location: Fine aggregate must be stored in a dry place as moisture will cause it to deteriorate and harden.
- Separation from other materials: To provide clear partitions or marks to prevent mixing to separate fine aggregate from other materials (cement, gravel, etc.).
- Storage location: As with storage of coarse aggregate, store on steel plates or concrete slabs, not directly on the soil.

#### 2.4.1.3 Suitable construction activity on site for the required quality

In order to achieve the required construction quality, Construction has to be carried out according to the instructions in the design documents, and the role of the construction supervisor is to check that the construction status is in accordance with the design documents, point this out, and guide the construction to the appropriate state.

However, as mentioned above, it is nearly impossible to perfectly construct the dimensions of the building's columns and beams, the arrangement of rebar, and all of the other aspects according to the blueprints. Therefore, it is important to keep the construction errors within the allowable range. Also, when constructing the materials delivered to the construction site according to the design documents, there are many points to consider in terms of handling the materials and on-site construction in order to ensure the quality of the building. Here, we will review the key points for supervision of these points, especially in rebar work, formwork work, and concrete work.

#### 1) Rebar work

Reinforcing bar work involves placing the necessary size and number of rebars for columns, beams, walls and floor panels according to the size and thickness required in the design documents. Each rebar will be cut to the appropriate dimensions for the location where it is to be placed. Since rebars are used to resist tensile forces, it is important that they are assembled (placed) in such a way that they do not bend, twist or

flex. Furthermore, the position and/or length in parts such as joints and anchorages must be precisely constructed. Here we will explain the important points at each stage of rebar work.

➤ Ensuring concrete covering thickness

The reinforcing bars that have been placed must be covered with the required thickness of concrete. This is important to isolate the reinforcing bars from the outside air and moisture, prevent rusting of the reinforcing bars, and maintain adhesion to the covering concrete. Although the BNBC also describes the thickness of the concrete covering, the BNBC is primarily about the contents that should be complied with regarding the strength design of reinforced concrete structures, and each building is ultimately described as following the designer's ideas. The contractor and construction supervisor must confirm the designer's intention (description in the design documents) and follow the specifications as specified. In particular, if there is no description in the design documents as a special specification for reinforcing bars, they must check with the designer and follow the following items as stipulated in the BNBC.

✧ BNBC has described the concrete covering on Part6\_Chapter 6 as below,

**8.1.7 Exposure Condition and Cover to Reinforcement**

**8.1.7.1** The nominal concrete cover to all reinforcement (including links), maximum free water-cement ratio and minimum cement content required for various minimum concrete strengths used in different exposure conditions shall be as specified in Table 6.8.3. However, for mild environment, the minimum concrete cover specified in Sections 8.1.7.2 and 8.1.7.3 for various structural elements may be used.

- ◇ In addition, required concrete covering size is shown on BNBC, Part 6 comment with table as below.

8.1.7.2 Cast-in-place concrete	
(a)	Minimum concrete cover for concrete cast against and permanently exposed to earth shall be 75 mm.
(b)	Concrete exposed to earth or weather, the minimum clear cover shall be as under.
	19 mm to 57 mm bar diameter: 50 mm
	16 mm diameter bar and smaller: 40 mm
(c)	The following minimum concrete cover may be provided for reinforcement for concrete surfaces not exposed to weather or in contact with ground:
	Slabs, Walls: Minimum Cover
	40 mm to 57 mm bar diameter 40
	36 mm bar diameter and smaller 20
	Beams, Columns :
	Primary reinforcement, Ties, stirrups, spirals 40
	Shells, folded plate members :
	19 mm bar diameter and larger 20
	16 mm bar diameter and smaller 16

Table 2-10 Concrete covering size on Rebar (BNBC\_6 table 6.8.3)

Environment	Exposure Conditions	Minimum $f'_c$ N/mm <sup>2</sup>						
		20	25	30	35	40	45	50
		Nominal cover (mm)						
Mild	Concrete surfaces protected against weather or aggressive conditions	30	25	20	20	20**	20**	20**
Moderate	Concrete surface away from severe rain subject to condensation Concrete surfaces continuously under water Concrete in contact with non-aggressive soil	40	35	30	25	20	20	20
Severe	Concrete surfaces exposed to severe rain, alternate wetting and drying or severe condensation	45	40	35	30	25	25	20
Very severe	Concrete surfaces exposed to sea water spray, corrosive fumes			50	40	30	30	25
Extreme	Concrete surfaces exposed to abrasive action, e.g. sea water carrying solids or flowing water with pH 4.5 or machinery or vehicles				60	50	40	30
Maximum water/cement ratio								
Minimum cement content, (kg/m <sup>3</sup> )								

\* This Table relates to aggregate of 20 mm nominal maximum size.  
 \*\* May be reduced to 15 mm provided the nominal maximum aggregate size does not exceed 15 mm

- ◇ Stipulation in Japan: In Japan, the Building Standards Act Enforcement Order requires that in order to ensure the durability of rebar, walls and floors other than load-bearing walls must be at least 2cm thick, load-bearing walls and columns at least 3cm thick, parts that come into contact with the ground (foundation rise, columns, beams, etc.) at least 4cm thick, and the foundation slab (excluding the rising part of a slab) at least 6cm thick. Refer to the table below. In addition, the Architectural Institute of Japan, a private organization, has standardized the parts that are not specified in detail in the Building Standards Act, such as material selection and construction methods, in order to improve the quality of buildings, in the JASS (Japanese Architectural Standard Specification). JASS 6 (Concrete Work Edition) also has similar provisions and is widely used as a reference for general engineers.

**Table 2-11 Stipulation of Enforcement Ordinance of Construction Standard Law, in Japan**

PART		Minimum Cover Thickness
Areas not in contact with soil	Walls other than load-bearing walls, Floors	20mm
	Load-bearing walls, columns, beams	30mm
Direct contact with soil	Walls, columns, beams The rising part of a slab footing	40mm
	Foundation (Excluding the rising part of a slab footing)	60mm (Excluding the rising part of the slab footing)

**Table 2-12 Stipulation of Enforcement Ordinance of Construction Standard Law, in Japan**

Quoted from JASS 5

PART			Concrete cover size of rebar on design		Minimum concrete cover size of rebar	
			Dressed Concrete *1	Exposed Concrete *2	Dressed Concrete *1	Exposed Concrete *2
Areas not in contact with soil	Roof Slab Floor Slab Wall	Interior	30mm and over	30mm and over	20mm and over	20mm and over
		Exterior		40mm and over		30mm and over
	Column Beam Structural Wall	Interior	40mm and over	40mm and over	30mm and over	30mm and over
		Exterior		50mm and over		40mm and over
	Retaining Wall		-	50mm and over *3	40mm and over *3	40mm and over *3
Direct contact with soil	Column · Beam · Floor Slab · Wall · Built up on the strip footing		-	50mm and over *4	40mm and over *4	40mm and over *4
	Foundation · Retaining Wall		70mm and over *4	70mm and over *4	50mm and over *4	60mm and more *4

\* Execution of a finishing for suitable durability

\* Nothing of a finishing for suitable durability

\* To be able to deduct 10mm with a consent of supervisor according to the required quality and construction method

\* In the case of light weight concrete, the value shall be added 10mm

➤ On-site processing of rebar

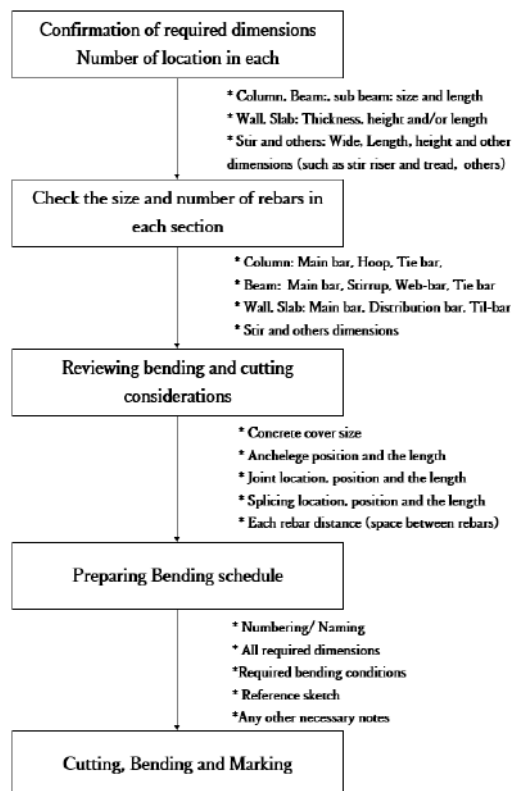
Usually, rebars are delivered to the construction site in a straight state with lengths of

6m or 12m. The rebars delivered to the construction site are then cut, bent, and otherwise processed so that they are properly positioned within the formwork of the dimensions required in the design documents, and then assembled into the formwork. In other words, one of the important points for construction quality is that each rebar to be assembled into main bar, hoop, stirrup, and other parts is processed to the correct dimensions. Here, we will explain in detail how to process steel bars based on the dimensions specified in the design documents for each part of the building, such as columns and beams.

The construction supervisor must verify that the contractor's rebar processing is correct, and if necessary, point out any mistakes and provide guidance on correcting the processing.

◇ On-site processing flow of rebar

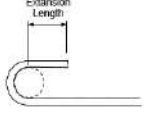
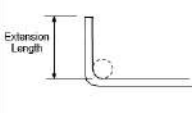
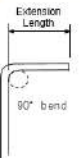

The flow chart below shows the procedure for on-site processing of rebar. It is important for the construction supervisor to check whether the actual work is being carried out according to the correct procedures and whether the instructions in the design documents are being followed correctly, and to point out any issues and request improvements as necessary.



Determining dimensions of each part in rebar processing

In order to determine the dimensions of the rebar, various conditions must be checked, and the correct dimensions must be determined. The dimensions shown in the design documents, such as the size of columns and beams, the thickness of walls and floors, and the dimensions of each part of the staircase, are the inside dimensions of the formwork into which the concrete will be poured. From these dimensions, it is necessary to consider various necessary matters such as the concrete cover thickness, the anchorage length at the joints, the overlap length and position of the rebar, the radius of

**Table 2-13 Standard hook (BNBC\_Part6\_8.1.2.1)**

	(a)	
	180° bend	90° bend
Sketch		
Extension Length	4 bar diameter and more, and 65mm and more	12 bar diameters and more
(c) Stirrup and Tie anchorage		
Sketch	(I)	(II)
	16mm diameter bar/ Similar	19mm ≤ bar diameter < 25mm
	6 bar diameters and more	12 bar diameters and more
Sketch	(iii)	(iv)
	25mm diameter bar/ Similar	Closed tie/ Continuous wound tie
	6 bar diameters and more	6 bar diameters and more, and 75mm more
(d) Seismic hook		
Application	Bending Angle and Extension length	
Seismic hook such as	135° and more angle, and 6 bar diameter, and 75mm and more	
A hook on stirrup, hoop or crosstie	90° and more angle, and 6 bar diameter, and 75mm and more, which	
Circular hoops		
* The hooks that engaged the longitudinal reinforcement and projects into the interior of the stirrup or hoop		

**Table 2-14 Minimum Bending Diameter (BNBC Table 6.8.1)**

Bar Size	Minimum Diameter of Bend
10 mm ≤ d <sub>b</sub> ≤ 25mm	6d <sub>b</sub>
25mm < d <sub>b</sub> ≤ 40mm	8d <sub>b</sub>
40mm < d <sub>b</sub> ≤ 57mm	10d <sub>b</sub>

**Table 2-15 BNBC Part6.8.1.2.2 (a)**

Stipulation on BNBC Part6 8.1.2.2 (a)		
	16mm and smaller size bar	Other size bar
Stirrup and tie hook	4 bar diameter	As Table 6.8.1

**Table 2-16 BNBC Part6.8.1.2.2 (b), (c)**

Stipulation On BNBC Part6 8.1.2.2 (b)	
Deformed Wire Larger than ASTEM MD40 size (ASTEM A1022)	Other wires
4 bar diameter and more	2 bar diameter and more
* Bends with inside sismeter of less than 8 bar diameter shall not be less than 4 bar dia meters from nearest welded intersection	

the corners of the hoop, stirrup, and bar end hook, and determine how long each rebar should be cut and how it should be bent. The matters to be considered are written in the design documents and BNBC, so if there are any unclear points, the construction supervisor must check with the designer and communicate them to the contractor.

In addition, BNBC has stipulated concerning a rebar bending, placing and fixing on Part 6 chapter8/" Detailing of Reinforcement in Concrete Structures".

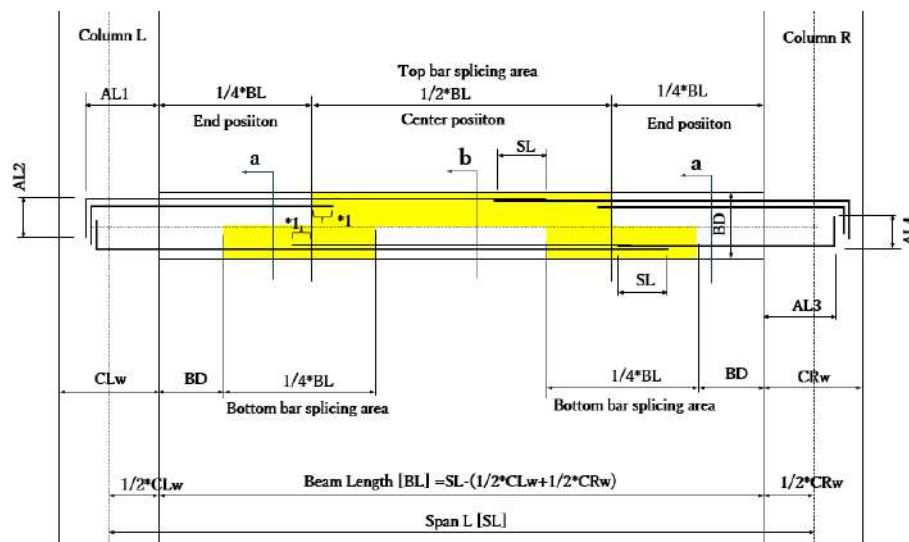
For Standard hook

Hook angle and the extension length shall be followed to the stipulations on BNBC. BNBC stipulations for standard hook is as Table 2-2 on the right, which is prepared following BNBC Part6-8.1.2.1

And the other Bending rules have been stipulated on BNMBC as shown here as well.

For the mentions, we provide a brief explanation with an illustration of some of the main considerations using the sample sketch.

The illustration below shows splicing (Colored by yellow), which is law tensile stress area.

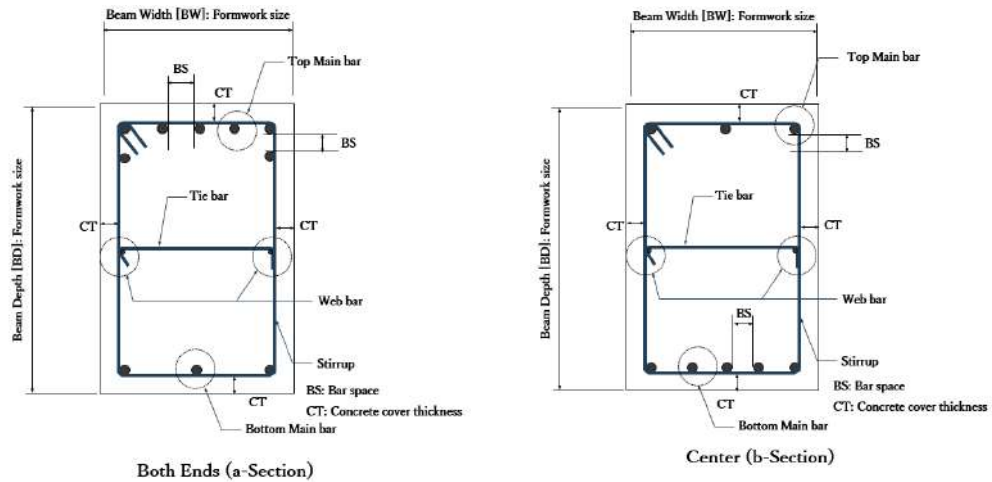


**Side view of Beam**

AL: Anchoring length

SL: Splicing length

\*1: Approx. 100mm into another zone

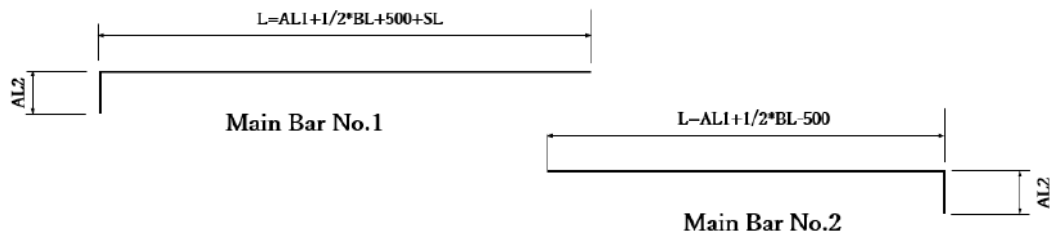


- ❖ Top Main bar: Both ends 5+2-D22, Center 3-D22
- ❖ Bottom main bar: Both 3-D22, Center 5-D22
- ❖ Stirrup: D-10 @150 (All section)
- ❖ Web bar: 2-D10 (All section)
- ❖ Tie bar: D10 @1000 (All section)

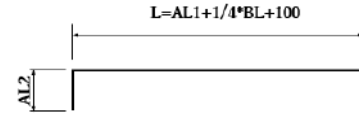
When the main reinforcement is anchored inside the column, the end is bent at a right angle into an L shape as shown in the reference sketch. The bending radius when bending into an L shape is specified for each diameter of the rebar in the BNBC and must be followed.

**[Main bar]**

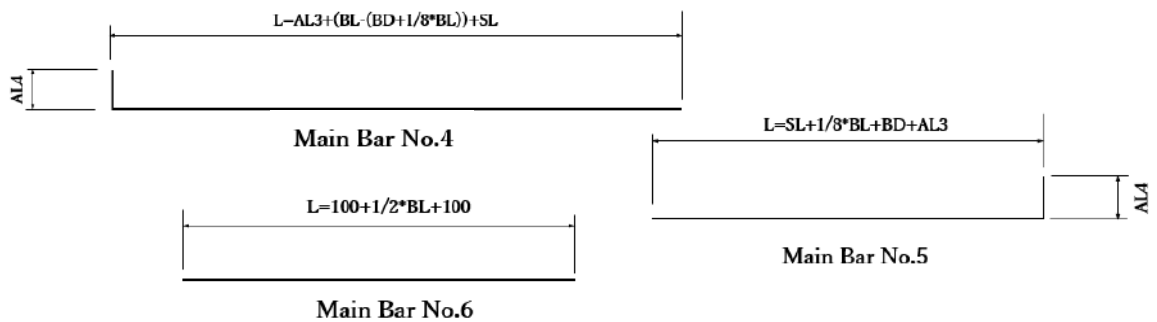
Top 3 bars (all section/ No.1+No.2): The splicing area shall be at the center position/ The one side of bar shall be bent as right angle for the anchoring/ Anchoring location shall be overcoming the column center line/ Splicing length and anchoring length shall be following the design documents. The all dimensions on below shall be shown outer length.



Top 8 bars (Both ends position/No.3): The one side of bar shall be bent as right angle/  
Anchoring location shall be overcoming the column center line/ anchoring length shall  
be following the design document/ Streight end side shall be entered to center of beam  
zone (\*1)



Bottom 3 bars (All section/No.4+ **Main Bar No.3** )ing area shall be at bottom bar  
splicing area/ The one side of bar shall be bent as right angle for the anchoring/  
Anchoring location shall be overcoming the column center line/ Splicing length and  
anchoring length shall be following the design documents.

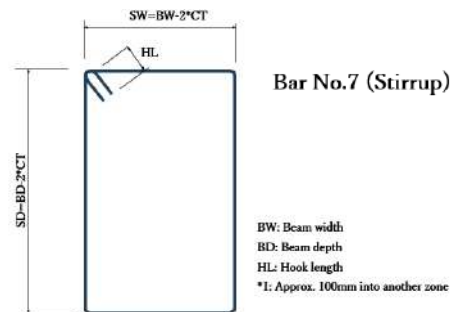


Bottom 2 bars (Center position/ No.6): Both ends of the bar shall be entered in both  
ends area

**[Stirrup]**

Stirrup must have a hook at its end, and the length of the hook and the bending radius  
of the four corners of the rebar are stipulated in the BNBC. Therefore, it must  
be processed in accordance with these regulations. Refer to table 2-13, 2-14, 2-14,  
2-15 and 2-16.

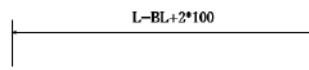
Length of SW and SD is showing as outer  
length, and Length of HL shall be from end  
of bending curve.



**[Web bar]**

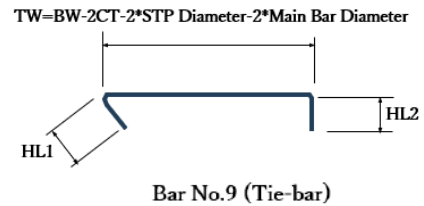
The web-bar should be inserted approximately 100mm into the pillar. In case of bar  
need to join the length, the splicing length had better to be about 10 times of diameter.

**[Tie bar]**



The tie bar is installed to be fixed bo **Bar No.8 (Web-bar)** ends have 135degree and  
90degree hooks, which hooks shall bend as shown on Table 2-13.

Length of TW is showing as outer length, and Length of H1 and H2 shall be from end of bending curve.

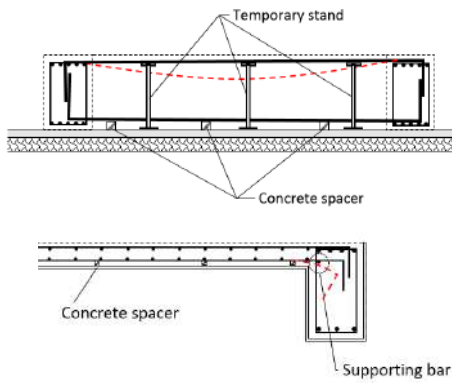


The above explains how to decide on the dimensions of beam reinforcing bars, but basically the dimensions of columns, walls, floors, stairs, etc. are also decided in the same way. The important points to consider when deciding on the dimensions are as follows:

- ✧ Splicing position has to be located in a low stress area
- Proper spacing must be maintained between the rebars so that there is no
- ✧ disruption to the filling of the concrete.
  - ✧ The splicing positions of the rebars should be planned to be offset by at least 500 mm so that adjacent rebars are not in the same position.
  - ✧ If the shape, length or bending radius of end hooks etc. are not specified in the design documents, they must be processed in accordance with BNBC regulations.
  - ✧ Preparing Bending schedule sheet

The planned processing dimensions for each rebar material are compiled in an easy-to-understand processing list and used during processing and assembly. This processing list is one of the QA documents and is an important document for construction quality. An example of a processing list is shown below.





**Figure 2-24 Position of rebar spacer**

◇ On-site Rebar Arrangement (Placing)

Rebar shall be placed without bent, twist and warp at the correct position, so that temporary stand, supporting bar and/or concrete spacer shall be used as position keeper during placing of bar. The placed rebar positions have been stipulated on BNBC Part6\_8.1.5

Placing tolerances and Concrete cover shall be followed.

in BNBC, the tolerances of concrete cover

thickness and placing condition are (Spacing)stipulated as follows.

8.1.5.1 Reinforcement shall be accurately placed and adequately supported before concrete is placed, and shall be secured against displacement within tolerances permitted in Sec 8.1.5.2 below.

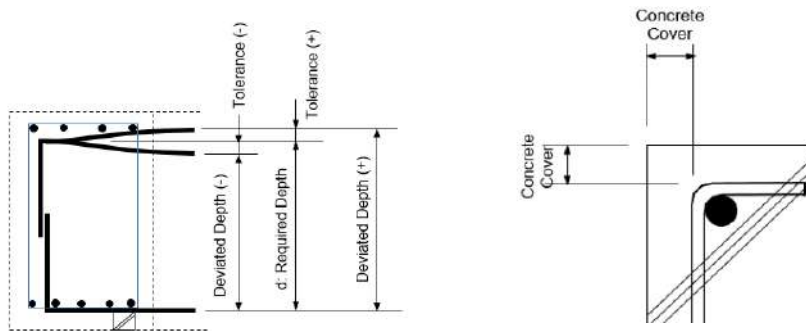
8.1.5.2 Reinforcement shall be placed within the following tolerances unless otherwise specified by the engineer:

- (a) Tolerances for depth  $d$ , and minimum concrete cover in flexural members, walls and compression members shall be as set forth in Table 6.8.2.
- (b) Notwithstanding the provision of (a) above, tolerance for the clear distance to formed soffits shall be minus 6 mm and tolerance for cover shall not exceed minus one third (1/3) of minimum concrete cover specified in the design drawings or specifications.
- (c) Tolerance for longitudinal location of bends and ends of reinforcement shall be  $\pm 50$  mm, except at discontinuous ends of brackets and corbels, where tolerance shall be  $\pm 13$  mm and at discontinuous ends of other members, where tolerance shall be  $\pm 25$  mm. The tolerance for concrete cover of Sec 8.1.5.2a shall also apply at discontinuous ends of members.

**Table 2-18 Tolerance for placing reinforcement (BNBC Part 6 Table 6.8.2)**

**Table 6.8.2: Tolerances for Placing Reinforcement**

Depth of Member, $d$	Tolerance for $d$	Tolerance for Minimum Concrete Cover
$d \leq 200$ mm	$\pm 10$ mm	-10 mm
$d > 200$ mm	$\pm 13$ mm	-13 mm



**Figure 2-25 Reference Sketch for BNBC Part 6 Table 6.8.2**

Descriptions for Spacing of Reinforcement on BNBC are below.

### **8.1.6 Spacing of Reinforcement**

**8.1.6.1** The minimum clear spacing between parallel bars in a layer shall be equal to one bar diameter, but not less than 25 mm, or 1.33 times of maximum nominal size of coarse aggregate, whichever is larger.

**8.1.6.2** Where parallel reinforcement is placed in two or more layers, bars in the upper layers shall be placed directly above those in the bottom layer with clear distance between layers not less than 25 mm.

**8.1.6.3** For compression members, the clear distance between longitudinal bars shall be not less than 1.5 bar diameters nor 40 mm nor 1.33 times of maximum nominal size of coarse aggregate.

**8.1.6.4** Clear distance limitation between bars shall apply also to the clear distance between a contact lap splice and adjacent splices or bars.

**8.1.6.5** In walls and one-way slabs the maximum bar spacing shall not be more than three times the wall or slab thickness  $h$  nor 450 mm.

**8.1.6.6** For two-way slabs, maximum spacing of bars shall not exceed twice the slab thickness  $h$  nor 450 mm.

**8.1.6.7** For temperature steel, maximum spacing shall not exceed 5 times the slab thickness  $h$  nor 450 mm.

#### **8.1.6.8 Bundled bars**

- (a) Groups of parallel reinforcing bars bundled in contact to act as a single unit shall be limited to four.
- (b) Bundled bars shall be enclosed within stirrups or ties.
- (c) Bars larger than 32 mm diameter shall not be bundled in beams.
- (d) Individual bars within a bundle terminated within the span of flexural members shall terminate at different points with at least  $40d_b$  stagger.
- (e) Where spacing limitations and minimum concrete cover are based on bar diameter  $d_b$ , a unit of bundled bars shall be treated as a single bar of a diameter derived from the equivalent total area.

✧ Concrete Cover thickness

Concrete cover thickness in various conditions are stipulated on BNBC Part6 part 8, 8. 1.7 and others.

Environ ment	Exposure Conditions	Minimum $f'_c$ N/mm <sup>2</sup>						
		20	25	30	35	40	45	50
		Nominal cover (mm)						
Moderate	Concrete surface away from severe rain Concrete subject to condensation Concrete surfaces continuously under water Concrete in contact with non-aggressive soil	40	35	30	25	20	20	20
Severe	Concrete surfaces exposed to severe rain, alternate wetting and drying or severe condensation		45	40	30	25	25	20
Very severe	Concrete surfaces exposed to sea water spray, corrosive fumes			50	40	30	30	25
Extrem e	Concrete surfaces exposed to abrasive action, e.g. sea water carrying solids or flowing water with pH $\leq$ 4.5 or machinery or vehicles				60	50	40	30
Maximum water/cement ratio		0.5	0.5	0.5	0.45	0.45	0.40	0.40
Minimum cement content, (kg/m <sup>3</sup> )		315	325	350	375	400	410	420
* This Table relates to aggregate of 20 mm nominal maximum size.								
** May be reduced to 15 mm provided the nominal maximum aggregate size does not exceed 15 mm								

✧ Necessary length of lap joint and Anchoring length

Regarding the necessary length of lap joints, design requirements are specified in BNBC Part 6 8.2. The necessary length of lap joints is basically determined by the ideas of each designer and should follow the length stated in the design documents. If there is no description in the design documents, it is necessary to check with the designer and get their instruction before construction, and necessary anchoring length shall be confirmed to designer as well as the length of lap joint.

A stress on one rebar shall be transferred correctly to another rebar, which would be influenced by the splicing length, therefore the splicing length is very important. The splicing length has been stipulated on BNBC Part6 8.2, which is shown on next page. (Which is a part of all)

### 8.1.7 Exposure Condition and Cover to Reinforcement

**8.1.7.1** The nominal concrete cover to all reinforcement (including links), maximum free water-cement ratio and minimum cement content required for various minimum concrete strengths used in different exposure conditions shall be as specified in Table 6.8.3. However, for mild environment, the minimum concrete cover specified in Sections 8.1.7.2 and 8.1.7.3 for various structural elements may be used.

#### 8.1.7.2 Cast-in-place concrete

- (a) Minimum concrete cover for concrete cast against and permanently exposed to earth shall be 75 mm.
- (b) Concrete exposed to earth or weather, the minimum clear cover shall be as under.

19 mm to 57 mm bar diameter: 50 mm

16 mm diameter bar and smaller: 40 mm

- (c) The following minimum concrete cover may be provided for reinforcement for concrete surfaces not exposed to weather or in contact with ground:

Slabs, Walls:	Minimum Cover
40 mm to 57 mm bar diameter	40
36 mm bar diameter and smaller	20
Beams, Columns :	
Primary reinforcement, Ties, stirrups, spirals	40
Shells, folded plate members :	
19 mm bar diameter and larger	20
16 mm bar diameter and smaller	16

Table 2-19 Concrete cover thickness (BNBC Part 6 Table 6.8.3)

Table 6.8.3\*: Concrete Cover and other Requirements for Various Exposure Conditions

Environment	Exposure Conditions	Minimum $f'_c$ N/mm <sup>2</sup>						
		20	25	30	35	40	45	50
		Nominal cover (mm)						
Mild	Concrete surfaces protected against weather or aggressive conditions	30	25	20	20	20**	20**	20**

For tensile force (Showing on next pages)

**Quoting from BNBC Part 6**

8.2 Development and Splices of Reinforcement

8.2.3 Development of Deformed Bars and Deformed Wires in Tension

8.2.3.1 Development length for deformed bars and deformed wire in tension,  $l_d$  shall be determined from either Sec 8.2.3.2 or Sec 8.2.3.3 and applicable modification factors of Sections 8.2.3.4 and 8.2.3.5, but  $l_d$  shall not be less than 300 mm.

8.2.3.2 For deformed bars or deformed wire,  $l_d$  shall be as follows:

Spacing and cover	19 mm diameter and smaller bars and deformed wires	20 mm diameter and larger bars
Clear spacing of bars or wires being developed or spliced not less than $d_b$ , clear cover not less than $d_b$ , and stirrups or ties throughout $l_d$ not less than the Code minimum Or, Clear spacing of bars or wires being developed or spliced not less than $2d_b$ and clear cover not less than $d_b$	$\left(\frac{f_y \psi_t \psi_e}{2.1 \lambda \sqrt{f'_c}}\right) d_b$	$\left(\frac{f_y \psi_t \psi_e}{1.7 \lambda \sqrt{f'_c}}\right) d_b$
Other cases		$\left(\frac{f_y \psi_t \psi_e}{1.1 \lambda \sqrt{f'_c}}\right) d_b$

8.2.3.3 For deformed bars or deformed wire,  $l_d$  shall be

$$l_d = \left( \frac{f_y}{1.1 \lambda \sqrt{f'_c}} \frac{\psi_t \psi_e \psi_s}{\left(\frac{c_b + K_{tr}}{d_b}\right)} \right) d_b \quad (6.8.1)$$

In which the confinement term  $\frac{c_b + K_{tr}}{d_b}$  shall not be taken greater than 2.5, and

$$K_{tr} = \frac{40 A_{tr}}{s n} \quad (6.8.2)$$

Where,  $n$  is the number of bars or wires being spliced or developed along the plane of splitting. It shall be permitted to use  $K_{tr} = 0$  as a design simplification even if transverse reinforcement is present.

8.2.3.4 The factors used in the expressions for development of deformed bars and deformed wires in tension in Sec 8.2.3 are as follows:

- Where horizontal reinforcement is placed such that more than 300 mm of fresh concrete is cast below the development length or splice,  $\psi_t = 1.3$ . For other cases,  $\psi_t = 1.0$ .
- For epoxy-coated bars or wires with cover less than  $3d_b$ , or clear spacing less than  $6d_b$ ,  $\psi_e = 1.5$ . For all other epoxy-coated bars or wires,  $\psi_e = 1.2$ . For uncoated and zinc-coated (galvanized) reinforcement,  $\psi_e = 1.0$ . However, the product  $\psi_t \psi_e$  need not be greater than 1.7.
- For 19 mm diameter and smaller bars, and deformed wires,  $\psi_s = 0.8$ . For 20 mm diameter and larger bars,  $\psi_s = 1.0$ .
- Where lightweight concrete is used,  $\lambda$  shall not exceed 0.75 unless  $f_{ct}$  is specified (see Sec 6.1.9.1 Chapter 6). Where normal weight concrete is used,  $\lambda = 1.0$ .

8.2.3.5 Excess Reinforcement: Development length may be reduced by the factor  $\left[ \frac{A_s \text{ required}}{A_s \text{ provided}} \right]$  where reinforcement in a flexural member is in excess of that required by analysis except where anchorage or development for  $f_y$  is specifically required or the reinforcement is designed under the provisions of Sec 8.3.2(b).

For Compression

**Quoting from BNBC Part 6**

8.2 Development and Splices of Reinforcement

8.2.4 Development of Deformed Bars and Deformed Wires in Compression

8.2.4.1 Development length for deformed bars and deformed wire in compression,  $l_{dc}$  shall be determined from Sec 8.2.4.2 and applicable modification factors of Sec 8.2.4.3, but  $l_{dc}$  shall not be less than 200 mm.

8.2.4.2 For deformed bars and deformed wire,  $l_{dc}$  shall be taken as the larger of  $\frac{0.24f_y d_b}{\lambda \sqrt{f'_c}}$  and  $0.043f_y d_b$  with  $\lambda$  as given in Sec 8.2.3.4(d) and the constant 0.043 carries the unit of mm<sup>2</sup>/N.

8.2.4.3 Length  $l_{dc}$  in Sec 8.2.4.2 shall be permitted to be multiplied by the applicable factors for:

- (a) Reinforcement in excess of that required by analysis:  $\left[ \frac{A_s \text{ required}}{A_s \text{ provided}} \right]$
- (b) Reinforcement enclosed within spiral reinforcement not less than 6 mm diameter and not more than 100 mm pitch or within 12 mm diameter ties in conformance with Sec 8.1.9.4 and spaced at not more than 100 mm on center: 0.75

Some points of splicing expecting for the above, BNBC has mentioned on the other clauses, the following clauses are a part of all

**8.2.5 Development of Bundled Bars**

**8.2.5.1** Development length of individual bars within a bundle, in tension or compression, shall be that for the individual bar, increased 20 percent for 3 bar bundles and 33 percent for 4 bar bundles.

**8.2.5.2** For determining the appropriate spacing and cover values in Sec 8.2.3.2, the confinement term in Sec 8.2.3.3, and the  $\psi_e$  factor in Sec 8.2.3.4(b), a unit of bundled bars shall be treated as a single bar of a diameter derived from the equivalent total area and having a centroid that coincides with that of the bundled bars.

**8.2.6 Development of Standard Hooks in Tension**

**8.2.6.1** Development length  $l_{dh}$  for deformed bars in tension terminating in a standard hook shall be computed as the product of the basic development length for deformed bars,  $l_{dh}$  of Sec 8.2.6.2 below and the applicable modification factor(s) of Sec 8.2.6.3, but  $l_{dh}$  shall be not less than  $8d_b$  nor less than 150 mm.

**8.2.6.2** For deformed bars,  $l_{dh}$  shall be  $\frac{0.24\psi_e f_y d_b}{\lambda \sqrt{f'_c}}$  with  $\psi_e$  taken as 1.2 for epoxy-coated reinforcement, and  $\lambda$  taken as 0.75 for lightweight concrete. For other cases,  $\psi_e$  and  $\lambda$  shall be taken as 1.0.

**8.2.6.3** Length  $l_{dh}$  in Sec 8.2.6.2 shall be permitted to be multiplied by the following applicable factors:

- |     |  |  |
|-----|--|--|
| (a) | For 36 mm diameter bar and smaller hooks with side cover (normal to plane of hook) not less than 65 mm, and for 90° hook with cover on bar extension beyond hook not less than 50 mm   | 0.7  |
| (b) | For 90° hooks of 36 mm diameter bar and smaller bars that are either enclosed within ties or stirrups perpendicular to the bar being developed, spaced not greater than $3d_b$ along $l_{dh}$ ; or enclosed within ties or stirrups parallel to the bar being developed, spaced not greater than $3d_b$ along the length of the tail extension of the hook plus bend | 0.8  |
| (c) | For 180° hooks of 36 mm diameter bar and smaller bars that are enclosed within ties or stirrups perpendicular to the bar being developed, spaced not greater than $3d_b$ along $l_{dh}$ .  | 0.8  |
| (d) | Where anchorage or development for $f_y$ is not specifically required, reinforcement in excess of that required by analysis  | $\left[ \frac{A_s \text{ required}}{A_s \text{ provided}} \right]$ |

In Sections 8.2.6.3(b) and 8.2.6.3(c),  $d_b$  is the diameter of the hooked bar, and the first tie or stirrup shall enclose the bent portion of the hook, within  $2d_b$  of the outside of the bend.

**8.2.6.4** For bars being developed by a standard hook at discontinuous ends of members with both side cover and top (or bottom) cover over hook less than 65 mm, the hooked bar shall be enclosed within ties or stirrups perpendicular to the bar being developed, spaced not greater than  $3d_b$  along  $l_{dh}$ . The first tie or stirrup shall enclose the bent portion of the hook, within  $2d_b$  of the outside of the bend, where  $d_b$  is the diameter of the hooked bar. For this case, the factors of Sec 8.2.6.3(b) and (c) shall not apply.

**8.2.6.5** Hooks shall not be considered effective in developing bars in compression.

## **8.2.7 Development of Flexural Reinforcement - General**

**8.2.7.1** Tension reinforcement may be developed by bending across the web to be anchored or made continuous with reinforcement on the opposite face of member.

**8.2.7.2** Critical sections for development of reinforcement in flexural members are at points of maximum stress and at points within the span where adjacent reinforcement terminates, or is bent. In addition, the provisions of Sec 8.2.8.3 shall also be satisfied.

**8.2.7.3** Reinforcement shall extend beyond the point at which it is no longer required to resist flexure for a distance not less than  $d$  nor less than  $12d_b$ , except at supports of simple spans and at free end of cantilevers.

**8.2.7.4** Continuing reinforcement shall have an embedment length not less than the development length  $l_d$  beyond the point where the bent or terminated tension reinforcement is no longer needed to resist bending.

**8.2.7.5** No flexural bar shall be terminated in a tension zone unless one of the following conditions is satisfied:

- (a)  $V_u$  at the location of termination is not over two-thirds of  $\phi V_n$ .
- (b) Stirrup area in excess of that normally required for shear and torsion is provided over a distance along each terminated bar or wire equal to  $0.75d$  from the point of cut-off. Excess stirrup area  $A_v$  shall be not less than  $\frac{0.41b_w s}{f_{yt}}$ . Spacing,  $s$  shall not exceed  $\frac{d}{8\beta_b}$ , where  $\beta_b$  is the ratio of area of reinforcement cut off to total area of tension reinforcement at the section.
- (c) For 36 mm diameter bar and smaller, the continuing bars provide twice the area required for flexure at the cut-off point and the shear  $V_u$  does not exceed three-quarter of  $\phi V_n$ .

**8.2.7.6** Where the reinforcement stress is not directly proportional to moment, such as in sloped, stepped, or tapered footings, brackets, deep flexural members, or members in which tension reinforcement is not parallel to the compression face, adequate anchorage shall be provided for the tension reinforcement. See Sections 8.2.8.4 and 8.2.9.4 for deep flexural members.

### 8.2.8 Development of Positive Moment Reinforcement

**8.2.8.1** At least one-third of the positive moment reinforcement in simple members and one-fourth of the positive moment reinforcement in continuous members shall extend along the same face of member into the support. In beams, such reinforcement shall extend into the support at least 150 mm.

These parts shall be fixed by the designer; therefore, the required splicing length shall be following design drawing. However, the drawing has not specified it, which shall be confirmed designer directly. And the site supervisor has to handle these technical matters. In Japan, the concrete cover thickness and splicing length have been stipulated as minimum values, which table would be shown as reference, and the table on the next page is quoted from JASS 5 of Japanese stipulation.

**Table 2-20 Concrete covering thickness (Quoted from JASS 5)**

Size of Concrete Cover for design and Minimum size				Quoted from JASS 5			
Position			Concrete cover size of rebar on design		Minimum concrete cover size of rebar		Stipulation of Enforcement Ordinance of Japanese Construction Standard Law for concrete cover size of rebar
			Dressed Concrete *1	Exposed Concrete *2	Dressed Concrete *1	Exposed Concrete *2	
Not Touching Soil	Roof Slab Floor Slab Wall	Interior	30mm and over	30mm and over	20mm and over	20mm and over	20mm and over
		Exterior		40mm and over		30mm and over	
	Column Beam Structural Wall	Interior	40mm and over	40mm and over	30mm and over	30mm and over	
		Exterior		50mm and over		40mm and over	
Retaining Wall		-	50mm and over *3	40mm and over *3	40mm and over *3	-	
Touching Soil	Column · Beam · Floor Slab · Wall · Built up on the strip footing		-	50mm and over *4	40mm and over *4	40mm and over *4	40mm and over
	Foundation · Retaining Wall		70mm and over *4	70mm and over *4	50mm and over *4	60mm and more *4	60mm and over

\* Execution of a finishing for suitable durability

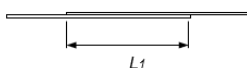
\* Nothing of a finishing for suitable durability

\* To be able to deduct 10mm with a consent of supervisor according to the required quality and construction method

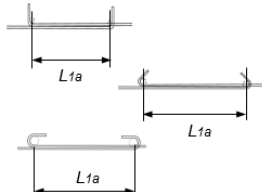
\* In the case of light weight concrete, the value shall be added 10mm

**Table 2-21 Length of lap joint on (Quoted from JASS 5)**

**Splicing length of streght bar  $L_l$**

Concrete Design Strength $F_c$ (N/mm <sup>2</sup> )	SD 295A SD295B	SD345	SD390	SD490	Sketch
18	45d	50d	-	-	
21	40d	45d	50d	-	
24~27	35d	40d	45d	55d	
30~36	35d	35d	40d	50d	
39~45	30d	35d	40d	45d	
48~60	30d	30d	35d	40d	

**Splicing length of streght bar  $L_{la}$**

Concrete Design Strength $F_c$ (N/mm <sup>2</sup> )	SD 295A SD295B	SD345	SD390	SD490	Sketch
18	35d	35d	-	-	
21	30d	30d	35d	-	
24~27	25d	30d	35d	40d	
30~36	25d	25d	30d	35d	
39~45	20d	25d	30d	35d	
48~60	20d	20d	25d	30d	

Notice (1) "d" in the table means a called number of deformed bar such as D10, D13, D16 and so on.

- (2) In the case of a different size of rebar, "d" shall be a smollar size of rebar
- (3) In the case of rebar with hook, the splicing length shall be between the starting points of bending for hook, and the hook length would not add the splicing length
- (4) Bending diameter of the hook (D) shall follow on Table, unless otherwise design document would specified
- (5) In the case of light weight concrete, the splicing length shll follow design requirement basically. As if there is no instruction on the design document, the length which shall be added 5d and permitted by supervisor would be applied for Light weight concrete which strength is  $F_c \leq 36\text{N/mm}^2$  and deformed bar excluding SD490.

➤ **Reference sketch of on-site rebar arrangement**

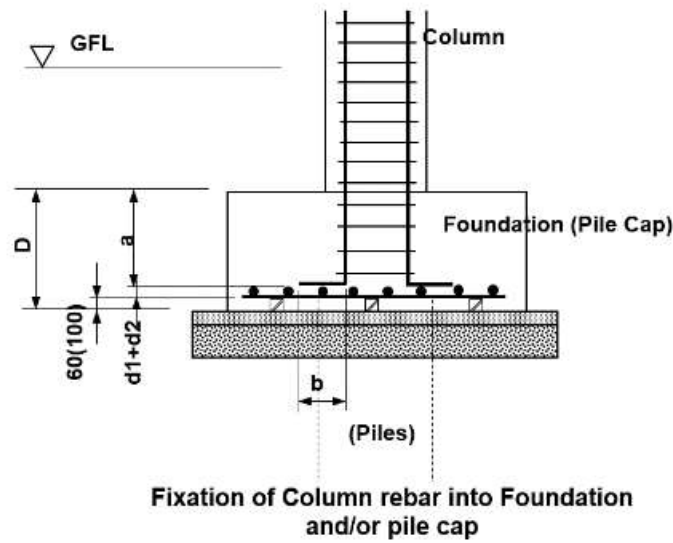
It goes without saying that regulations regarding the arrangement of reinforcing bars must be strictly adhered to, but when arranging reinforcement bars on site, there are other things that must be taken into consideration in addition to the regulations and notes. Some examples are illustrated for reference.

**[References of Placing rebar-1]**

✧ **Column rebar into Pile-Cap/ Foundation Length of Fixation of rebar**

- ✓ Fixation length= a + b, and b = 200

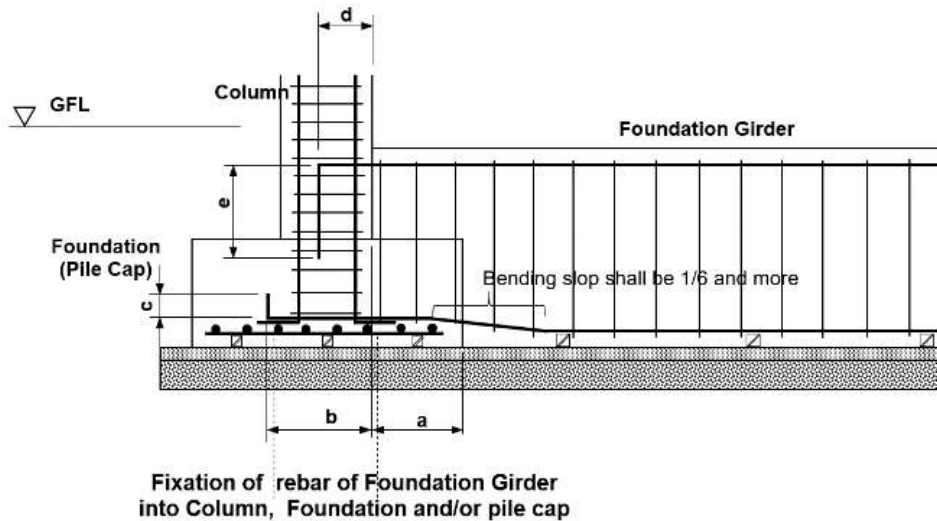
cf: The hook at the hoot of column main rebar is for workability for rebar placing.



D: Depth of Foundation and/or Pile cap  
d1: Diameter of main rebar at bottom of Foundation and/or Pile cap  
d2: Diameter of distribution bar at bottom of Foundation and/or Pile cap

**Figure 2-26 Foot of column bar**

- ◇ Fixation of Ground beam rebar into Column and/or Foundation
  - ✓ Fixation length
    - Into Pile cap and/or Foundation= $a + b + c$
    - Into Column= $d + e$



a + b: Horizontal length of Rebar Fixation from foundation and/or pile cap surface  
c : Hook length  
d : Horizontal length of Rebar Fixation from column surface  
e : Hook length

**Figure 2-27 Anchoring Length in Foundation**

✧ Girder Rebar into Column: Fixation length= $a + c$ , and  $b + d$

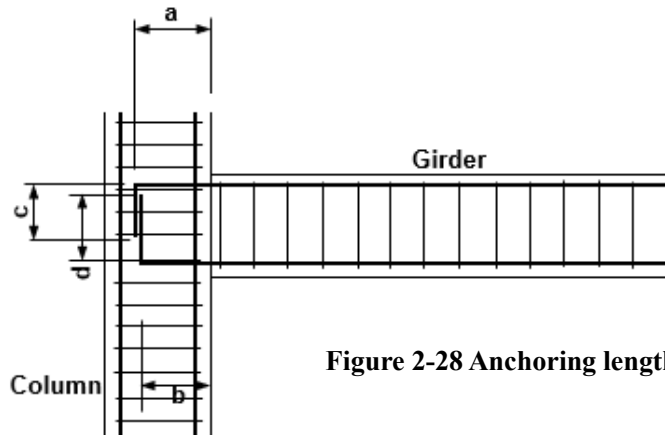


Figure 2-28 Anchoring length/ Girder Main bar

✧ Girder passing throw at Column: Girder rebar shall not be spliced at the position.

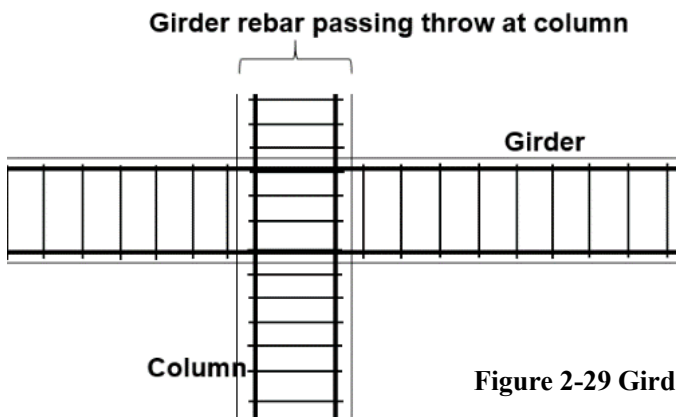


Figure 2-29 Girder Main Bar at panel zone of Column

✧ Sub-beam Rebar into Girder

✓ Fixation length= $a + c$ , and/or  $b + d$

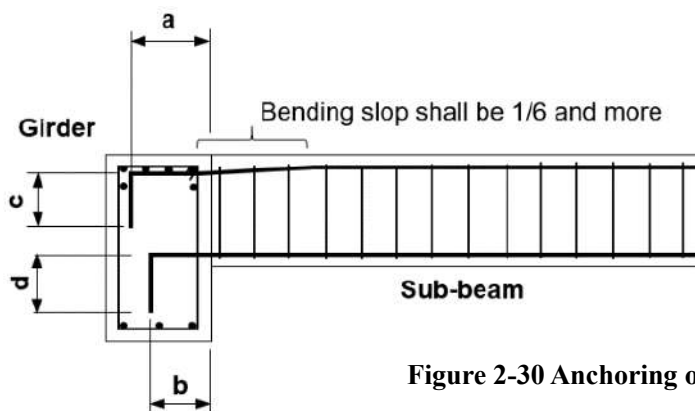
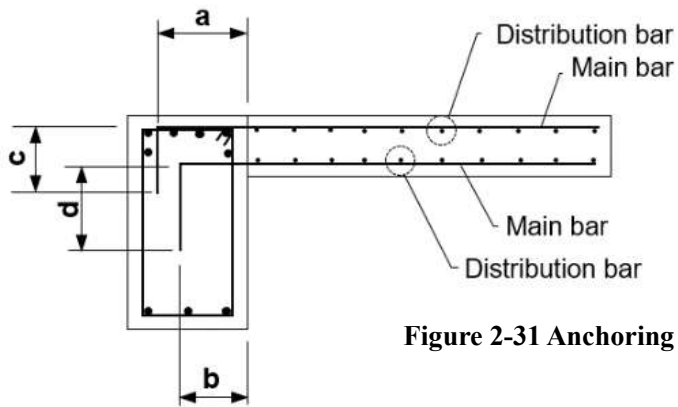


Figure 2-30 Anchoring of Sub-beam main bar into Girder

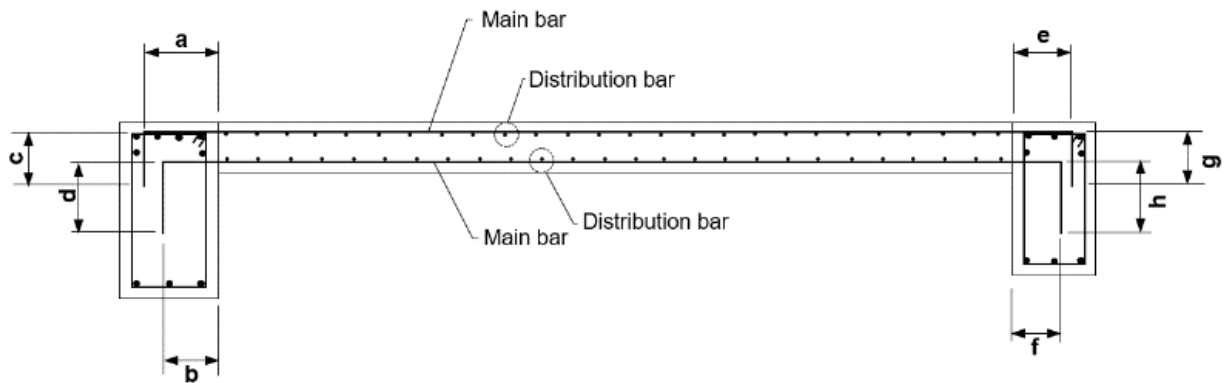
✧ Slab rebar of Cantilever-slab into Girder and/or Beam

✓ Fixation length: =  $a + c$ , and  $b + d$



**Figure 2-31 Anchoring of Main bar of Cantilever Slab**

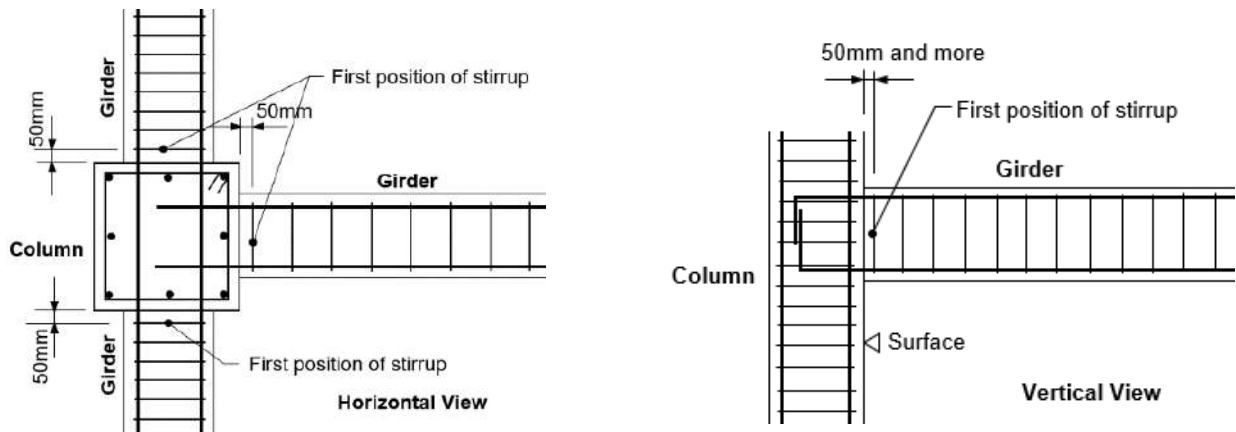
- ✓ Fixation length at left side=  $a + c$ , and/or  $b + d$   
at right side=  $e + g$ , and/or  $f + h$



**Figure 2-32 Anchoring of Slab Main bar (Both side fixed)**

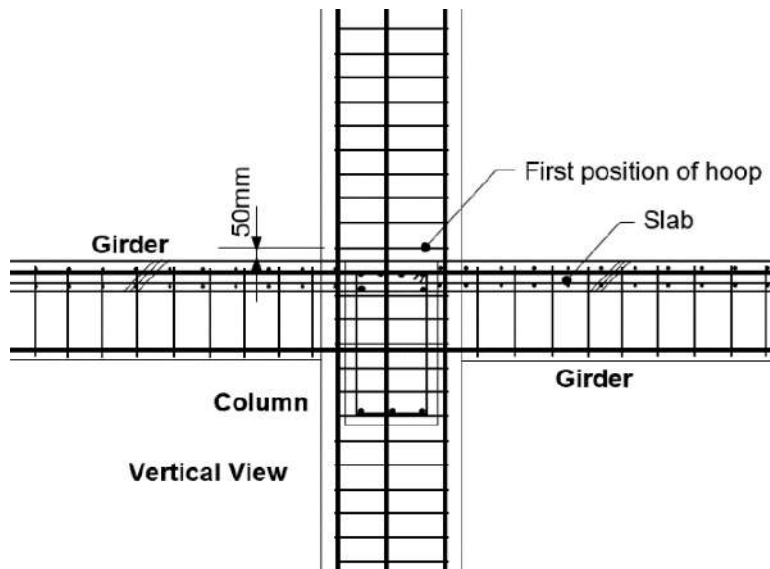
Careful point of arrangement for Hoop and/or Stirrup (References of Placing rebar-  
Careful point of arrangement for Hoop and/or Stirrup (References of Placing rebar-

- ◇ First position of Hoop and/or Stirrup  
Stirrup: It shall be placed at approximately 50mm from column surface.



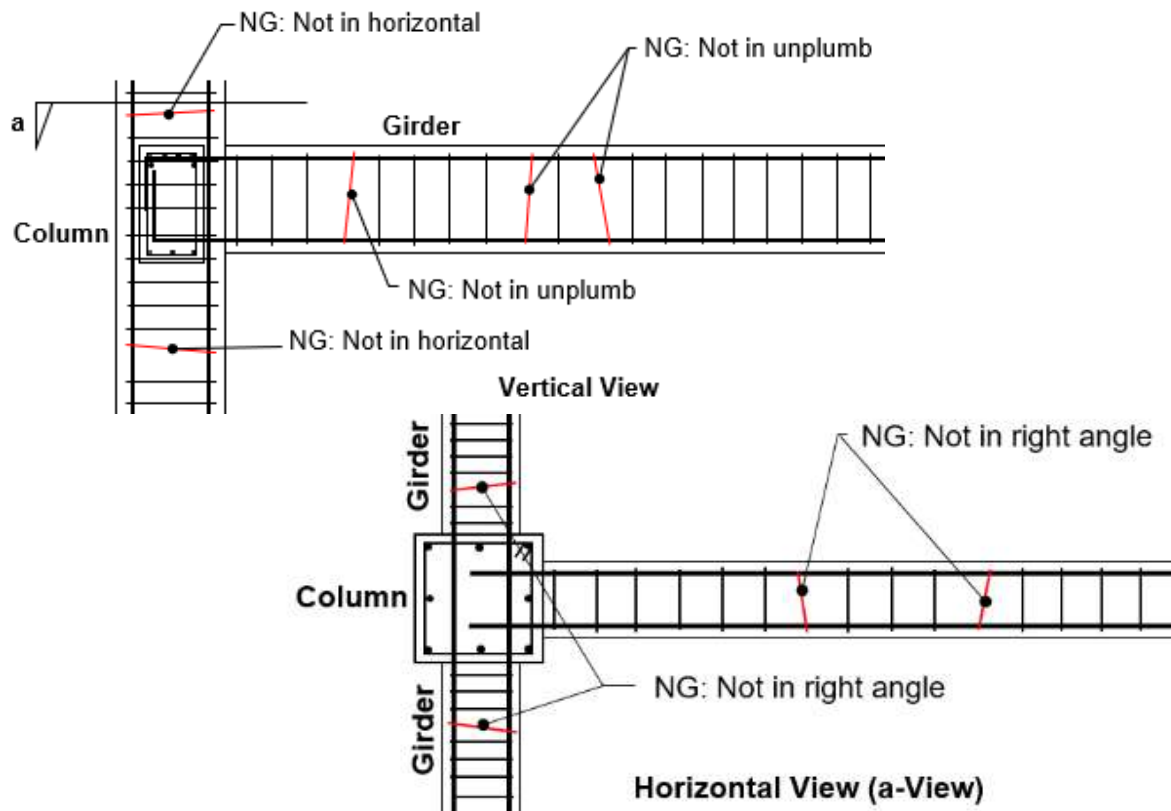
**Figure 2-33 First position of Stirrup (From Column)**

- ◇ Hoop: It shall be placed at approximately 50mm above the slab surface.



**Figure 2-34 First position Stirrup (Above of Slab)**

- ◇ Fixing condition of Hoop and Stirrup  
Hoop and Stirrup shall be set in plumb and/or horizon, and that stirrup shall also be set in right angle toward the direction.

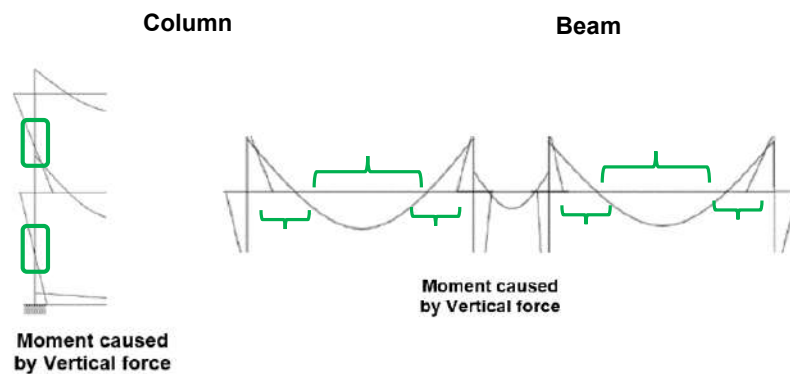


**Figure 2-35 Condition of Stirrup/ Hoop arrangement**

◇

◇ Splicing position

When Main rebar of Column, Girder and/or Beam will be spliced, the splicing position shall be in small stress area. Building frames have borne compressive and tensile stresses in part by part. Refer to 3.1 “Building quality (Building strength)”  
 The below sketches are showing low tensile stress area under each load such as vertical and horizontal.



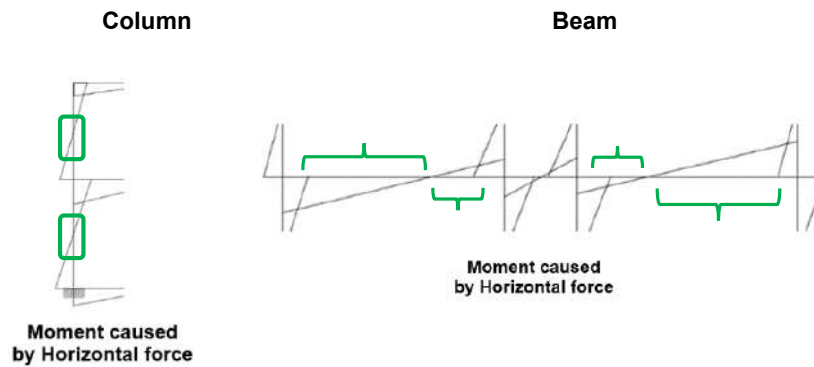


Figure 2-36 Small stress area

In short, the splicing position shall be as follows.

**[Column]**

In both cases such as Vertical and Horizontal forces, the head and foot of column shall bear maximum stress, therefore, the splicing position shall be in middle part.

**[Girder and Beam]**

In both cases, the condition of moment is as a sketch on the right side, so that the stress which appears on the Girder and Beam is compressive and tensile stresses at part by part. We have to consider both cases at the same time and the splicing area shall be selected. Normally, a splicing area will be as shown the below sketch., which is quoted from JASS 5, in Japan.

Refer to Figure 2-37: Splicing area quoted from JASS 5

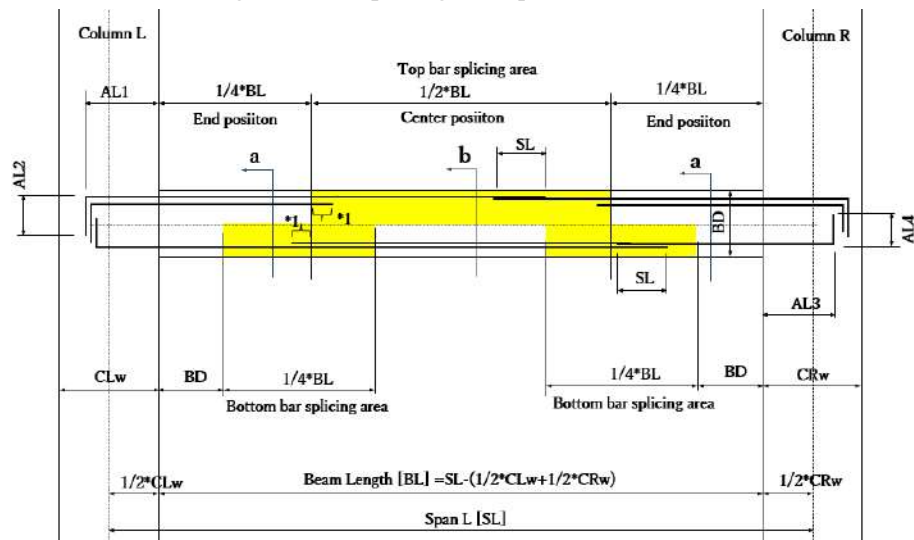
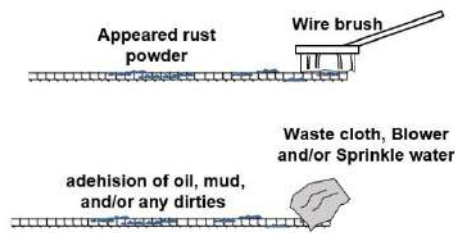


Figure 2-37 Splicing area of Girder and/or Beam

In short, *the splicing shall be in a small tensile area*, and before installing of rebar, it shall be cleaned up the rust, oil, muddy and any other dirty as Figure 2-38.



**Figure 2-38 Removal of Rust on the rebar**

BNBC has stipulated clearly for the above as shown below.

#### Quoting from BNBC Part 6

##### 8.1.4 Surface Conditions of Reinforcement

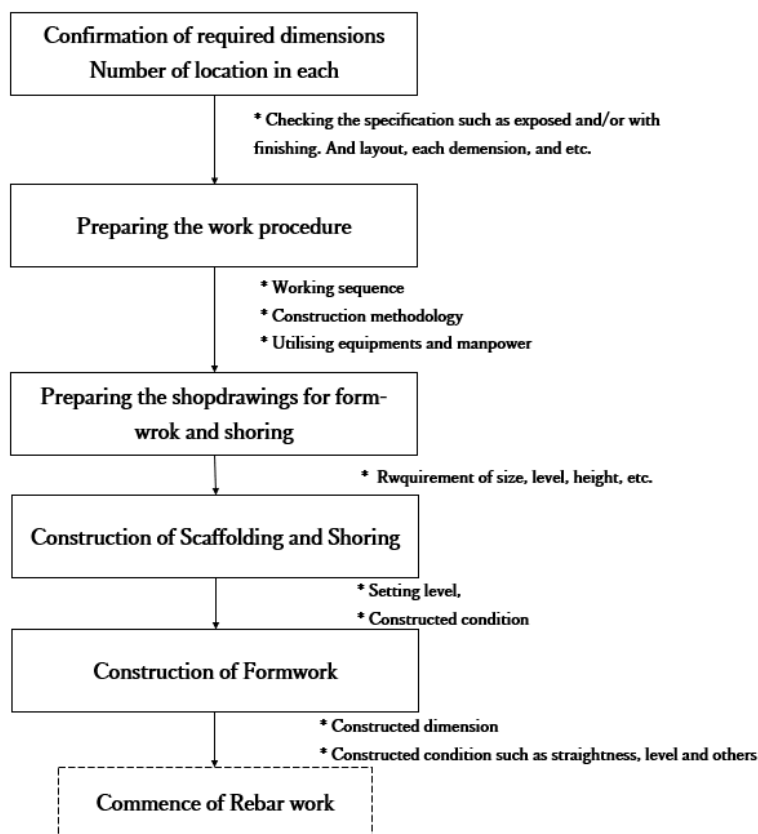
8.1.4.1 When concrete is placed, metal reinforcement shall be free from mud, oil, or other nonmetallic coatings that decrease bond. Epoxy-coating of steel reinforcement in accordance with standards referenced in this Code shall be permitted.

8.1.4.2 Metal reinforcement with rust, mill scale, or a combination of both, shall be considered satisfactory, provided the minimum dimensions (including height of deformations) and weight of a hand-wire-brushed test specimen are not less than applicable ASTM specification requirements.

#### 2) Shoring and Formwork

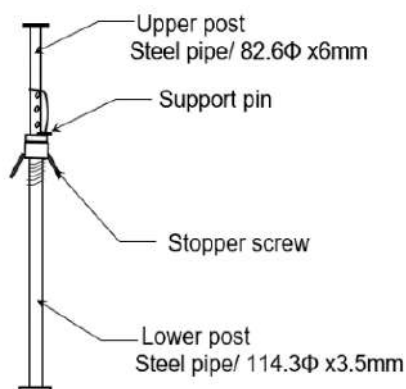
It is important for the quality of construction that the concrete has to be poured into the formwork rigidly and densely at the site. For this reason, when pouring concrete, it is necessary to use an appropriate vibrator and thoroughly compact the area where the concrete has been poured. In addition to these tasks, the formwork assembled at the site and the shoring that supports it are subjected to large weights, vibrations, and shocks due to the pressure of the concrete pump and the work of many workers standing on the formwork. The formwork and shoring must be constructed robustly enough to withstand these external forces and their own weight of the concrete and rebar. At many construction sites in Dhaka, bamboo is used for shoring for floor slabs and beams. Of course, the use of bamboo is described in the BNBC as a traditional construction method, but nowadays, as mentioned above, it is necessary to ensure the sufficient strength of the shoring to ensure quality. Here, we will introduce examples of assembly of shoring using scaffolding materials and/or steel support pipe materials, etc. and formwork using plywood materials, and how to check its strength.

➤ Work-flow of Formwork



➤ Shoring system

Shoring systems are required to construct the Building frame such as column, Girder/Beam, and slab, which shall plan suitably, and there are several kinds of shoring systems such as using pipe support, and/or using frame scaffolding and others.



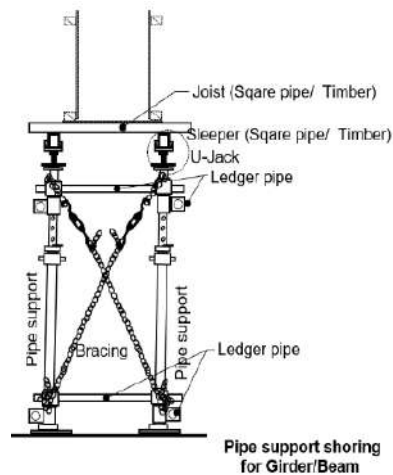
**Figure 2-39 Part name of Pipe support**

The most important point is to have sufficient strength for dead load, live load such as workers and equipment and any impaction during concreting work, such as casting, tamping/ vibrating and others.

◇ Pipe support shoring

The figure on the left is a sketch of the pipe support, which has a double pipe structure so that its length (height) can be easily adjusted. In addition, it can be fine-tuned with a steel pin, so that it can be easily adjusted to the height of the beam base and/or slab formwork that it supports.

The illustration below is an example of beam formwork support using pipe supports.



**Figure 2-40 Sample of shoring by Pipe-support for Beam formwork**

**[Base plank]**

The thickness is approximately 25mm, which shall be set in each pipe support line.

**[Pipe support]**

It shall be installed in each 900 mm~1000 mm (depending on the loads to be born), and it shall be set in plumb

**[U-Jack]**

It shall be set at each pipe support top position.

**[Sleeper Pipe/ Timber]**

It is a square pipe and/or timber, and that it shall set in each U-Jack line.

**[Joist (Pipe/ Timber)]**

Joists shall be installed in each 300 mm~600 mm, which depends on the loads to be bear and the bending rigidity of the material.

**[Ledger pipe]**

It works to connect each pipe support to prevent warp and distortion, which setting position shall be depended on the supporting height and at least two layers for safety

**[Brace]**

The supporting system shall be rigid to resist the warp and distortion, so that the support system shall be reinforced be a brace, which materials are steel chain and turn-buckle.

**[Allowable Bearing force of Pipe support]**

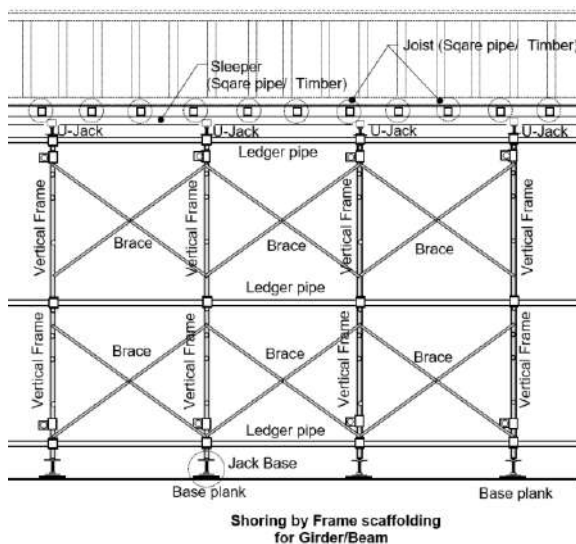
Usually, it is approximately 2000 kg, which depends on the material, the sketch shows normal type of the pipe support in Japan, and that the cross-sectional performance is showing on below table.

**Table 2-22 Allowable stress on Pipe support (Quoting from JIS))**

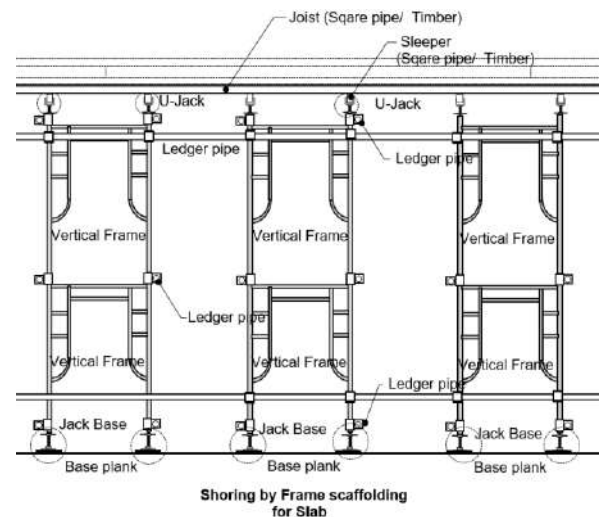
Performance	Upper Post Φ82.6 x 6mm	Lower Post Φ114.3 x 3.5mm
Cross-sectional area A [cm <sup>2</sup> ]	12.40	12.18
Geometical moment of inertia [cm <sup>4</sup> ]	71.30	187.10
Section modulus [cm <sup>3</sup> ]	17.26	32.75
Radius of gyration of area [cm]	2.44	3.92

◇ Shoring of Frame scaffolding

This style is to construct a shoring system for Girder/Beam and slab using scaffolding, so that U-Jack will be set at top of vertical frame, and then sleeper pile/timber will be installed at the U-Jack. Joist pile/timber and bottom shuttering panel consequently installed on the sleeper pipe/ timber, and the scaffolding has to be reinforced by ledger pipe and/or connection pipe, if necessary.



**Figure 2-41 Shoring of Frame scaffolding (Beam)**



**Figure 2-42 Shoring of Frame scaffolding (Slab)**

Moreover, frame scaffolding consists of vertical frames with jack base (for the bottom), Horizontal frame, joint pin and braces (both sides), so frame scaffolding can be used as a shoring system when fully constructed with all constituent parts avoiding collapse and other accidents.

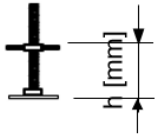
◇ Strength of Frame scaffolding

Allowable Bearing Power of Vertical Frame: Approx. 42500 N (per 1 parts)

Allowable Bearing Power of Jack Base:

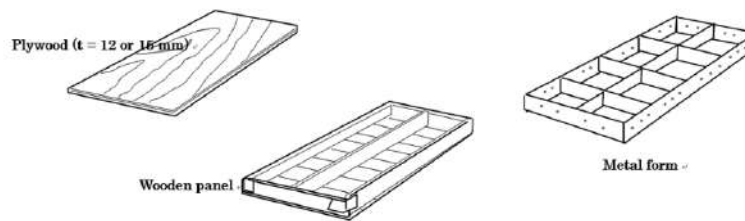
Jack base can adjust the supporting height, so that the allowable bearing power will depend on the supporting height, each value is below.

**Table 2-23 Allowable loads on Jack base (Quoting from JIS)**

Sketch	Ussing height h[mm]	Allowable Bearing Power [N]
	200mm and less	Approx. 21,000 N
	250mm and less	Approx. 20,000 N
	300mm and less	Approx. 19,000 N
	350mm and less	Approx. 18,500 N

➤ **Formwork**

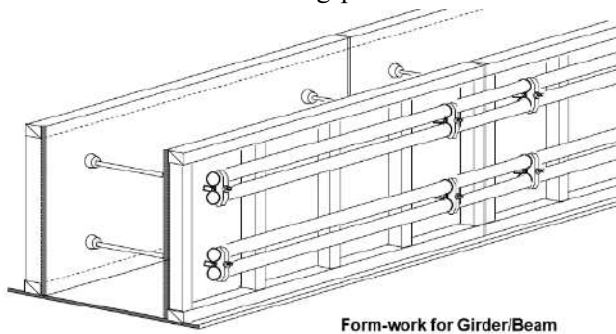
The shuttering panel is normally a steel panel and/or wooden panel, and the shuttering panel shall have a suitable strength to bear the concrete casting pressure.



**Figure 2-43 Kinds of shuttering panel**

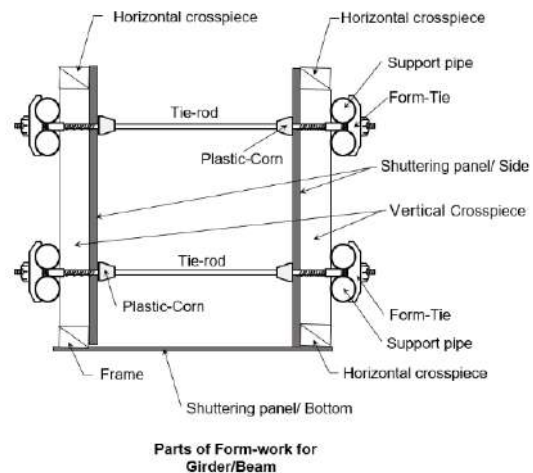
**[Composition of form work]**

Formwork has composed the mold for pouring concrete together with the other reinforcing parts. The sketch on the below shows the composition of Girder/Beam,

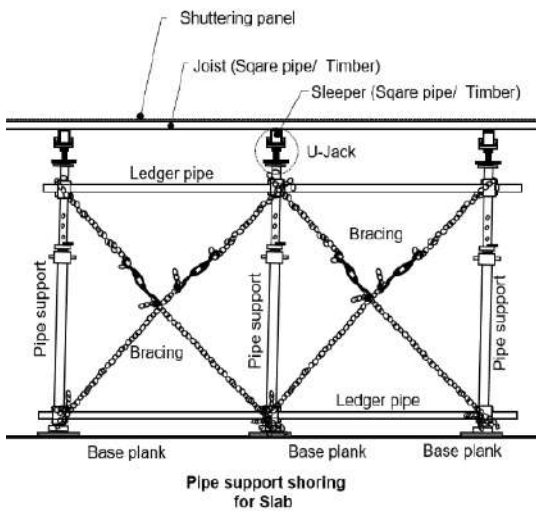


**Figure 2-44 Formwork for Girder/Beam**

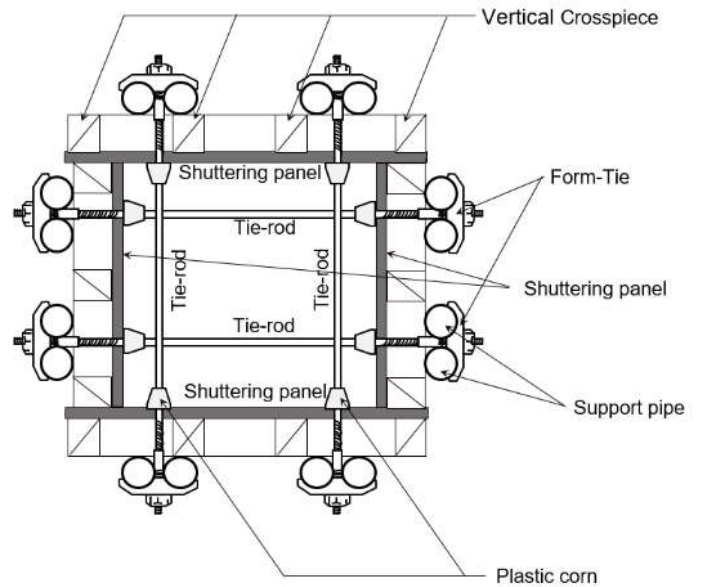
column, and slab form work, which is one sample of various types. Shuttering panel is reinforced against concrete pressure by a crosspiece, a tie-rod and a form-tie, especially the bottom shuttering for slab will be borne by joist of Shoring.



**Figure 2-45 Each Parts for Girder formwork (Vertical cross section)**

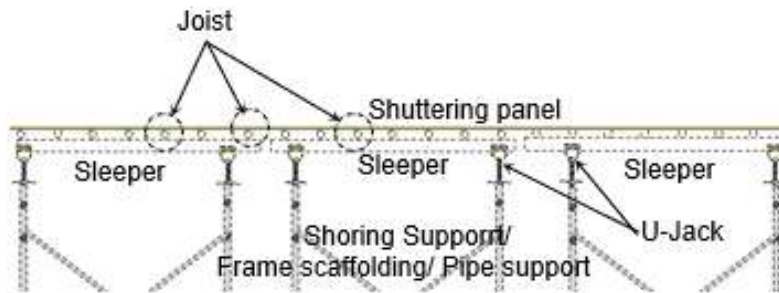


**Figure 2-47 Slab form-work**



**Parts of Form-work for Column**

**Figure 2-46 Each Parts for Column formwork**  
(Horizontal cross section)



**Figure 2-47 Slab form-work**

Slab form-work and bottom shuttering panels have been borne by shoring materials such as sleeper and Joist.

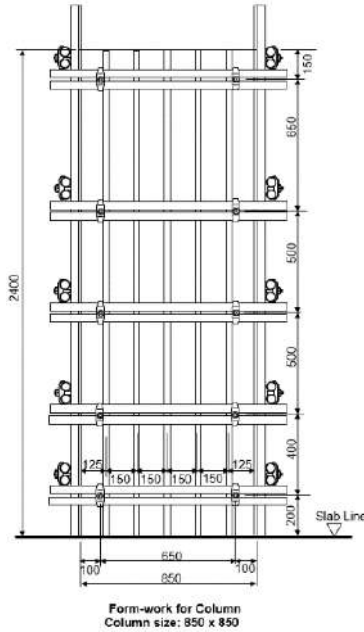
**[Strength of formwork]**

Formwork is a general term for the mold formed by formwork panels and other reinforcing materials into which concrete is poured.

As if the form work has not had enough strength, it would deform and/or be broken, therefore, it shall

be reinforced by Sleeper and Joist, or crosspiece and support pipe.

Basically, Form work shall bear some stresses such as concrete weight, casting pressure, the own weight of shuttering panel, rebar weight, other materials weight such as embedded materials and temporary weight such as worker, tools, etc.



**Figure 2-48 Column form-work**

Side shuttering panel of Column and Girder/Beam have been affected by the pressure on the surface of the poured concrete, and tie-rod and cross piece are as well. Therefore, the shuttering panel, tie-rod and other parts have to be confirmed the safety against the concrete pressure by calculation. In the case of no using tie-rod, shuttering panel and arrangement of supporting material shall be checked by calculation as well.

The "Standard Specifications for Construction Works 5/Concrete Works" created and published by the Architectural Institute of Japan stipulates the following regarding formwork design, so that it would be shown for reference.

### 9.7 Structural calculations for formwork

- a. Formwork strength and rigidity calculations are performed for the vertical load, horizontal load, and lateral pressure of concrete during concrete construction, taking into account vibration and impact during pouring.
- b. The vertical load during concrete construction refers to the vertical external force applied to the squares due to the mass of concrete, reinforcing bars, formwork, construction machinery, various materials, and workers, and its value is determined according to the actual situation.
- c. The horizontal load during concrete construction refers to the horizontal external force applied to the formwork due to wind pressure, eccentric load during concrete pouring, and starting, stopping, and running of machinery, and its value is determined according to the actual situation.
- d. The lateral pressure of concrete for formwork design is based on Table 9.1.

**Table 9.1 Concrete lateral pressure for formwork design (JASS 5)**

Pouring speed (m/h)		less than 10		over 10 to 4.0 and less		over 2.0
		1.5 less	Over 1.5 to 4.0 and less	2.0 and less	Over 2.0 to 4.0 and less	4.0 and less
Part	H(m)					
	Column		$1.5W_0+0.6W_0 \times (H-1.5)$		$2.0W_0+0.8W_0 \times (H-2.0)$	
Wall	Length 3m and less	$W_0H$	$1.5W_0+0.2W_0 \times (H-1.5)$	$W_0H$	$2.0W_0+0.4W_0 \times (H-2.0)$	$W_0H$
	Length 3m more		$1.5W_0$		$2.0W_0$	

[Note] H: Head of fresh concrete (m) (height of concrete poured above the position where lateral pressure is required)

$W_0$ : Unit volume mass of fresh concrete (t/m<sup>3</sup>) multiplied by gravitational acceleration (kN/m<sup>3</sup>)

- e. The allowable stress of materials used in structural calculations of formwork shall be based on (1) and (2) below.

(1) For shoring, the value set forth in Article 241 of the Industrial Safety and Health Regulations

(2) For items other than shoring, the average value of the short-term allowable stress and long-term allowable stress in the following laws, regulations, standards, etc.⇩

(i) Articles 89 and 90 of the Enforcement Order of the Building Standards Act⇩

(ii) The Architectural Institute of Japan's "Draft Guidelines for Formwork Design and Construction", "Steel Structure Design Standards", "Light Steel Structure Design and Construction Guidelines", and "Wood Structure Design Standards"⇩

The following is a reference calculation example based on the abovementioned regulations of the Architectural Institute of Japan. (Quote and reference: Formwork Design and Construction Guidelines/Edited by the Architectural Institute of Japan)

**[Reference calculation 1] Column form-work**

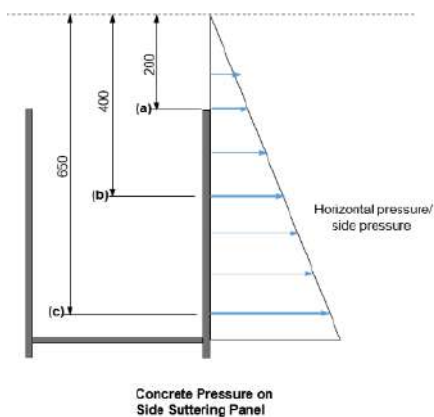
The material performance of column form-work for reference calculation is shown in the table below

**Table 2-24 Allowable stress on shuttering materials (Quoted from JIS)**

**Material Performance**

Kinds /Shape		Section Modulus $Z$ ( $\times 10^3 \text{mm}^3$ )	Geometrical Moment of Inertia $I$ ( $\times 10^4 \text{m}^4$ )	Allowable Bending Unit Stress $f_b$ (N/mm <sup>2</sup> )	Modulus of Direct Elasticity $E$ (kN/mm <sup>2</sup> )	Remark
Shuttering panel	Plywood, t=12mm	0.024 *1)	0.0144 *1)	7.8	3.5	Long side use on Vertical
Crosspiece	50 x 25mm	10.4 $10^3$	26	10.3	6.9	Vertical direction
Sport pipe	$\Phi$ 48.6 t=2.4mm	3.83	9.32	156.9	206	Horizontal direction
Tie-rod	$\Phi$ 7, Carbon steel rod	Allowable Tension: 14kN/piece				

\* 1): Unit wide is 1mm



◇ **Calculation of Side Pressure**

The side pressure effect on the shuttering panel as the left side sketch.

The side pressure on each position such as (a), (b) and (c) is as below.

Side pressure (Pa):  $23.5 \times 0.20 = 4.70 \text{ kN/m}^2$

Side pressure (Pb):  $23.5 \times 0.40 = 9.40 \text{ kN/m}^2$

Side pressure (Pc):  $23.5 \times 0.65 = 15.3 \text{ kN/m}^2$

**Figure 2-49 Side pressure**

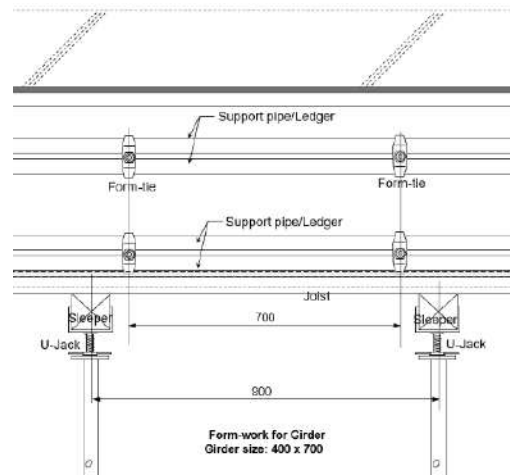
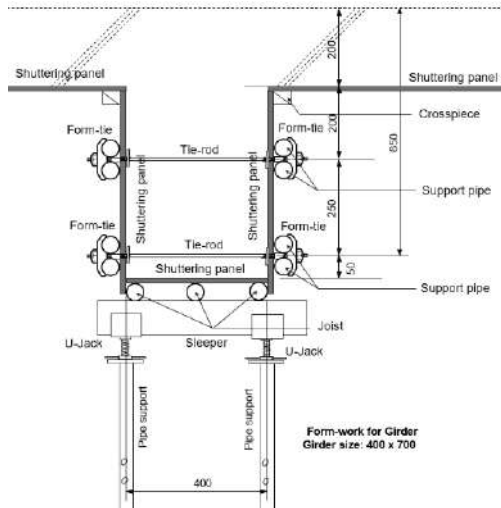


Figure 2-50 Sample for Beam-formwork

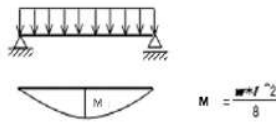
➤ **Checking the shuttering panel**

The side pressure is considered value at lower tie-rod position as safety side, therefore,

$$P = 15.3 \text{ kN/m}^2$$

And the load at the panel in each 1mm,

$$w = 15.3 \times 10^{-3} \text{ mm}$$



$$\text{Bending Stress } \sigma \text{ [N/mm}^2\text{]} = \frac{M}{Z} = \frac{wl^2}{8 \times Z}$$

$$= 15.3 \times 10^{-3} \times 250^2 / (8 \times 24) = 4.98 \text{ N/mm}^2 < 7.8 \text{ N/mm}^2 \rightarrow \text{OK}$$

Figure 2-51 Moment on Simple Beam

$$\text{Flexure } \delta \text{ [mm]} = \frac{5 \times wl^4}{384 \times EI}$$

$$= 5 \times 15.3 \times 10^{-3} \times 250^4 / (384 \times 3.5 \times 10^3 \times 144) = 1.54 \text{ mm}$$

➤ **Checking Support pipe**

The load at the lower tie-rod in each 1mm,

$$w = 15.3 \text{ kN/m}^2 \times 0.175 \text{ m} = 2.68 \text{ kN/m} \rightarrow 2.68 \text{ N/mm}$$

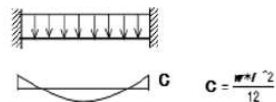


Figure 2-52 Bending Moment Both end fixed

In the case of the tie-rod pitch is 700mm, and support pipe is two pipes, therefore,

$$\text{Bending Stress } \sigma \text{ [N/mm}^2\text{]} = \frac{M}{Z} = \frac{wl^2}{12 \times Z}$$

$$= 2.68 \times 700^2 / (12 \times 3.83 \times 10^3 \times 2)$$

$$= 14.3 \text{ N/mm}^2 < 156.9 \text{ N/mm}^2 \rightarrow \text{OK}$$

$$\text{Flexure } \delta \text{ [mm]} = \frac{wl^4}{128 \times EI}$$

$$= 2.68 \times 700^4 / (128 \times 206 \times 10^3 \times 9.32 \times 10^4 \times 2) = 0.13 \text{ mm}$$

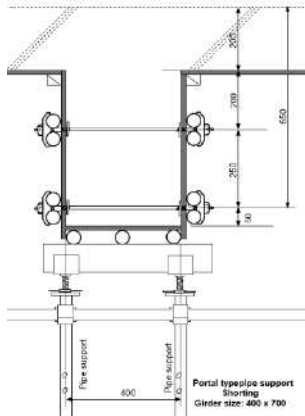


Figure 2-53 Beam formwork

➤ **Checking Tightening Material**

The load affected the tie-rod (P),

$$P = 2.68 \text{ N/mm} \times 700 \text{ mm} = 1880 \text{ N} = 1.88 \text{ kN} < 13.73 \text{ kN} \rightarrow \text{OK}$$

The diameter of the tie-rod is 7mm, which cross-section 34mm, therefore, when the Girder width (B) is 400mm, using half of a width,

$$\text{Flexure } \delta[\text{mm}] = \frac{1}{2} \times B \times P / (S \times E)$$

$$= 400 \times 0.5 \times 1880 / (34 \times 206 \times 10^3) = 0.05 \text{ mm}$$

Therefore,

$$\text{Total Flexure } \sum \delta = 1.54 + 0.13 + 0.05 = 1.72 \text{ mm}$$

✧ **Calculation of Bottom shuttering**

Calculation of Vertical Loads (w);

The dead load of the Girder/Beam had better to include the rebar weight (1.0 kN/m<sup>3</sup>), however, herein it will be ignored

$$\text{Vertical Loads} = \text{Dead Load} (23.5 \text{ kN/m}^3 \times 0.7 \text{ m} + 0.4 \text{ kN/m}^2)$$

$$+ \text{Live Load} (1.5 \text{ kN/m}^2)$$

$$= 18.35 \text{ kN/m}^2$$

➤ **Checking the shuttering panel/ Bottom**

In the case of 200mm pitch of the Joist, the loads borne by the shuttering panel in each meter w =,

$$w = 18.35 \text{ kN/m}^2 \rightarrow 1.84 \times 10^{-2} \text{ N/mm}^2$$

Therefore,

$$\text{Bending Stress } \sigma [\text{N/m}] = \frac{M}{Z} = \frac{wl^2}{8 \times Z}$$

$$= 1.84 \times 10^{-2} \times 200^2 / (8 \times 24) = 3.83 \text{ N/mm}^2 < 7.8 \text{ N/mm}^2$$

→ OK

$$\text{Flexure } \delta[\text{mm}] = \frac{5 \times wl^4}{384 \times EI}$$

$$= 5 \times 1.84 \times 10^{-2} \times 200^4 / (384 \times 3.5 \times 10^3 \times 144) = 0.76 \text{ mm}$$

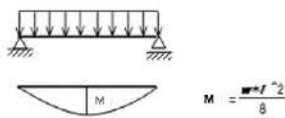


Figure 2-54 Moment on Simple Beam

➤ **Checking the Joist**

In the case of the 200mm pitch of the Joist, Loads effected on the Joist in each meter w =,

$$w = 18.35 \text{ kN/m}^2 \times 0.2 \text{ m (Joist pitch)} = 3.67 \text{ kN/m}$$

$$\rightarrow 3.67 \text{ N/mm}$$

Therefore,

$$\text{Bending Stress } \sigma [\text{N/m}] = \frac{M}{Z} = \frac{wl^2}{12 \times Z}$$

$$= 3.67 \times 900^2 / (12 \times 3.83 \times 10^3) = 64.7 \text{ N/mm}^2 < 156.9 \text{ N/mm}^2 \rightarrow \text{OK}$$

OK

$$\text{Flexure } \delta[\text{mm}] = \frac{wl^4}{128 \times EI}$$

$$= 3.67 \times 900^4 / (128 \times 206 \times 10^3 \times 9.32 \times 10^4) = 0.98 \text{ mm}$$

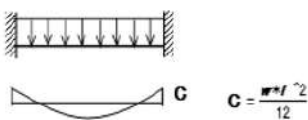


Figure 2-55 Bending Moment Both end fixed beam

➤ **Checking the Sleeper**

Basically, Pipe support shall be fixed by connection pipe as portal type. In the case of the 900mm pitch of the Sleeper, Loads effected on the Sleeper in each meter  $w =$ ,

$$w = 18.35 \text{ kN/m}^2 \times 0.9\text{m (Sleeper pitch)} = 16.52 \text{ kN/m}$$

$$\rightarrow 16.52 \times \text{N/mm}$$

$$\text{And the total loads } p = 16.52 \text{ N/mm} \times 400\text{mm} = 6.52 \times 10^3 \text{ N}$$

Half of the total loads are borne at both edge position, and that it will directly effort the pipe support.

Another half of the total weight effort at the center position of sleeper.

Therefore, Sleeper shall bear half of total load at the center position.

$$P = p \times 1/2 = 6.52/2 = 3.3 \times 10^3$$

$$\text{Bending Stress } \sigma \text{ [N/m]} = M/Z = pl / (4 \times Z)$$

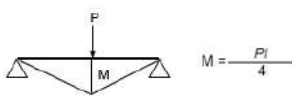
$$= 3.3 \times 10^3 / (4 \times 167 \times 10^3) = 0.005 \text{ N/mm} < 10.3 \text{ N/mm}$$

→ OK

$$\text{Flexure } \delta \text{ [mm]} = pl^3 / (48 \times EI)$$

$$= 3.3 \times 10^3 \times 400^3 / (48 \times 6.86 \times 10^3 \times 833 \times 10^4) = 0.077\text{mm}$$

→ I can be ignored.



**Figure 2-56 Moment of Concentrated load on both side hinge Beam**

➤ **Checking the Sleeper**

The pitch of pipe support is 900mm, the vertical loads of each pipe support  $P$  is,

$$P = 18.35 \text{ kN/m}^2 \times 0.9\text{m} \times 0.4\text{m} \times 0.5 = 3.3 \text{ kN} < 14.7 \text{ kN} \rightarrow \text{OK}$$

3) Concrete work (Transportation, Pouring into mold and Curing)

Concrete construction requires detailed requirements for the specifications of the raw materials used in the concrete and the required strength, as specified by the design documents. The concrete work has included many important construction points that affect the quality of the construction, such as the material mix plan, checking the mixed condition by trial mixing, and actually conducting compressive strength tests for the sampled test piece, as well as site preparations and other matters to be observed during actual on-site construction. The construction supervisor must check whether these construction points are being carried out reliably, make necessary comments as appropriate, and provide guidance on improvements.

Especially, on-site concrete pouring work has three steps such as “Transportation”, “Pouring” and “Curing”.

Herein the important/ Careful point in each step will be explained as follows

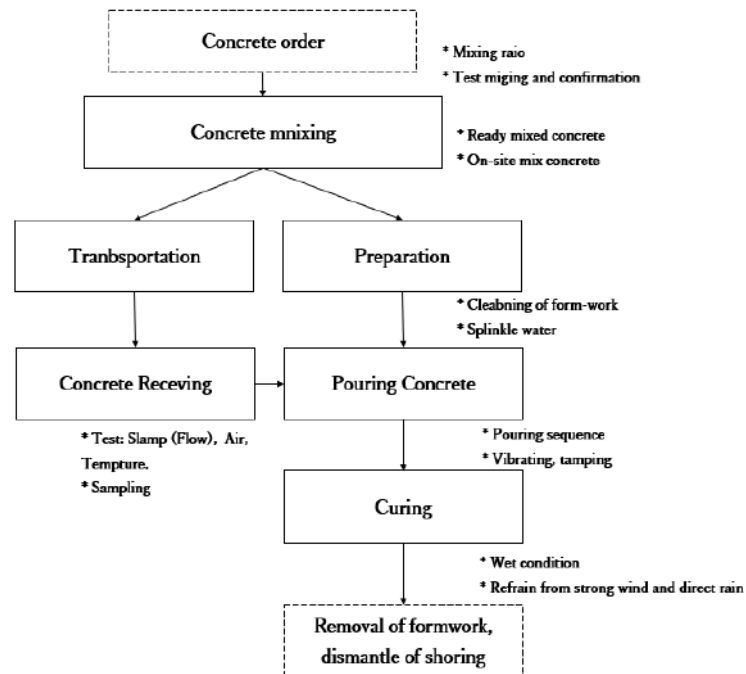
Furthermore, related items include

2.3.1.3 3) "Construction point for concrete work"

2.4.1.2.4) "Concrete test in prior of pouring in place"

so, it is useful to check these as well.

➤ Working Flow



➤ Transportation

When using Ready Mix Concrete, it is necessary to decide which concrete plant to order from after giving careful consideration to the geographical conditions from the concrete plant to the construction site.

● Consideration regarding concrete transportation time

The concrete is produced by a reaction of hydration of cement, so that the time from mixing time at the concrete plant to completion of pouring concrete on site will impact the concrete quality. Furthermore, the higher the temperature, the faster the effect will be. Furthermore, the higher the temperature, the faster the concrete will harden, and the transport time from the concrete plant to the construction site can vary greatly depending on the conditions of the transport route (travel distance, traffic congestion, etc.). After concrete is mixed, the concrete's slump decreases over time, its temperature increases, and its air content decreases. These effects can adversely affect the quality of the concrete, such as causing poor pouring and reduced durability.

For these reasons, the following regulations are in place in Japan:

T: Temperature,

TL: Time limit from mixing to completion of pouring concrete.

$T < 25\text{ }^{\circ}\text{C} \rightarrow \text{TL}=120\text{ minutes}$ ,  $T \geq 25\text{ }^{\circ}\text{C} \rightarrow \text{TL}=90\text{ minutes}$

For this reason, careful consideration of transportation must be given when selecting a plant for supplying Ready Mix Concrete.

**Points to consider when selecting a concrete plant (Ready Mix Concrete)**

- ✧ The location of the concrete plant such (Impact to transportation time)
- ✧ Working time such as morning time, daytime, and/or nighttime. (Impact to Temperature for transportation).
- ✧ Traffic condition on the route from Concrete plant to the site. (Impact on transportation time)

To prevent the temperature of concrete from rising, you can use cooling water or ice in the mixing water. Also, if the outside temperature exceeds  $30\text{ }^{\circ}\text{C}$ , it is effective to add an admixture (water-reducing agent) to the ready-mix concrete to delay hydration time. However, these treatments must be carefully considered when creating the mix plan and decided in consultation with the designer. In seasons or regions where the outside temperature is high during the day, measures such as pouring concrete in the early morning or at night when the outside temperature is low are also necessary. Incidentally, if the cement temperature rises by  $8\text{ }^{\circ}\text{C}$ , the aggregate temperature rises by  $2\text{ }^{\circ}\text{C}$ , and the mixing water temperature rises by  $4\text{ }^{\circ}\text{C}$ , the temperature of the ready-mix concrete will rise by  $1\text{ }^{\circ}\text{C}$ .

- Interval of concrete delivery on site

When ordering Ready Mix Concrete, it is necessary to carefully consider the time required from the delivery of concrete to the completion of pouring. As mentioned above, concrete has time constraints from mixing to the completion of pouring. It is important to start pouring immediately after the concrete is delivered to the site from the concrete plant and complete pouring as soon as possible. If the concrete arrives at the site too early, the concrete pouring at the pouring point cannot keep up, and there will be a waiting time for unloading at the site. Also, if there is too much time between the arrival of the concrete at the site, the concrete poured earlier will harden too much, which will hinder the integration with the concrete poured later and cause cold joints. In this way, it is necessary to balance the amount of concrete delivered to the site and the amount poured at the pouring point.

Therefore, in order to optimize the arrival time (interval) of concrete at the site, the construction supervisor must check the contractor's concrete pouring plan, provide comments and advice as necessary, and strive to ensure that the quality of the concrete construction does not deteriorate.

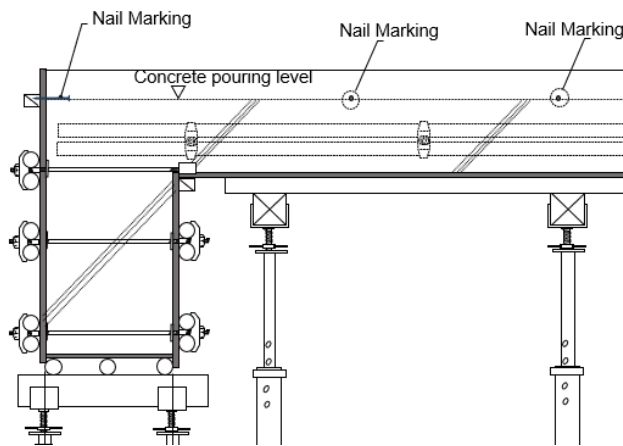
For these reasons, it is important to check the following points to confirm how the

contractor has determined the concrete delivery interval request to the concrete supplier/concrete plant.

**[Concrete casting time for one delivery]**

- ◇ Casting method: Casting method such as manpower only, using crane with bucket and/or concrete pump.
  - ◇ Casting location: underground, ground and/or super structure
  - ◇ Weather on the casting day: rain, cloudy, and/or fine, and also cold or hot.
- Preparation for pouring concrete in place

Before pouring concrete on-site, several preparatory steps are required, and it is important to carry out the following preparatory steps to prevent deterioration of the



quality of the poured concrete.

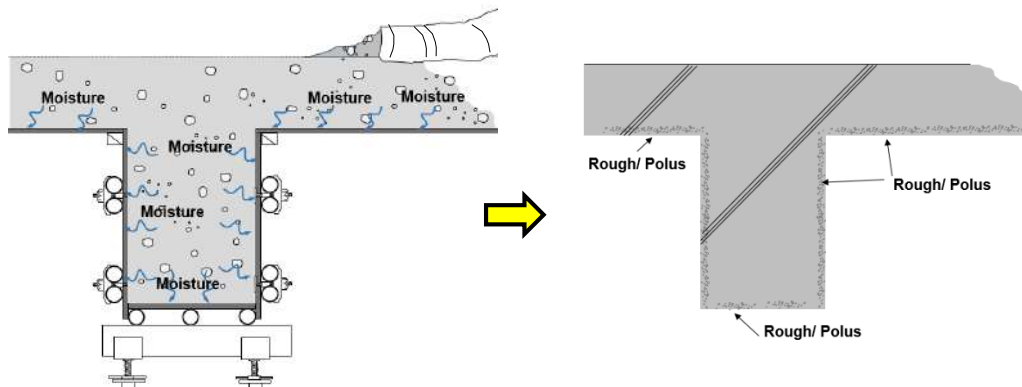
● **Marking the height of concrete pouring**

Mark the height of each part on the formwork where the concrete must be poured. The markings must be made in a way that is clearly visible even while the concrete is being poured.

**Figure 2-57 Nail marking for concrete pouring level**

- **Sprinkling water on the concrete surface of the formwork**

Formwork assembled on-site is generally in a very dry state. If the moisture of the concrete poured into the formwork penetrates the formwork material, the moisture of the concrete in the part in contact with the formwork will be taken by the formwork, resulting in a shortage of moisture for the specified water-cement ratio. This phenomenon can cause the smoothness of the concrete surface to be lost after the formwork is removed and become porous, resulting in a lower quality than expected. To prevent this condition, the formwork before pouring concrete is thoroughly watered to make it moist before pouring concrete. Before starting concrete pouring, the construction supervisor must confirm that the formwork in the part where concrete will be poured is sufficiently moist before approving the start of concrete pouring.



**Figure 2-58 Deterioration of the quality of the concrete surface due to moisture loss**

Deterioration of the quality:

Rough/Polus: Water penetration and Concrete neutralization

→To lead rusting rebar→Deterioration of concrete strength

- Cleaning of formwork

When pouring concrete, mud and debris must not be allowed to get into the concrete being poured. For this reason, it is important to make sure that all impurities such as dust and debris that have accumulated in the formwork during the assembly of the formwork and during the installation of the rebar, as well as mud and rust that have adhered to the surface of the formwork and rebar, have been removed by washing them away with water and other method before starting pouring work in the area where the concrete will be poured.

- Preparation for concrete pouring

In order to properly proceed with concrete pouring work, the following preparations must be made for the pouring area.

- ◇ Create a pouring plan
- ◇ Secure a work path for pouring
- ◇ Prepare the equipment to be used (type/number, etc.)
- ◇ Prepare a temporary power source
- ◇ Night lighting equipment, etc.

The construction supervisor has to ensure that all preparations for pouring work are complete and that the concrete pouring work can proceed safely and smoothly. It is also important to provide appropriate guidance and instructions as necessary

- Concrete pouring in place

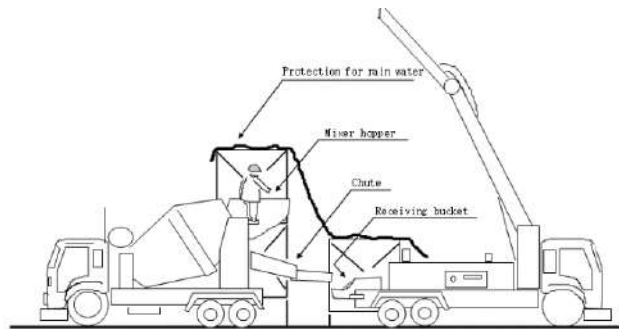
When concrete has been received on site, the concrete should be carried from receiving point to casting location on site using equipment, some of which are

a wheelbarrow, crane with bucket, and/or concrete pump, and it would be poured at the casting position, and then the poured concrete would be compacted to make a rigid condition.

In each working step, there are some important points for the quality, which points in each step are below.

❖ Concrete receiving on site

When receiving concrete, the input hopper must be covered with a vinyl sheet or similar to prevent rainwater from mixing with the concrete in the drum of the concrete mixer truck. Similarly, when using a concrete pump, it is necessary to prevent rainwater from entering the concrete receiving bucket. Similarly, when using a concrete pump, it is necessary to prevent rainwater from entering the concrete receiving bucket.

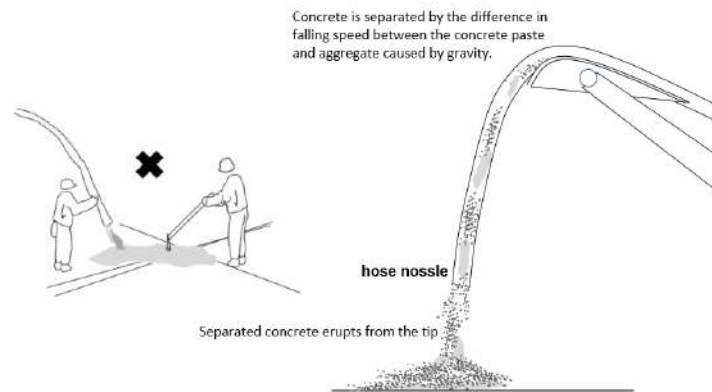


**Figure 2-59 Protection concrete bucket**

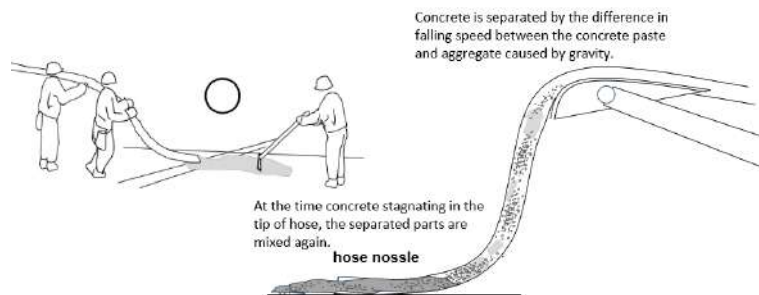
❖ Preventing concrete from separating during pumping

When pumping and pouring concrete with a concrete pump, care must be taken to prevent the concrete from separating. When using concrete pump, it is especially important to lay the nozzle of the concrete pump on the pouring surface so that the concrete does not fall from a high position onto the pouring site. In addition, there are steps to prevent air pockets from forming in the concrete being pumped.

For this reason, the nozzle of the concrete pump must always be lying flat on the pouring site, and pumping pressure must be applied to the concrete without interruption.



**Figure 2-60 Incorrect handling of concrete hose**



**Figure 2-61 Correct handling of concrete hose**

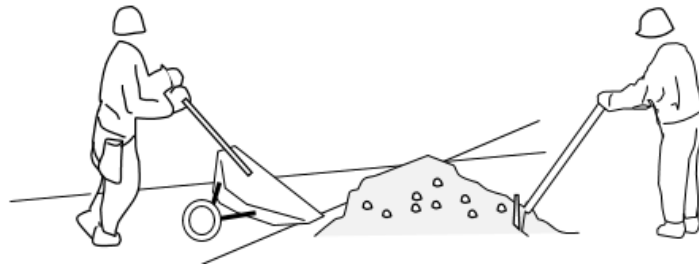
❖ Concrete with a crane and bucket

Before pouring, the bucket has to be clean with washing to prevent impurities from getting into the concrete. A pouring hose is attached to the bucket's pull-out section, but it is important to handle this hose in the same way as when using a concrete pump, by laying the hose horizontally on the pouring surface to prevent the concrete from separating.

❖ Carrying concrete by Wheelbarrow

When the volume of the pouring concrete is small and the pouring location is ground level and/or underground level, a wheelbarrow is reasonable. However, it is carried by manpower, so that the access route shall be kept in good condition for safety and the workability.

Furthermore, sufficient of manpower and pouring equipment has to be prepared to complete the pouring concrete within suitable pouring time.

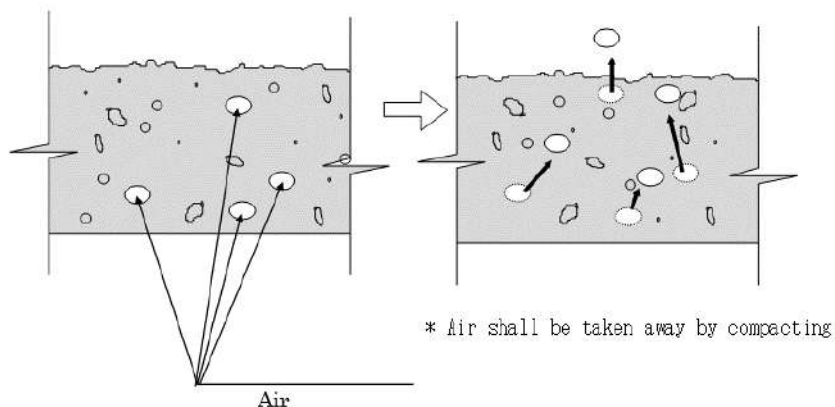


**Figure 2-62 Carrying Concrete by wheel**

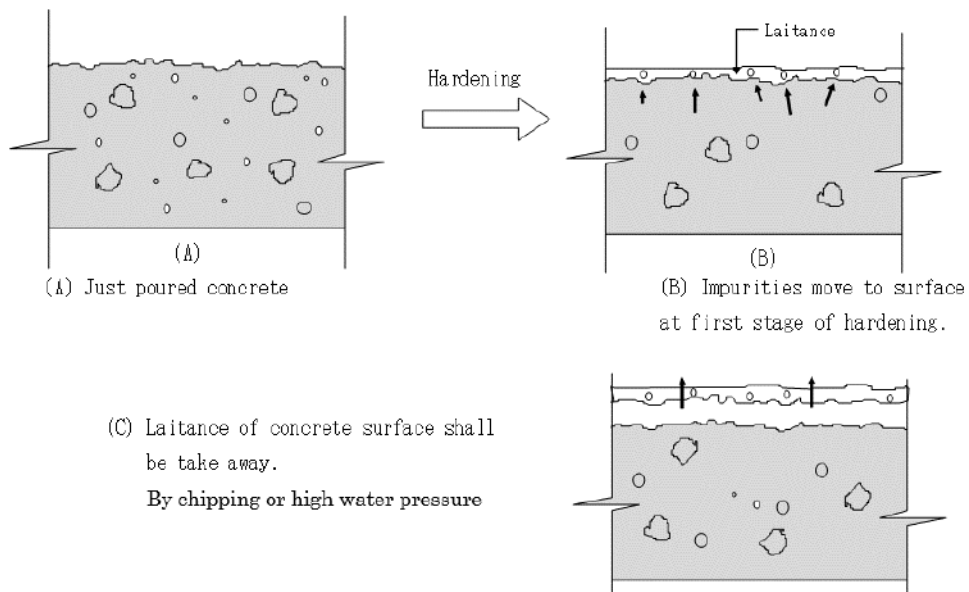
✧ Tamping of poured concrete

Concrete is poured into the casting area together with impurities such as excess air and dust during transportation within the site and during casting. Such excess air in the concrete will cause the concrete to become porous after hardening. There is also concern that the inclusion of impurities such as dust may have a negative effect on the quality of the concrete, such as reducing its strength. For this reason, it is important to vibrate the concrete using a vibrator or tamp the surface of the poured concrete using a square timber or plastering trowel in order to promote the floating of these impurities such as excess air and dust to the surface. Normally, some impurities rise up to the surface according to the vibration and it will make a weakness layer, which impurities has been called “Laitance”.

The illustration below shows the current situation in which impurities such as excess air and dust in the concrete rise to the surface and form a layer.



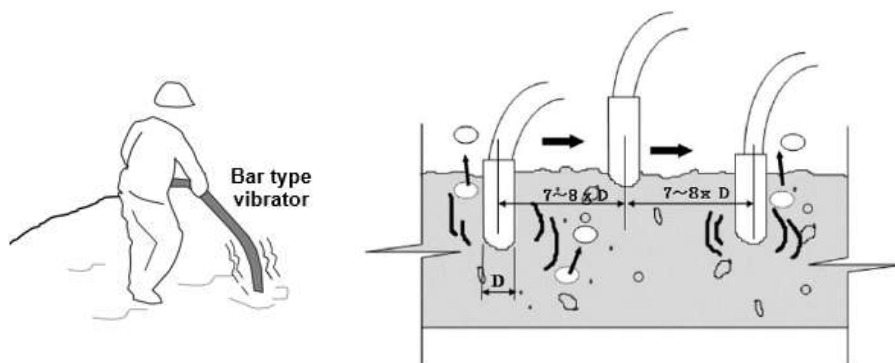
**Figure 2-63 releasing for air bubbles**



**Figure 2-64 Laitance on the surface of concrete**

- ◇ Using method of stick type vibrator

In the case of using a stick type vibrator to accelerate taking away an air bubble, it shall stick in the pouring concrete in short time uniformly. It is incorrect to stick in at a same position for a long time. The next sketch is correct using image.

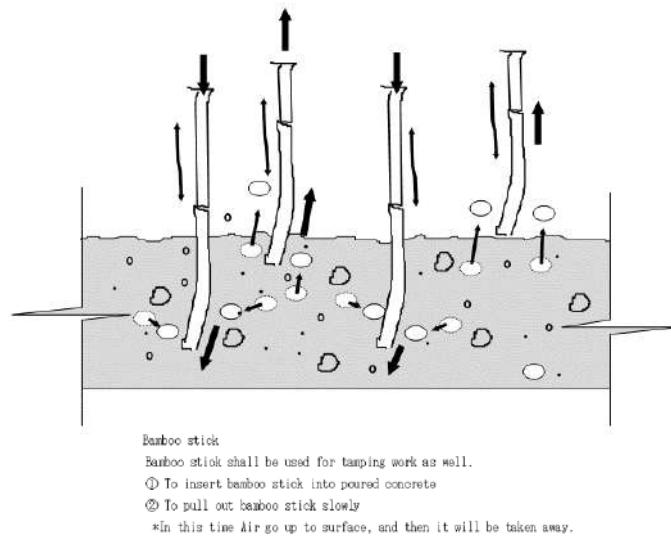


\*it is less than 30 seconds at same position

**Figure 2-65 Imaging sketch for using bar vibrator**

- ◇ Usage of Bamboo stick for tamping concrete

Tamping concrete with a bamboo pole is also an effective way to compact the poured concrete and encourage excess air trapped in the concrete to rise to the surface. In this case, it is important to compact the poured area evenly in each layer of concrete poured.



**Figure 2-66 Tamping of using Bamboo stick**

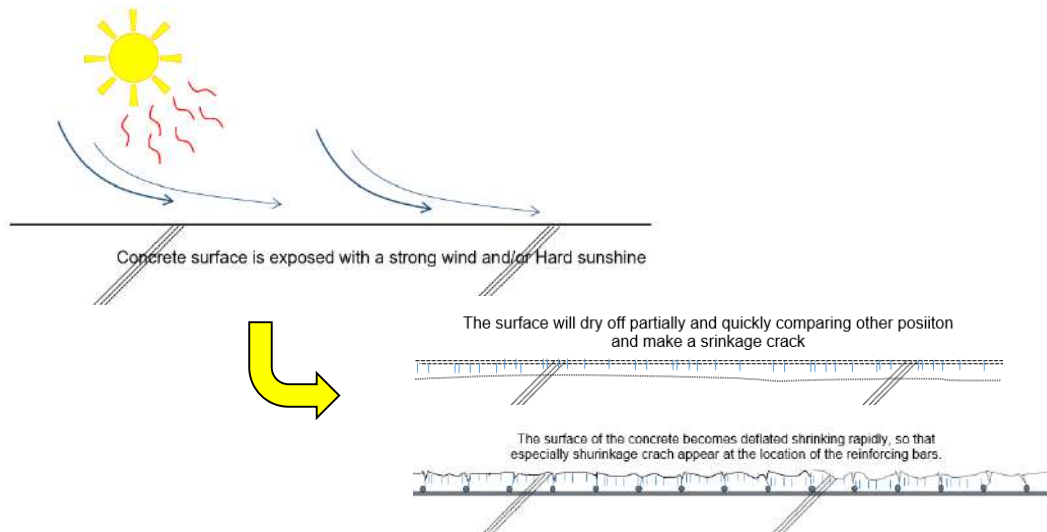
- Concrete curing

- ◇ Initial curing of concrete

Poured concrete hardens slowly, and since it does not achieve sufficient strength in the initial hardening stage, care must be taken not to subject the poured concrete to vibration or impact until a certain level of concrete strength has been achieved, in order to avoid causing internal cracks or other serious effects on the strength of the poured concrete, which is called as initial curing of concrete.

- ◇ Rapid drying of concrete surfaces

It is desirable for poured concrete to dry slowly overall so that shrinkage cracks are less likely to occur (the occurrence of shrinkage cracks also depends on the water-cement ratio of the concrete). However, in general, in a natural environment, the surface is exposed to direct sunlight and wind and dries quickly, but the inside of the concrete is in a moist state during the hydration reaction and is not exposed to direct sunlight or wind, so it dries slowly. This causes differences in the drying speed between the surface and the inside of the concrete, and rapid drying on the surface of the concrete can cause phenomena such as cracks and thinning of the concrete surface



**Figure 2-67 Imaging sketch for rapid draying off**

✧ Wet curing of concrete pouring areas

It is desirable to keep the concrete surface moist so that the poured concrete dries slowly overall. Therefore, immediately after pouring the concrete, it is effective to cover the surface with a vinyl sheet or similar to protecting it from the effects of direct sunlight, wind, rain, etc., and after the surface has hardened to a certain extent, to lay a cloth or jute bag on the surface, and spray water on it to keep it moist during the hardening period.

Cover the concrete surface with a rag or jute bag and soak it in water, and keeping it constantly so the water doesn't evaporate.



**Figure 2-68 Imaging sketch for wet curing**

In addition to wet curing with water, there is also a concrete curing method that involves applying chemical curing materials. It is advisable to use these methods after properly assessing the usage conditions and locations and obtaining approval from the construction supervisor.

● Removal of form-work and dismantling of shoring

When removing formwork, the regulations for removal of formwork and dismantle of shoring stipulated for each part must be followed, and when dismantling the shoring and formwork for slab and beam bottom formwork, the actual concrete strength must be confirmed through a concrete compressive strength test. In addition, when using high-early-strength concrete or pouring normal concrete with a strength that exceeds the concrete's design strength in order to speed up the removal of the formwork, the specifications of the concrete

to be used must be shown to the designer, a discussion must be held, and the designer's approval must be obtained before construction can be carried out. Furthermore, before removing the formwork, a concrete compressive strength test must be conducted to confirm removal, and the results must be submitted to the designer, and permission must be obtained again.

**Table 2-25 Leaving terms for shuttering panel**

The terms for leaving shuttering panel in each part

	Part	side	underneath/ Bottom	
Underground	Foundation	24 hours	-	
	Underground beam	24 hours	-	
Superstructure	Column	24 hours	-	
	Girder/ Beam	Normal stories	48hours	Four weeks and After one floor above concreting
		Roof	48hours	100% Strength
	Slab	Normal stories	48hours	Four weeks and After one floor above concreting
		Roof	48hours	100% Strength

The "Standard Specifications for Construction Work, Volume 5, Concrete Work" created and published by the Architectural Institute of Japan stipulates the following regulations regarding concrete wet curing and formwork removal, which are provided for reference.

## 8.2 Wet Curing<sup>↵</sup>

a. After pouring, the concrete is moist cured by covering it with a low-permeability barrier plate, covering it with a curing mat or watertight sheet, sprinkling or spraying it, applying a membrane curing material, etc. The period of moist curing shall be as shown in Table 8.1 according to the planned service life.<sup>↵</sup>

Table 8.1 Wet curing period (JASS 5)

Planned service life Sement types	Short term and standard	Long-term and ultra-long-term
High early strength portland cement	3 days and more	5 days and more
Ordinary Portland Cement	5 days and more	7 days and more
Other cements	7 days and more	10 days and more

b. For members with a concrete thickness of 18 cm or more, when using early-strength, normal, or moderate-heat Portland cement, moist curing may be terminated even before the end of the moist curing period in section a above if it is confirmed that the compressive strength of the concrete has reached 10 N/mm<sup>2</sup> or more for short-term and standard-term planned service lives, and 15 N/mm<sup>2</sup> for long-term and extra-long-term planned service lives. In such cases, the curing method for the specimen shall be in-situ underwater curing or in-situ sealed curing. <sup>↵</sup>

c. If the shuttering panel is removed after the period specified in 9.9, but before the number of days specified in the above or the compressive strength specified in item b above is reached, the concrete must be kept moist by sprinkling, spraying moisture, or other methods for the number of days or until the specified compressive strength is reached.<sup>↵</sup>

d. When the temperature is high, the wind is strong, or the concrete is exposed to direct sunlight, the concrete surface must be kept moist so that it does not dry out.<sup>↵</sup>

## 8.4 Protection from vibration and external forces<sup>↵</sup>

a. Manage work in the surrounding area so that the concrete is not adversely

affected by harmful vibrations or external forces during setting and hardening.

b. After pouring the concrete, no work should be done on it for at least one day. If walking or working is unavoidable, obtain the approval of the construction supervisor.

### 9.10 Retention period of formwork

a. The retention period of foundations, beams, columns and shuttering panels shall be until it is confirmed that the compressive strength of the concrete has reached 5N/mm<sup>2</sup> or more for short-term and standard-term planned service life, and 10N/mm<sup>2</sup> for long-term and extra-long-term planned service life. However, if moist curing is not performed to the compressive strength shown in 8.2b after removal of the shuttering panels, the shuttering panels shall be left in place until they reach 10N/mm<sup>2</sup> or more and 15N/mm<sup>2</sup> or more, respectively.

b. If the average temperature during the retention period of the dams is 10° C or more, and the concrete age is more than the number of days shown in 9.2, it may be removed without the need for a compressive strength test, regardless of item a.

Table 9.2 Concrete age for determining the retention period of foundations, beams, columns and shuttering panel

Cement Types Average Temperature	Age of concrete (days)		
	High early strength portland cement	Ordinary Portland Cement Blast-furnace cement type A Silica cement type A Fly ash cement type A	Blast-furnace cement type B Silica cement type B Fly ash cement type B
20°C and more	2	4	5
10°C and more to 20°C less	3	6	8

c. In principle, the sheathing panels underneath of floor slabs, roof slabs, and then beams shall be removed after the shoring has been removed.

d. The shoring shall be retained in place until it is confirmed that the compressive strength of the concrete under both the slabs and beams is 100% or more of the design strength.↵

e. If the load applied to the member after the shoring is removed exceeds the design load of the member in the structural calculations, it shall be removed after calculations have confirmed that it is safe, regardless of the period of removal mentioned above.↵

f. If the shoring is removed earlier than the period of removal mentioned above, it must be confirmed that the concrete strength of the structural

concrete, calculated using appropriate calculations, is greater than the strength of the structural concrete that can safely support the load applied to the member immediately after its removal.

Regardless of the results of this calculation, the compressive strength of the structural concrete for which the shoring can be removed must be 12N/mm<sup>2</sup> or more.

g. The period for which cantilever or eaves supports shall be in place shall be in accordance with items d and e above.

**"Notes"** 1) The test method for estimating the strength of structural concrete shall be in accordance with JASS 5T-603, and the curing method for specimens shall be in-situ underwater curing or in-situ sealed curing.

#### **9.12 Removal of Formwork**

a. The formwork shall be gently removed after the period specified in 9.9 has been reached.

b. Inspection after removal of the shuttering panels and repair of pouring defects shall be in accordance with 7.

c. Immediately after removal of the shuttering panels, curing shall be performed in accordance with 8.

d. After removal of the formwork, the presence or absence of harmful cracks and deflections shall be investigated, and if any abnormalities are found, the contractor shall follow immediately by supervisor requirement and instruction.

e. The contractor shall carefully manage the surface condition of the sheathing plate when processing and assembling the formwork so that the concrete surface in contact with the sheathing plate attains the specified finish. After removing the shuttering panels, the contractor shall perform head treatment of the formwork separator and correct any defects as described in 9.4 to achieve the specified surface

## 2.5 Disaster prevention construction (M&E fire prevention equipment related)

In recent years, in order to minimize damage from disasters such as fires and earthquakes, particular importance has been placed on earthquake-resistant buildings and designs that take fire prevention measures into consideration. This article explains the construction supervision of fire prevention equipment and related matters.

The basic principle for protecting buildings and users from fire is to first prevent the occurrence of a fire, then detect the fire early and try to extinguish it at an early stage. If early extinguishing fails, it is very important to evacuate to a safe place as quickly as possible. Applying the above points to construction problems in building construction,

**[Fire prevention]:** Selection of flame-retardant materials, wiring and piping work that leads to the prevention of gas leaks and electric leakage, etc.

"Early detection of fire": Installation of detection equipment such as smoke detectors, heat detectors, and gas detectors, installation of alarm devices, etc.

**[Initial fire extinguishing]:** Installation of portable fire extinguishers, installation of automatic fire extinguishing equipment such as sprinkler systems and carbon dioxide extinguishing systems, etc.

**[Evacuation to a safe place]:** Installation of evacuation stairs, fire doors, emergency lighting equipment, evacuation guidance equipment, etc.

However, in addition, important points in construction are confirmed, taking into account the prevention of the spread of fire and ensuring evacuation time for facility users.

In any case, it is important for the contractor to comply with the requirements of the design documents and complete the building according to the drawings. In addition, Chapter 8 of the BNBC stipulates matters related to the design, construction and inspection of building incidental equipment construction. We will confirm important considerations in construction supervision, including confirmation of the contents of the BNBC.

Again, in the unlikely event that a disaster occurs and material damage, especially human damage, occurs, the contractor and construction supervisor will be severely questioned about the presence or absence of construction errors. Therefore, it is important for construction supervisors to fully understand that "it is strongly required to prevent mistakes during construction and provide correct construction guidance" and perform management duties.

### 2.5.1 BNBC Building Equipment Standards

The BNBC also specifies the design, construction, and inspection of building equipment, and it is important that contractors fully understand the BNBC regulations and proceed with construction in accordance with the design documents, etc.

### 2.5.1.1 BNBC Provisions on Protection of Users from Fire

The following provisions are made regarding three-stage measures to protect facility users from fire, some of which are "Early detection," "Initial fire extinguishing," and "safe evacuation."

#### [Early detection]

Regarding the first step in fire prevention, which is to detect a fire early and inform users, BNBC Part 4 explains as follows in Chapter 4, "Standards for Equipment and Facilities."

#### [BNBC Part 4]

### **4.6 Fire Detection and Alarm System**

#### **4.6.1 Fire Detection Shall be Done by the Following Ways**

(a) Human surveillance:

Human surveillance shall be acceptable where the user and occupant are capable of maintaining surveillance for detecting fire and smoke when a person appointed and assigned to detect fire shall be termed as Fire watch.

(b) Automatic smoke or/and heat detection :

The installation of automatic fire and smoke detection system shall be a necessity when the size, arrangement and occupancy of a building become such that a fire itself cannot provide adequate warning to its occupants.

The automatic fire and smoke detection system shall include, spot or line type heat sensitive detectors and optical, ionized or chemical sensitive type of smoke detectors.

(c) Video surveillance :

Cameras capable of registering and transmitting real time images in to a monitoring device having display commonly termed as CCTV shall be installed systematically to cover an area for detecting any incision of smoke and fire. This CCTV will remain under either human surveillance or monitored by compatible software to transmit signal automatically to the fire alarm system and also to the authorized persons.

#### **4.6.2 Fire Alarm System**

4.6.2.1 In a fire incident, panic management shall be the prime concern for a successful relocation, delayed egress or evacuation of occupants from a building structure. Activation of alarm shall be sequential and compatible with all design scenarios. Means of egress system is so designed that all alarms of a building shall not be activated at a time. A general announcement of fire shall be done for the occupant or the word "Fire" shall be avoided but authorized persons responsible for evacuation shall be alerted through Password or Pass Phrase. As per design scenarios a systemic execution protocol shall be developed where a building shall be sub-divided into zones for installation alarms and for fight in place, relocation of occupants, delayed egress or immediate evacuation.

Alarm system can be of different types, such as audible alarm, visual alarm, vibration alarm, and display alarm.

- (a) Audible alarm: Ringer, bell, horn, chime and voice command via public address system (PA system) are the examples of audible alarm system.
- (b) Visual Alarm: A bright white light emitting device with specific intensity and cycle of emission is capable to draw attention of a person having limited hearing shall be termed as visual alarm. A visual alarm shall be installed where a person working alone in a room or a space having hearing limitations. In a public place or in any place more than two persons are present and one having normal hearing ability shall not require to install visual alarm.
- (c) Vibration Alarm: Alarm activated through vibration can be used for alarm.
- (d) Display Alarm: Textual, graphical or pictorial display on screens or monitors can be used as alarm.

4.6.2.2 Each floor shall be separated as zone for the purpose of alarm annunciation.

4.6.2.3 A floor is subdivided by fire or smoke barriers and allows relocation of occupants from area of incident to another area on the same floor each area shall be considered as a zone and annunciated separately for the purpose of alarm location.

4.6.2.4 Notification zones shall be consistent with emergency response or evacuation plan for the protected premises. The boundaries of notification zones shall be coincident with building peripheral walls, fire or smoke compartment boundaries, floor separations or other fire safety subdivisions.

4.6.2.5 If required by the authorities having jurisdiction, the alarm system be allowed the application of alarm signal to one or more zones at the same time, shall allow voice paging to the other zones or in any combination.

4.6.2.6 Alarm annunciation at the fire command center shall be by means of audible and visible indicators.

4.6.2.7 Activation of fire extinguishment system shall have a supervisory alarm. An automatic extinguishment system capable of discharging other than water extinguishing agents shall have dedicated and distinct alarm system and shall be actuated before discharging such agents.

Further explanations have been provided in BNBC Part 8 in the following section of Chapter 1:

**[BNBC Part 8]**

**1.3.31 Fire Alarm and Emergency Lighting Circuits**

Fire alarm and emergency lighting circuits shall be segregated from all other cables and from each other in accordance with BS 5839 and BS 5266. Telecommunication circuits shall be segregated in accordance with BS 6701 as appropriate.

### **1.3.37 Fire Detection and Alarm System inside a Building**

The major parts of a Fire Detection and Alarm System inside a Building may be listed as

- (a) A number of different types of Fire Detectors/ detection devices wired in a number of radial circuits
- (b) Manual call points
- (c) A central control panel for fire detection
- (d) A number of alarm sounders/alarm devices wired in a number of radial circuits
- (e) Cables for wiring the fire detectors/detection devices
- (f) Cables for wiring the alarm sounders/alarm devices

#### Control Panel

The control panel will indicate in which detection circuit (zone) an alarm or fault condition has been generated and will operate common or zonal sounders and auxiliary commands (for example door release or fire brigade signaling).

#### Detectors

A number of types of detectors (smoke detectors, heat detectors, ionization smoke detectors, optical beam smoke detectors, opto-heat detectors) for the installation

#### Alarm Devices

Alarm devices fall into two types, audible and visual. The audible types are most common, with a variety of types being available from bells to all kinds of different electronic sounders including those containing pre-recorded spoken messages. The choice of device is dependent on local preference, legal requirement and the need to have a tone distinct from all other building audible alarms.

Speech alarms or links to PA systems overcome some of the complacent responses to warning tones and can be used to good effect when carrying out regular fire tests in buildings where there are many people unfamiliar with the regular routines - such as hotels. Finally visual alarms are to be used where the hard of hearing may be occupying a building or where the ambient noise is such (above 90 dBA) that audible warning may not be heard, where hearing protectors are in use or where the sounder levels would need to be so high that they might impair the hearing of the building occupant.

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### Cables for Fire Detectors

BS 5839-1 introduced more onerous requirements for the types of cables used in fire detection and alarm systems. Fireproof cables should now be used for all parts of the system and enhanced fire resistance cables should be used where there is a requirement to ensure cable integrity over a longer period of time. For example when connecting to alarm sounders or where connection between sub-panels provides any part of alarm signal path.

Fire alarm cables should be segregated from the cables of other systems; they should be clearly marked, preferably coloured red and should be routed through parts of the building that provide minimum risk. This latter point is particularly relevant where the use of the building is being changed - for example if a fuel store is being moved.

### Specific Areas of Application for Fire Detection and Alarm Equipment

The BS 5839 suite of standards relate to specific areas of application for fire detection and alarm equipment. Specifically part 1 relates to public premises and part 6 relates to residential premises. BS5839-1 is a comprehensive code of practice for fire detection and alarm systems, the requirements relate to both life and property protection and the standard includes much advice and comment which is very useful in informing the building owner or system specifier of the background to the requirements.

### Codes of Practice for Different Types of Fire Protection Systems

The parts of BS7273 are codes of practice for different types of fire protection systems. Generally this is considered separately to fire alarm systems but there may be occasions where a tradeoff can be made between the two systems, or where the two systems interact and must be interfaced.

### Standards Related to Design and Performance of Items of Equipment that Make up a Fire Detection and Alarm System

The EN 54 suite of standards relates to the design and performance of items of equipment that make up fire detection and alarm system. Each part relates to a different piece of equipment, for example part 3 relates to alarm devices, part 11 to call points, part 4 to power supplies etc.

### Fire Detection Zones

Fire detection zones are essentially a convenient way of dividing up a building to assist in quickly locating the position of a fire. BS 5839-1 has some specific recommendations with respect to detection zones.

Wiring of the fire detection and alarm system will be done using the concealed wiring and the surface wiring methods described in the power line wiring section of this document.

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#### **1.3.41 Qualification of the Contractor of Electrical and Electronic Engineering Works in a Building**

A Contractor who will be working with the electrical and electronic engineering works in a building must have appropriate ABC license from the electrical licensing board of government of Bangladesh.

The contractor must have sufficient number of well trained and experienced technicians to execute the job. For big volume of work, the contractor must have at least one Electrical Engineer assigned for the job.

As mentioned above, fire detection systems and fire alarms are regulated. In particular, these works must be carried out by qualified contractors and engineers, so construction supervisors must pay attention to whether or not the contractors and engineers hold these qualifications.

#### **[Initial extinguishing]**

Fires can be easily extinguished in the early stages unless they are caused by an explosion or other special reasons. The simplest equipment used for early fire extinguishing is a fire extinguisher, and an installed type is a sprinkler system. The BNBC also has regulations regarding the installation of sprinklers, but these detailed regulations are of course taken into consideration by the designer in the building plan and compiled as design documents, so there is no problem if the construction is carried out according to the design documents, but it is also important for the construction supervisor to understand the contents and supervise the construction.

BNBC Part 4, Chapter 4, Section 4.2 provides explanations and provisions for fixed fire hydrant systems, but since the provisions in this manual are for the design, only that title of the section is introduced for reference.

#### **[BNBC Part4, Chapter Section 4.2]**

### **4.2 Fixed Type Fire Hydrant System**

4.2.1 Water Quantity for Fire Protection

4.2.2 Water Sources for Fire Protection

**Table 4.4.1: Fire Protection Flow Requirements\***

Building Type**	Sprinkler System (litre/min.)	Standpipe and Hose System (litre/min.)	Duration in Minutes for Building Heights		
			Up to 51 m	51 m to 102 m	Above 102 m
Light hazard- I	1000	1000	30	38	45
Light hazard- II	1900	1900	50	62	75
Ordinary hazard- I	2650	1900	75	95	112
Ordinary hazard-II	3200	1900	75	95	112
Ordinary hazard-III	4800	1900	75	95	112

Notes:

\* See also Sec 4.2.2.3.

\*\* Values will be for one riser serving floor area of 1000 m<sup>2</sup>.

Light hazard-I	:	Occupancy groups, A1, A2, A3, E1
Light hazard-II	:	Occupancy groups, A4, A5, B, C, D,E2, E3, I2, I4, F1
Ordinary hazard-I	:	Occupancy groups, I1, I3, I5, F2, F3, G1
Ordinary hazard- II	:	Occupancy groups, G2 , H1
Ordinary hazard- III	:	Occupancy groups, H2
Extra hazard	:	Occupancy group J-pressure and flow requirement for this group shall be determined by Fire Department but shall not be less than required value for Ordinary hazard- III

#### 4.2.3 Design Considerations for Standpipe and Hose System

##### 4.2.2.1 Direct connection to water main

##### 4.2.2.2 Roof gravity tanks

##### 4.2.2.3 Storage tank

##### ➔ 4.2.2.4 Water supply test

##### 4.2.2.5 Fire pump

#### 4.2.3 Design Considerations for Standpipe and Hose System

##### 4.2.4 Wet Riser

##### 4.2.5 Down Comer

##### 4.2.6 High Velocity Water Spraying Projector System

##### 4.2.7 Water Mist Technology

##### 4.2.8 Drenchers

##### 4.2.9 Dry Riser System

##### 4.2.10 Design Consideration of Sprinkler System

##### 4.2.11 Connection

##### 4.2.12 Inspection, Testing and Maintenance

➔ 4.2.12.1 Inspection

All piping and equipment shall be inspected for satisfactory supports in accordance with Sec 6.15 in Part 8 of this Code and protection from damage and corrosion. All outlets shall be free

**Table 4.4.5: Size of Water Supply Steel Pipe to Sprinklers**

Pipe Size mm (inch) nominal	No. of Sprinkler for Light Hazard*	No. of Sprinkler for Ordinary Hazard *	No. of Sprinkler for Ordinary Extra Hazard *
25(1)	2	2	1
32(1¼)	3	3	2
38(1½)	5	5	5
50(2)	10	10	8
63(1½)	30	20	15
75(3)	60	40	27
88(3½)	100	65	40
100(4)	NL**	100	55
125(5)	-	160	90
150(6)	-	275	150
200(8)	-	400***	225***

\* Definitions of these terms are given in Table 4.4.1.

\*\* No limit.

\*\*\* One sprinkler system riser or combined system riser shall serve the floor area not more than 4850 m<sup>2</sup> for light and ordinary hazardous occupancy and 2325 m<sup>2</sup> for extra hazardous occupancy

**Table 4.4.6: Size of Water Supply Copper Pipe to Sprinklers**

Pipe Size mm (inch) nominal	No. of Sprinkler Connection for Light Hazard*	No. of Sprinkler Connection Ordinary Hazard *	No. of Sprinkler Connection Ordinary Extra Hazard *
25(1)	2	2	1
32(1¼)	3	3	2
38(1½)	5	5	5
50(2)	12	12	8
63(1½)	40	25	20
75(3)	65	45	30
88(3½)	115	75	45
100(4)	NL**	115	65
125(5)	-	180	100
150(6)	-	300	170
200(8)	-	***	***

\* Definition of these terms is given in Table 4.4.1.

\*\* No limit.

\*\*\* One sprinkler system riser or combined system riser shall serve the floor area not more than 4850 m<sup>2</sup> for light and ordinary hazard occupancy and 2325 m<sup>2</sup> for extra hazard occupancy

**Table 4.4.7: Ceiling Area for a Sprinkler**

Construction Type	Light Hazard		Ordinary Hazard		Extra Hazard	
	Protected area	Spacing (Max)	Protected area	Spacing (Max)	Protected area	Spacing (Max)
	ft <sup>2</sup> (m <sup>2</sup> )	ft (m)	ft <sup>2</sup> (m <sup>2</sup> )	ft (m)	ft <sup>2</sup> (m <sup>2</sup> )	ft (m)
Roof or Floor on Trusses, Girders or Beam With High Piling ***	200 (18.6)	15 (4.6)	130 (12.1)	15 (4.6)	100 (9.3)	12 (3.7)
Open Wood Joists With High Piling ***	225 (20.9)	15 (4.6)	130 (12.1)	15 (4.6)	100 (9.3)	12 (3.7)
Other Type of Construction With High Piling ***	168 (15.6)	15 (4.6)	130 (12.1)	15 (4.6)	100 (9.3)	12 (3.7)

\* Maximum distance in m between sprinklers and between line of piping.

\*\* The definitions of these terms are given in Table 4.4.1.

\*\*\* Storage facilities which permit closely piled materials over 4.5 m or materials on rack over 3.6 m.

**Table 4.4.8: Piping for Sprinkler System**

Material	Standard
Copper and Copper-Alloy	ASTM B32, ASTM B75, ASTM B88, ASTM B25, ANSI B36
Steel	ASTM A53, ASTM A120, ASTM A135, ASTM A795

#### ➔ 4.2.12.2 Testing

Fire protection plumbing system or part thereof shall be tested and approved after installation by the Authority.

(a) Testing of Standpipe System: The hydrant pipes shall be hydraulically tested to a pressure 1400 kPa or 150% of working pressure whichever is the higher for 2 hours without any leakage at any points. The system shall be able to maintain above test pressures. The system shall also be tested for the required flow at the

(b) Testing of Sprinkler System: This system shall be tested for at least 2 hours for a pressure of 1000 kPa or at 350 kPa in excess of normal working pressure when normal working pressure will be more than 650 kPa. The system shall be able to maintain above test pressures. The system shall also be tested for the required flow at the highest outlet.

(c) Testing of Sprinkler System Pump: The pump used for sprinkler system firefighting purpose shall be tested by approved authority for their performance characteristics and this test report must be submitted at the time of supply of pump. The pump shall be retested or repaired to its original condition if their performance characteristics fall below more than 10 percent of the supplier's test characteristic curve or as specified for the fire protection water supply system.

#### 4.2.12.3 Maintenance

The system shall be maintained for safe operating conditions and tested at least once a year.

#### **[Evacuation to a safe place]**

Regarding evacuation routes, the regulations that must be observed when designing them are stipulated in BNBC Part 4, Chapter 3. The fixed items are as follows:

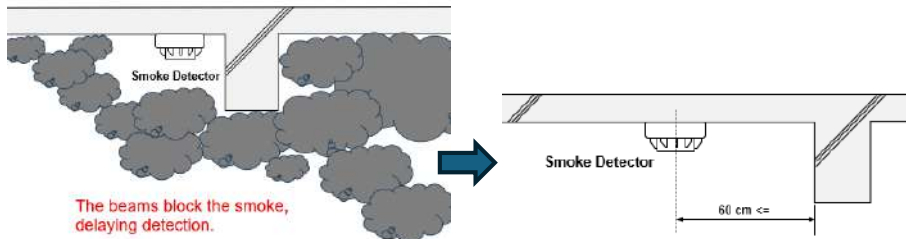
Any compartment or a room or a control area surrounded by barrier walls within a building structure shall be protected from smoke penetration during a fire incident occurred elsewhere in the building shall be termed as smoke proof enclosure.

A stairway with in an envelope shall be termed as Interior stairway or staircase. Any exterior side having opening of 50 percent or more in such a way that there shall be no smoke accumulation shall be termed as open stair.

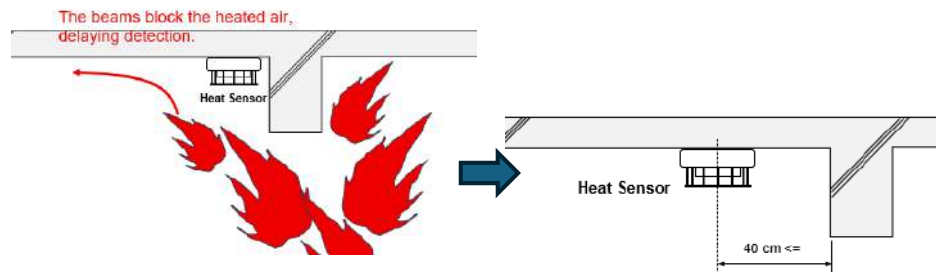
As mentioned above, BNBC specifies in detail how to ensure the safety of facility users in the event of a fire, so if the applied building plan is approved by RAJUK, the builder can achieve the required quality by following the design documents. However, in order to correctly build what is required in the design documents, it is important to ensure that basic construction precautions are followed during construction.

#### **[Proper installation location of detector and alarm]**

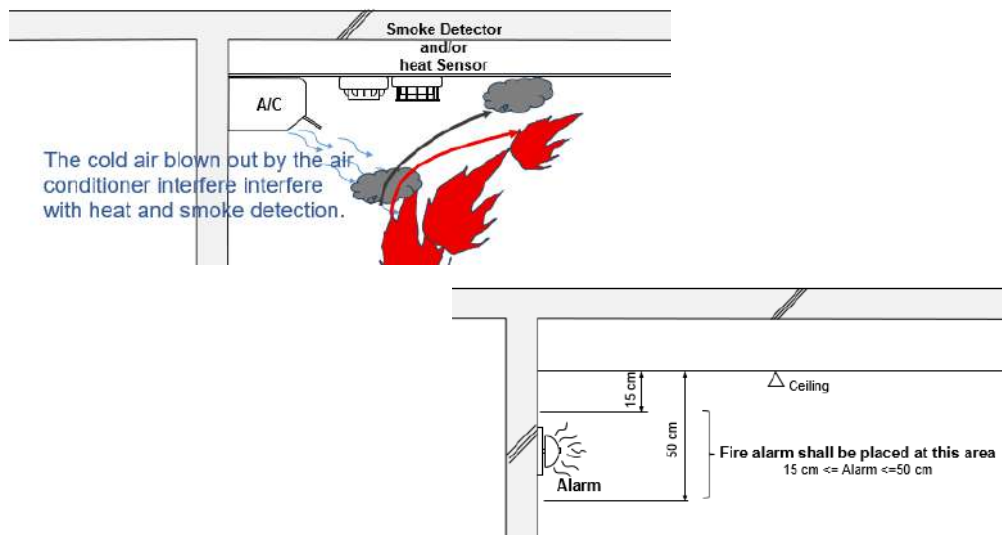
Smoke detectors, heat detectors and/or gas detectors must be installed in appropriate locations to quickly detect any abnormal conditions. In other words, if the detector is installed in a position that is difficult it from detecting a fire, the detection will be delayed, which could allow the fire to spread. Refer to Chapter 2, 2.3.2.1.



**Figure 2-69 Smoke detection failure**



**Figure 2-70 Thermal detection failure**



**Figure 2-71 Correct installation position for alarm**

When a fire occurs and evacuation is necessary, sufficient time for evacuation is required. For this reason, construction must be carried out in a way that prevents

smoke and fire from spreading as much as possible, and even if fire doors and fire-resistant walls are designed, if the door installation method and/or the treatment method around the installed parts such as pipes are incorrect, the spread of smoke and the spread of fire cannot be effectively prevented.

The provisions in BNBC part 4, Chapter 2 "Precautionary Requirements" Clause 2.5 "Openings In Separation Wall" have stipulated for the matter, which is below.

**[BNBC Part4, Chapter 2, 2.5 “Opening In Separation Wall”]**

## **2.5 Openings In Separation Wall**

Opening means a hole or an aperture in the building envelope or in any wall within the building through which air can pass. Protective type opening means a hole or an aperture shall have open able closures with fire resistive assemblies to restrict air movement.

Separation wall not constructed monolithically or homogeneously and having joints shall be complied with requirements of smoke lock and fire resistance rating as per provisions of this Code.

Vertical solid elements which create a barrier within a space or create a building envelope shall be designated as wall or partitions as per provisions of this Code.

- (a) The openings in occupancy separation wall shall conform to the provisions set forth in the Part 3 of this Code.
- (b) Openings in fire separating walls and floors shall not exceed the approved limit and the opening shall be of protective type and conform to the approved provisions of this Code.
- (c) Fire separation walls shall not have opening exceeding 11.2 m<sup>2</sup> in area and the aggregate width of all openings at any floor level shall not exceed 25 percent of the length of the wall. When an entire storey floor area has fire separation walls on two opposite sides have openings shall be covered by automatic fire suppression system, the maximum allowable opening may be doubled with a minimum distance of 0.9 m between adjacent openings.
- (d) Each protected openings in a fire separation wall shall be limited to 5.6 m<sup>2</sup> in area with a maximum height of 2.75 m and width of 2.20 m. Wall or floor openings shall be protected with approved fire resisting means conforming to approve standards as per provision of this Code. When

openings in floors have protected enclosures or have enclosure walls which form a shaft and have openings on enclosure wall shall be protected by fire assemblies.

- (e) Openings of service lines like cables, electrical wirings, telephone cables, plumbing fixture etc. shall be protected by enclosures having an approved fire resistance rating. Medium or low voltage electrical wire running through shaft or ducts shall be either armoured or cased within metal conduits as per provisions of Part 8 of this Code.
- (f) All openings in the fire separation walls shall be protected with fire resistance assemblies or automatic fire suppression system as per provisions of this Code.

Furthermore, BNBC part 4, chapter 3 clause 3.13 "Smoke Proof Enclosure" provides measures against the spread of fire.

**[BNBC Part4, Chapter 3, 3.13 “Smoke Proof Enclosure”]**

**3.13 Smoke Proof Enclosure**

Any compartment or a room or a control area surrounded by barrier walls within a building structure shall be protected from smoke penetration during a fire incident occurred elsewhere in the building shall be termed as smoke proof enclosure.

A stairway with in an envelope shall be termed as Interior stairway or staircase. Any exterior side having opening of 50 percent or more in such a way that there shall be no smoke accumulation shall be termed as open stair.

**3.13.1** An interior stairway conforming to Sec 3.10 and having entry from an exterior balcony or through a ventilated vestibule conform a smoke proof enclosure provided no direct opening or any aperture allowed on the walls of the stair from the building side.

**3.13.2** All exit stairways mentioned above shall be protected by a smoke proof enclosure when serving occupants are located in a high rise building.

**3.13.3** There shall be provision to access enclosed stairways through vestibule or an open balcony. The minimum width of a vestibule shall be equal to width of connected passages or corridors specified in section 3.7 in this Chapter and the minimum length of a vestibule in the direction of travel shall be 1.8 m.

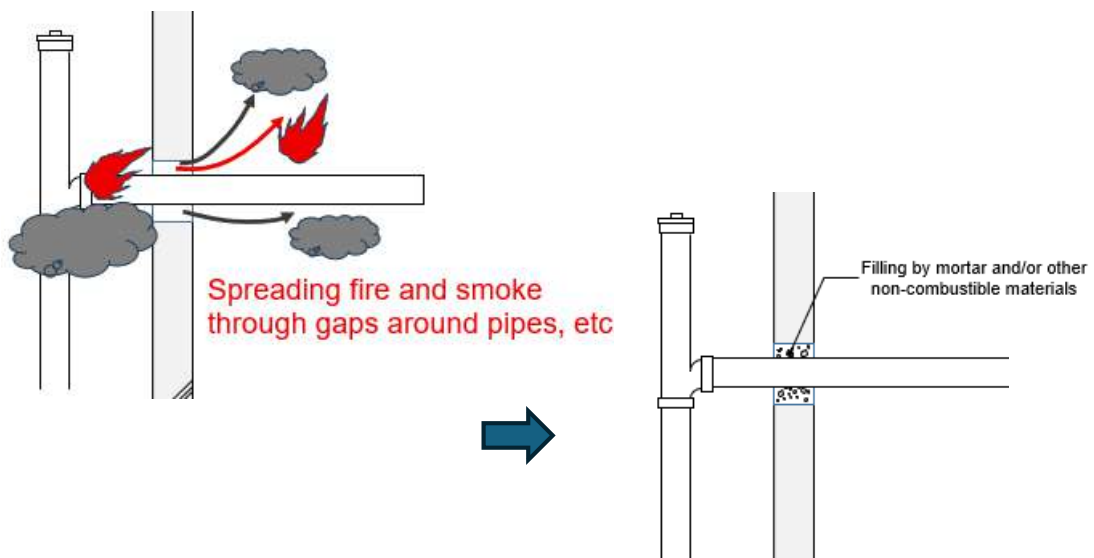
**3.13.4** The minimum fire resistance rating of the walls forming a smoke proof enclosure around stairway including the vestibule thereof shall be 4 hours and separated from the area of incidence having no openings other than a fire door for the entry to the vestibule. For fire rating of the door see Chapter 1 Part 3.

**3.13.5** All doors in smoke proof enclosure and the vestibule shall be self-closing type or they shall be fitted with automatic closing devices actuated by the fire detection system.

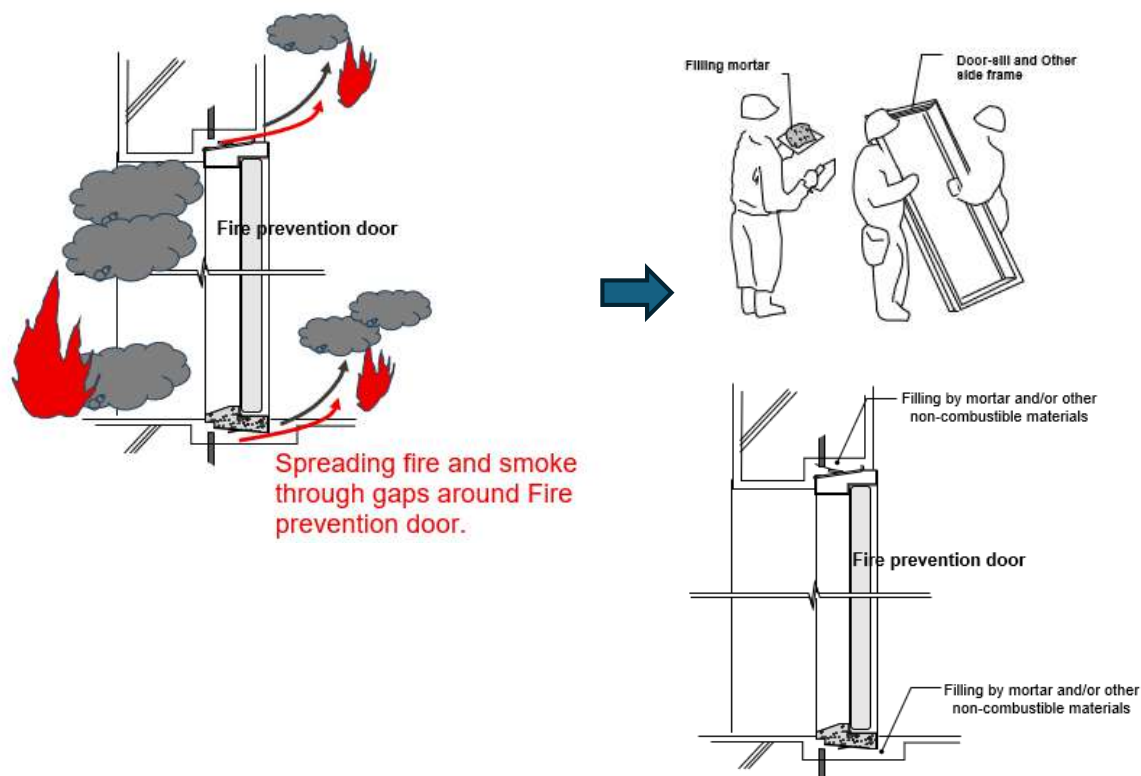
**3.13.6** The vestibule shall have adequate natural ventilation. Each vestibule shall have a minimum area of openings of 2 m<sup>2</sup> divided into two in an exterior wall facing a courtyard, street or public way wider than 6 m. The location of one opening measuring 1.5 m<sup>2</sup> shall be as high as possible and another shall be 0.5 m<sup>2</sup> as low as possible.

**3.13.7** If the enclosed staircase is windowless, mechanical ventilation shall be installed. If the vestibule is windowless, mechanical ventilation shall also be installed. In addition to ventilation a positive pressure of 50 Pa shall be maintained in the vestibule. This positive pressure must be developed within 30 seconds of the incident of fire. When the staircase and the vestibule are windowless emergency illumination shall be provided.

When pipes or wiring need to penetrate the floors or walls of each floor, these penetrations must be filled with non-combustible materials such as mortar, and great care must be taken to ensure that there are no gaps at the penetration points. In addition, great care must be taken with the installation areas of doors, inspection hatches, etc., to ensure there are no gaps between the installation openings as well. It is especially important for the construction supervisor to personally check the construction status around the door frames of fire doors installed on evacuation stairs, etc., and to leave photographic records.



**Figure 2-72 Treatment of pipe penetrations**



**Figure 2-73 Treatment around door frames**

In addition, the next Clause 2.6 "Smoke and Heat Vents" shows provisions to prevent excessive smoke from filling the building in the event of a fire.

**[BNBC Part4, Chapter 2, 2.6 "Smoke and Heat Vents"]**

**2.6 Smoke and Heat Vents**

Interior or indoor air qualities are maintained as good as natural outdoor air qualities as per provisions of this Code through openings in the building envelope shall be designated as Natural Ventilation.

Interior or indoor air qualities are maintained by the means of mechanical devices shall be designated as Mechanical Ventilation. Restricted ventilation means excessive smoke accumulation within a building during fire.

- (a) Smoke and heat vents shall be installed in areas of restricted ventilation such as windowless buildings, underground structures, and factories floor spaces of restricted ventilation.
- (b) Where exit access travel distance is more than 23 m, smoke and heat vents shall be constructed in accordance with the provisions of this Code.

- (c) The vent area and spacing of the vents shall comply with Table 4.2.1.
- (d) Closures of natural draft, smoke and heat vents shall be installed in such a way that fire service personnel can open it easily during a fire.
- (e) Smoke and heat vents on roof or ceiling or wall shall normally be kept open. In case of closed vents, automatic activation of the openings by heat responsive device rated at 38° C to 104° C above ambient shall be a requirement. The releasing mechanism shall be capable of opening the vent fully when the vent is exposed to a time-temperature gradient that reaches an air temperature of 260° C within 5 minutes. The vents shall also be capable of being opened by manual operation.
- (f) Fire Vents requirements for Industrial and Storage Buildings are given in Appendix B of Part 4.

**Table 4.2.1: Smoke and Heat Vent Size and Spacing**

Use group	Hazard Condition	Vent Area to Floor Area Ratio	Max Spacing of Vent Centres
Occupancy H1	Low Hazard	1:150	45 m
Occupancy H2	Moderate Hazard	1:100	36 m
Occupancy J1	High Hazard	1:30 to 1:50	22.5 m to 30 m
Occupancy J2, J3, J4	High Hazard	1:30 to 1:50	22.5 m to 30 m
Occupancy K1, K3	Low Hazard	1:150	45 m

## 2.5.2 General construction considerations for M&E work

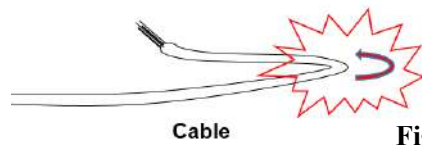
### 2.5.2.1 Precautions when installing electrical equipment

Electric leakage accidents are considered to be the main cause of fires in facility equipment. There are several possible causes for electric leakage, such as defects in the circuits or wiring themselves. Here we will introduce some points that should be taken into consideration during construction work.

#### 1) Prevention of Cable damage

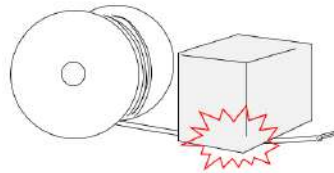
If a break occurs inside the cable, it will generate heat when electricity is applied, and in the worst case scenario, it will cause a fire. However, even if the inside of the covered wiring is broken, it is very difficult to tell from the outside if there is no damage to the covering, and it cannot be confirmed after wiring. Therefore, it is important to handle the wiring with great care during installation.

- a) Prevention of scratch wound and/or cut on the cable
- b) Prevention for Drastic cable bent



**Figure 2-74 Drastic cable bent**

- c) Prevention of placing heavy objects or packaging containers with sharp corners on the cable.



**Figure 2-75 Incorrect handling**

- 2) Prevention of incorrect cabling

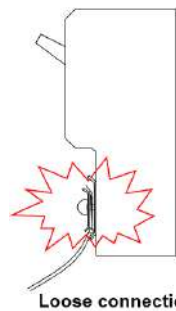
Wiring work must be done carefully based on the design drawings. In particular, care must be taken to prevent loose connections, which is root of generating heat causing a fire.

**[Laying cable/Wire]**

- a) Laying cable/ wire shall be executed with suitable additional length
- b) Do not lay a cable with much surplus length.
- c) Laid cable shall not lay in a muddle (Correct cable arrangement is necessary)

**[Connecting Cable/Wire]**

- d) Wiring to the connection terminal



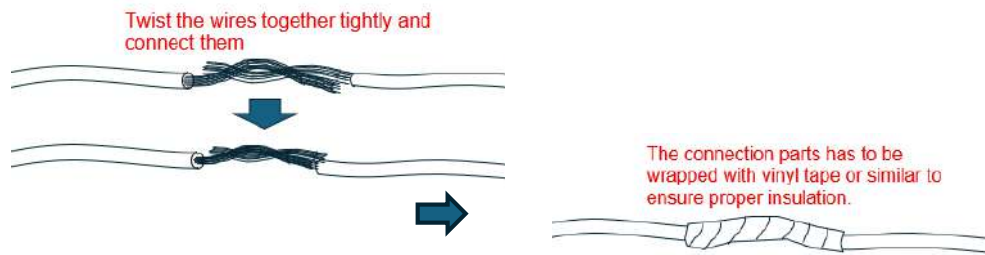
When cables connect to the terminal on the breaker and/or others, the cable shall be fixed rigidly to prevent heating up of cables.

A cable connecting to an outlet, lighting fixture and others are also same as well as a connection to terminal

**Figure 2-76 Loose cable connection**

- e) Connecting of cables together

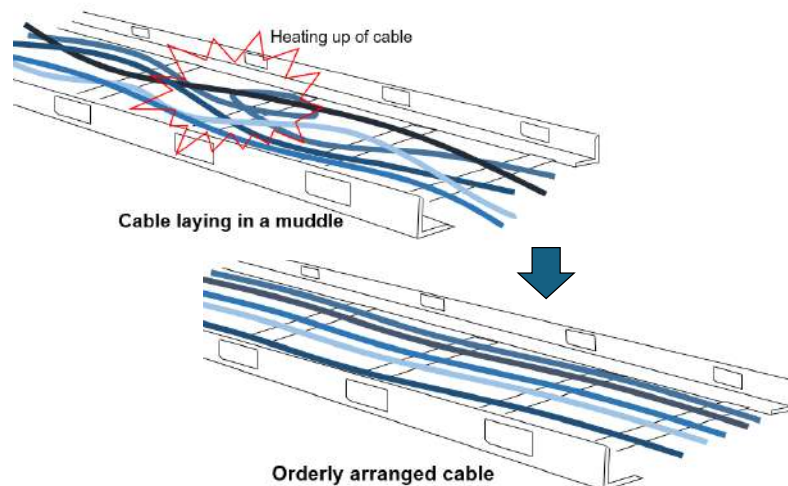
When connecting cables, it is used in a joint connector which is provided matchable types in each cable. In the case of direct connection of conductors, which is iv cables each wire shall joint with twisting it tightly. In each case, the joint shall cover with insulating material such as vinyl tape. Furthermore, if the wire connections are loose, they may generate heat and cause a fire, so that it is necessary to be taken care of.



**Figure 2-77 Cable joint without Cable connector**

f) Cable arrangements

Laid cable on a cable tray and/or set cable at a cable ladder shall not be in a muddle condition to avoid heat generation with electrical resistance occurs caused that the conductor is bent in a complex manner., so that the cable shall be arrange the condition after laying a cable.



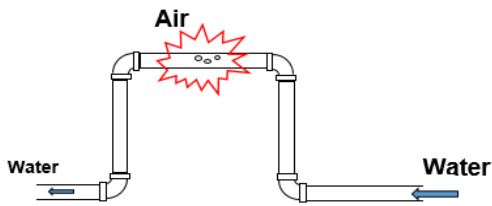
**Figure 2-78 Cable arrangement**

2.5.2.2 Precautions when installing plumbing work

Basically, piping work consists of water supply equipment and drainage equipment, but there are some points to be aware of when installing water supply piping and drainage pipes. Here are some points to consider.

1) Water supply facility

The careful point for water supply facility is to avoid a convexity piping, which causes the

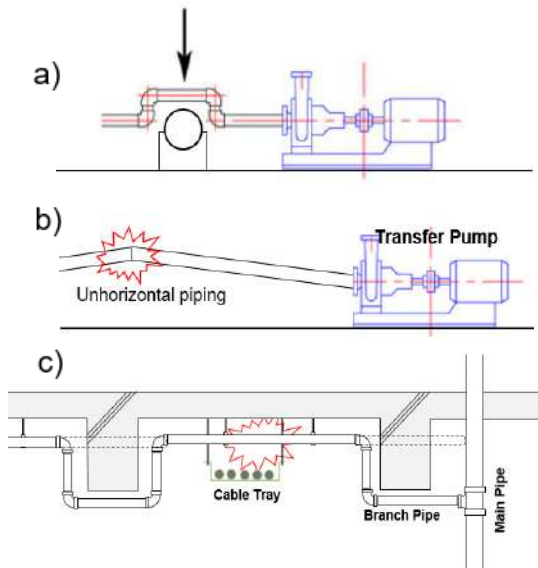


**Figure 2-79 Convexity Piping**

condition in the case.

interruption for the stream in the pipe. Air will gather at the above position in the pipe and the air mass will interrupt the stream water.

According to interference with other piping or equipment sometime, the convexity piping appears under construction in different of design requirements, therefore the piping condition shall be checked and improve the



a) In the case of Crossing of pipe and/or others

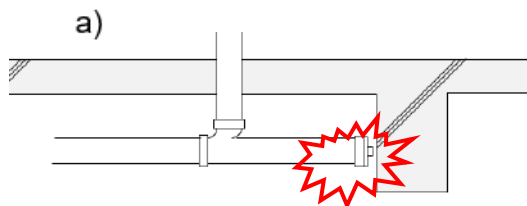
b) Convex line

c) Interference of and piping or Incorrect beam penetration position

**Figure 2-80 Variations of convexity piping**

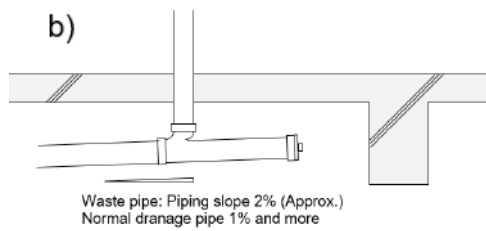
2) Drainage facility

The drainage facility also has an important point for the piping, basically, piping route, each pipe size and other arrangement shall follow the design drawing, and however some working points during construction time lead the facility to incorrect condition.



a) The setting location of clean out  
(Impossible of cleaning the pipe)

**Figure 2-81 Incorrect position of clean out**



- b) Piping slope  
 Waste pipe: 2% and more  
 Normal drainage pipe: 1% and more

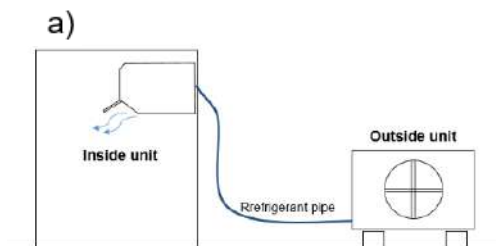
**Figure 2-82 Incorrect position of clean out**

### 2.5.2.3 Precautions when installing Mechanical work

#### 1) Air-conditioning facility

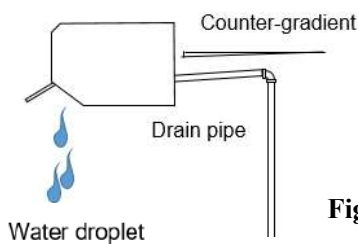
Air conditioning system has several types of system, such as central air conditioning system, split unit type and so on. Each type has a merit and/or demerit, which has been considered and selected by designer, and the careful point during construction time. Site engineers should inform and discuss some problems with designers, if any.

With conventional split air conditioning, depending on the length of the refrigerant piping and the method of construction of the drainage piping during installation, problems such as the air conditioner not working properly or water dripping from the cool air outlet may occur. In addition, with central air conditioning systems, condensation can occur in areas where the insulation of the duct that supplies cold air from the cooling tower is improperly installed, so care must be taken.



- a) Length of refrigerant pipe  
 Total length of refrigerant pipe shall be approx. 30m~35m, which is stipulated by manufacture.

**Figure 2-83 Limit of refrigerant pipe length**

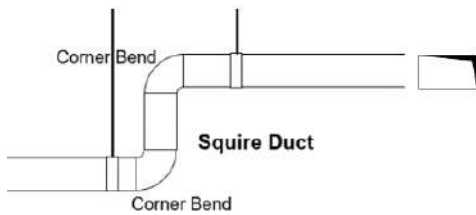


- b) Water droplet at inside unit  
 Drainpipe for inside unit shall not be counter-gradient to avoid a droplet.

**Figure 2-84 Laying slope of drainpipe for AC Inside Unit**

#### 2) Ventilation facility

Air ventilation systems, especially ducted mechanical ventilation systems, must be constructed carefully to avoid damage to the duct's cross section due to processing of the duct corners or deformation of the duct itself. Furthermore, there are various types of ventilation caps that are attached to exterior walls, such as those that can prevent rainwater from entering and those with fire dampers, so it is necessary to correctly select the type specified in the design documents.



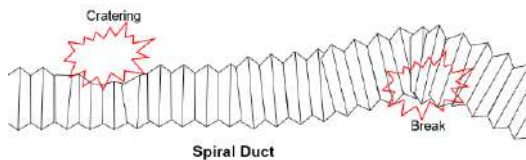
**Figure 2-85 Arrangement of square duct**

a) Corner bend for square duct

In the case of rectangular ducts, the number of corner bend positions should be kept to a minimum to avoid compromising ventilation efficiency, and the duct at the corner position must be sized so as not to cause any loss of cross-sectional area.

b) Damage to the flexible duct

While aluminum flexible ducts can be easily reshaped in installation, they must be handled with care as they can easily become deformed, such as crushed, and the cross-sectional area of the duct can easily become lost.



**Figure 2-86 Damages of spiral duct**

2.5.2.4 BNBC regulations regarding M&E work

General M&E work is summarized in BNBC, Part 8, so you need to check and fully understand the contents before carrying out construction. In addition to regulations related to design, it also contains important regulations for the practical aspects of construction/construction supervisors, such as construction and construction qualifications, inspection applications and use permits. Here it introduces an main index list to make it easy to check the BNBC regulations.

Additionally, items requiring special attention during construction are indicated in bold diagonal type with arrows.

## **BNBC Part 8**

### **Chapter 1 Electrical and Electronic Engineering Services for Buildings**

- 1.1 Introduction
- 1.2 Lighting and Illumination

#### **➔ 1.3 ELECTRICAL AND ELECTRONIC INSTALLATIONS IN BUILDINGS**

- 1.4 Related Codes and Standards
- 1.5 List Of Related Appendices

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- 2.1 General
- 2.2 Scope
- 2.3 Application
- 2.4 Terminology
- 2.5 General Provisions
- 2.6 Planning
- 2.7 Air-Conditioning System Design
- 2.8 Air Distribution System
- 2.9 Air-Conditioning Equipment
- 2.10 Refrigerating Equipment
- 2.11 Ventilation Systems
- 2.12 Energy Conservation

#### **➔ 2.13 Inspection, Testing and Commissioning**

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- 3.2 Scope
- 3.3 Terminology
- 3.4 Building Acoustics: General Considerations and Provisions
- 3.5 Planning and Design For Noise Control
- 3.6 Reverberation Time, Sound Pressure Level and Diffusion of Sound
- 3.7 Speech Privacy
- 3.8 Sound Amplification System
- 3.9 Occupancy A: Residential Buildings
- 3.10 Occupancy B: Educational and Occupancy C: Institutional Buildings
- 3.11 Occupancy D: Health Care Buildings
- 3.12 Occupancy I: Assembly
- 3.13 Occupancy E: Business and Occupancy F: Mercantile Buildings
- 3.14 Occupancy G: Industrial Buildings
- 3.15 Acoustical Requirements of Special Occupancies
- 3.16 Related References
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- 4.2 Essential Requirements for Lifts
- 4.3 Design Considerations
- 4.4 Escalators
- 4.5 Moving Walks
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- 5.2 Terminology
- 5.3 Permit For Water Connection
- 5.4 Licensing/Registration of Plumbers
- 5.5 Water Supply Requirements
- 5.6 Estimation of Demand Load
- 5.7 Water Sources and Quality
- 5.8 Water Supply System
- 5.9 Storage of Water
- 5.10 Design of Distribution System
- 5.11 Distribution in Tall Buildings
- 5.12 HOT WATER SUPPLY INSTALLATION
- 5.13 Materials, Fittings and Appliances

### **➡ 5.14 General Requirement for Pipe Work**

- 5.15 Safe Conveyance and Distribution of Water & Prevention of Backflow

### **➡ 5.16 Laying of Pipes on Site**

- 5.17 Hangers and Support
- 5.18 Protection of Potable Water Supply
- 5.19 Health Care Water Supply
- 5.20 Cleaning and Disinfecting the System

### **➡ 5.21 Inspection, Testing and Completion Certificate**

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- 5.23 Individual Water Supply System
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- 6.4 Drainage and Sanitation Plans

### **➡ 6.5 Licensing of Plumber**

- 6.6 Drainage and Sanitation Requirement
- 6.7 Materials and Appliances
- 6.8 Hangers and Support and Pipe Jointing

- 6.9 Design Considerations
- 6.10 Design of Drainage and Sanitation System

➡ **6.11 Construction Relating to Conveyance of Sanitary Wastes**

- 6.12 Refuse Chute System
- 6.13 Basement Floor Drainage System
- 6.14 Health Care Drainage System

➡ **6.15 Inspection, Testing and Completion Certificate**

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- 7.2 Scope
- 7.3 Terminology
- 7.4 Rainwater Harvesting Requirements
- 7.5 Rainwater Harvesting Plans
- 7.6 Licensing of Plumber
- 7.7 Rain-Water Harvesting
- 7.8 Roof Top Rainwater Harvesting
- 7.9 Artificial Ground Water Recharge
- 7.10 Drainage and Sanitation Requirement
- 7.11 Materials and Appliances
- 7.12 Construction of Rainwater Storage Tank

➡ **7.13 Installation and Construction of Rainwater Harvesting and Drainage System**

- 7.14 Hangers and Support
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- 7.16 Protection Against Rodent
- 7.17 Gradient of Pipes

➡ **7.18 Inspection Chambers and Manholes**

➡ **7.19 Bedding and Backfilling**

- 7.20 Design of Rainwater or Storm Water Drainage Piping
- 7.21 Sizing and Finding the Number of Rainwater Drainage Piping

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- 7.23 Guide to Maintenance
- 7.24 List of Related Appendices

**Chapter 8 Fuel Gas Supply**

- 8.1 General

➡ **8.2 Gas Piping Installation**

- 8.3 Use of Liquefied Petroleum Gas (LPG)
- 8.4 LPG Bulk Storage Installations

➡ **8.5 Installation of Specific Appliances**

- 8.6 Related Codes and Standards
- 8.7 List of Related Appendices

## Chapter 3 CONSTRUCTION SUPERVISION WORK

To repeat, as we have seen, in order to ensure the construction quality of a building, it is necessary to reliably achieve the requirements of the design documents during construction at the construction site, as well as to correctly handle the various construction materials, taking into account their characteristics, and to ensure that the selected materials perform as specified without impeding their performance. Therefore, the construction supervision required of a construction supervisor is to actually check and judge whether the construction contractor is using the specified materials to properly construct the building according to the design documents (design drawings), and if necessary, to provide guidance and instructions to ensure that the required construction quality is achieved.

Therefore, what the construction supervisor should check is;

- ✧ Procurement of materials of the required quality of design documents
- ✧ Handling including proper storage of procured materials
- ✧ Execution according to the design document on site

Herein, we will and confirm how these tasks are carried out accurately with relating to the QA/QC activities.

### 3.1 Construction work

At a construction site, the main objective of a contractor is to complete the construction work within the contracted construction period and budget while ensuring quality. Since the construction content varies depending on the construction environment, scale, and time of construction, it is important for the contractor to understand each request and thoroughly consider the construction method and procedures before commencing construction in a planned manner. Therefore, it is important for the construction supervisor to check the contractor's plans and implementation content, point out any mistakes, and provide guidance as necessary, while guiding the construction toward achieving its goals. In other words, it is essential for the construction supervisor to understand that knowledge of construction plans and construction content is too.

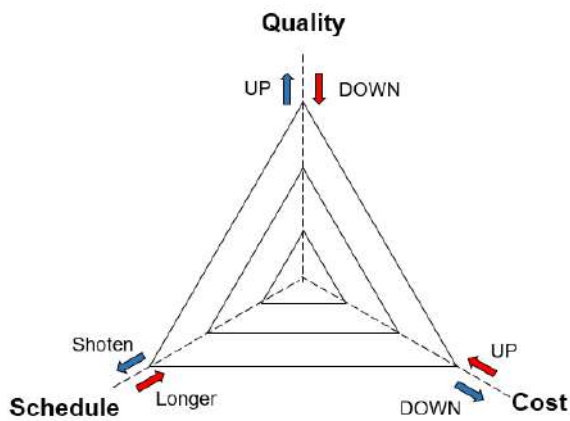
#### 3.1.1 Planning and Execution

The plan here means how the contractor will "maintain the required quality, complete the construction safely, within the contracted construction period, and under the consent budget." The diaphragm shown below shows the relationship between these elements.

**[Quality]** If it is upgraded, "Cost" will rise up, and "Schedule" (construction terms) will be longer.

**[Cost]** If it goes down (reduction), the "quality" will go down, or the "schedule" will be longer.

**[Schedule]** If the construction period is shortened, more "cost" will be spent to ensure "quality" or "quality" will decrease.



**Figure 3-1 Relation of 3 elements on Construction**

Furthermore, because safety has a serious impact on all three of these elements, safe construction is a fundamental premise when considering appropriate "costs, expenses, and construction time."

If safety is compromised, it will lead to delays in the "process," increased "costs," and reduced "quality." Therefore, safety risk is synonymous with "quality" risk, and it can be said that safety is a very important element for the quality of a building.

### 3.1.2 Quality Assurance and Quality Control

#### 3.1.2.1 Quality Assurance

Quality Assurance refers to "all activities that ensure that products and services meet pre-defined quality standards. Specifically, it is defined as planning, management, evaluation, and improvement to ensure quality at each stage of product and service development, production, and provision." In terms of construction work, it is the process of how to plan (construction drawings and construction instructions), how to check and consider (inspect), and how to consider improvement plans (discussion). It also includes the storage of construction records for maintenance management after completion, and the scope of quality assurance extends to the entire life cycle of products and services, from product design to production, sales, and after-sales service.

Specific quality assurance activities at construction sites include:

- ✧ Quality planning: Setting quality standards (checking tolerances, etc.), creating construction instructions and construction drawings, etc.
- ✧ Quality management: Material inspection and construction inspection (reinforcement inspection and formwork completion inspection, etc.)
- ✧ Quality evaluation: Confirming and recording construction results (pile driving records, concrete compressive strength tests and storage of records, etc.)
- ✧ Quality improvement: Considering construction errors and ways to improve them, etc.

The above are possible.

#### 3.1.2.2 Quality Control

On the other hand, quality control (QC) refers to the activities and methods to check whether products and services meet certain quality standards and prevent the occurrence of defects.

Specifically, it includes product inspection, management of manufacturing processes, and improvement activities. In the case of construction work, it means ensuring quality that meets the requirements of design documents and reducing defective construction, thereby increasing customer satisfaction and improving the reliability of the company. The following activities are expected for quality control at construction sites.

\*Product inspection: Check whether the product is made according to specifications and meets the standards (compared with design documents)

\*Manufacturing process management: Manage procedures and the environment so that the construction process is stable and buildings of the required quality can be completed within the construction period. (Elimination of unreasonable, wasteful, and dangerous work: each process chart, construction procedures)

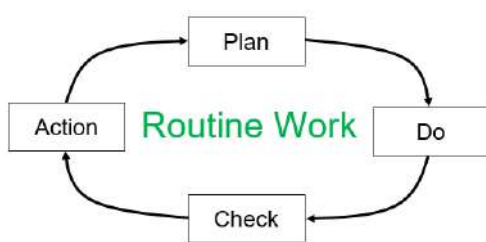
\*Analysis and improvement of construction defects: Consideration of construction defects, etc., and improvement measures (construction procedures, construction methods)

\*Seven QC tools: Quality control is performed using methods such as the seven QC tools (Pareto chart, characteristic diagram, histogram, control chart, scatter diagram, graph, check sheet).

In construction work, these include construction management organization charts, daily work reports to check workers and work efficiency, and output curves.

### 3.1.3 QA/QC activities at construction sites (PDCA working cycle)

It goes without saying that it is important to ensure QA/QC at construction sites to ensure construction quality. Specifically, the flow of planning, execution, evaluation, and improvement is carried out daily, and it is important for construction supervisors to check whether these implementation contents are being carried out reliably and leading to quality assurance, point



**Figure 3-2 PDCA Working Cycle**

out any mistakes, and providing guidance as necessary.

In practice, it is carried out in the following steps:

Step 1: Formulation of implementation plan

Step 2: Execution of plan

Step 3: Evaluation of effectiveness

Step 4: Formulation of improvement measures

This is called the PDCA cycle and is a QC activity

that is well known worldwide. In this way, construction work and its results are checked daily or step by step, and measures are planned and implemented without downtime (if there is any). Here we will see what each step is specifically for construction work.

#### 3.1.3.1 Construction Plan (Plan)

In planning, we plan in detail who will do what, when (at what time) and how, and thoroughly

consider whether the plan will achieve the required quality, whether there are any risks to achieving the objectives in implementing the plan, etc. Here, we confirm the specific contents of the construction plan. The specific planned items are shown below.

1) Construction schedule

Construction schedules include overall schedules, monthly schedules, and weekly schedules, and the work content to be carried out during each period must be specifically described. In any case of schedule, the optimal number of workers and work efficiency and productivity based on the size of the construction site are considered for each scheduled term, and the construction work content for each period (weekly, monthly, overall period) is planned exactly.

- ✓ Overall schedule,
- ✓ Structural construction schedule
- ✓ Finishing work schedule
- ✓ Monthly schedule
- ✓ Weekly schedule
- ✓ Daily schedule

These schedules serve as a guide for the work and is used as a schedule for work over various time periods according to the required construction management.

2) Creation of construction procedure/Methodology (Plan)

Needless to say, on-site work must be planned to take into consideration the site conditions, the difficulty of the work, points to note, construction delays, and construction risks such as declines in construction quality and construction accidents. Plans made in this way must be accompanied by work procedure manuals in advance to avoid confusion and misunderstandings at construction sites where many workers are engaged in construction work. Construction supervisors are also required to thoroughly review and consider the contents of the plan, and then provide appropriate guidance and criticism. The procedure has to include the contents as below.

## Contents

### A. General

A-1 Purpose

A-2 Scope of Explanation

A-3 Governing laws, regulations, rules, etc.

A-4 Outline of the work

A-5 Working Flow

\* Working sequence, priority and/or relationship among all

A-6 Execution schedule

A-7 Careful point and/or Important point

\* Anyother points to be clear-understanding of the work

A-8 Safety measures

### B. Particular (Detailed explanation)

B-1

B-2

B-3

B-4

B-5

B-xx

B-xxx

\* Each working step shall be explained in detail

\* Important point, Careful point, and risk hedge for safety work shall be included on the explanation

### C. Formats

\*Sample for report, record and others

- ◇ General
- ✓ Purpose
- ✓ Scope of explanation
- ✓ Outline of work
- ✓ Working flow
- ✓ Schedule sheet with explanation
- ✓ Other necessary points: Such as careful points, special instructions and others.
  
- ◇ Particular (Details of each task)

- ✓ Work content
- ✓ Working sequence
- ✓ Work method
- ✓ Number of Work personnel
- ✓ Precautions
- ✓ Others

When the construction supervisor receives a construction procedure document from the contractor, he/she should check its contents based on the points listed below, approve it if there are no particular problems, and point out any doubts and provide advice and suggestions as necessary.

- ✧ Points to note when checking the contents of construction procedure/Methodology
  - ✓ To be a plan in keeping with the surrounding environment.
  - ✓ To have to be a plan using construction machinery that is available locally.
  - ✓ Personnel planning based on the size of the work area.
  - ✓ To have been taken into consideration the weather conditions of the planned area (rainy season, dry season, etc.).
  - ✓ Appropriate temporary plans (scaffolding, lifting equipment, etc.) matched with the work.
  - ✓ The workflow in the correct order
  - ✓ Plan for worker productivity and efficiency
  - ✓ A plan that is free of waste and unreasonableness etc.

If any problems are found that do not comply with the specifications in the design documents, it is important for the construction supervisor to discuss with the contractor, designer, and, if necessary, the client to seek a solution.

### 3) Shop-Drawing

It can be said that construction drawings are documents that are compiled so that construction workers can easily check them while working on the construction site in order to fully reflect the requirements of the design documents. With the recent spread of CAD-Drawing, we see cases where design drawing data is used almost as is as construction drawings, but this is not the original use of design drawings. Although design drawings are written slightly differently depending on the designer, when constructing a building on site, construction must be carried out in accordance with all the instructions in the design documents, such as specifications, special notes, and other instructions, in addition to the information in the design drawings. Checking all of this necessary information on site is very cumbersome and time-consuming and can lead to mistakes. Therefore, the basis of construction drawings is a compilation of all the

necessary information for the area to be constructed.

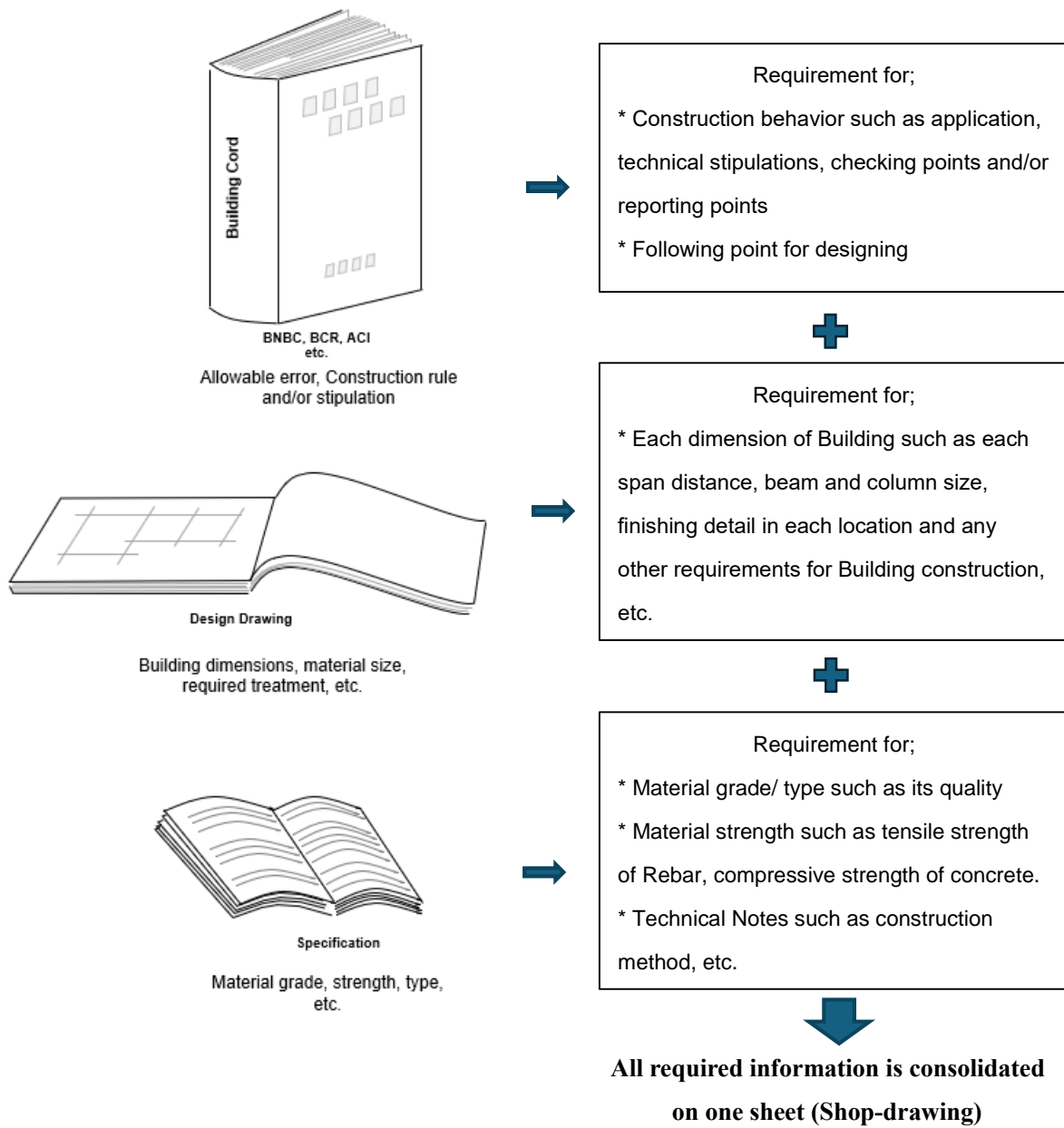


Table 3-1 is a summary of examples of common construction drawings, with the reference column to the right of the contents listing the relevant information

**Table 3-1 Major shop drawing on Piling, Foundation, and Structural works**

Category	Name	Descriptions	Reference Design document		
			Drawing	Specification	General notes
Piling Work	Pile arrangement	Piling position, piling depth or top level/ bearing soil layer, Type of pile, etc.	✓	✓	✓
	Pile fabrication drawing	[Pre-fabricated pile] size, length ,number. Reinforcing method, etc.	✓	✓	✓
	Pile rebar	[Bore Pile] Main rebar, spiral rebar, Hoop/ Size number pitch joint length)	✓	✓	-
Pile Cap	Pile cap arrangement	Size(X,Y,Z), Number, Top level, Type, Each Location, etc.	✓	-	-
Earth Work	Excavation drawing	Excavation area, depth, shoring/slope protection plan, etc.	✓	-	-
	Graveling/ Lean Concrete	Material specification, laying area and thickness, compacting requirement, etc.	-	✓	✓
Concrete Work	Rebar bending schedule	Size, Legth and shape(total/hook), Number in each kind of bar.	✓	✓	✓
	Rebar arrangement	[Column] Number and size of main bar, Size and pitch of Hoop, Splicing area and length of main bar, bottom and top hook shape and length.	✓	-	✓
		[Girder/Beam] Number and size of main bar, Size and pitch of Stairrup, Splicing area and length of main bar, anchoring style and length Web abr and tie bar	✓	-	✓
		[Slab] size and pitch of main ber on top and bottom layer and size and pitch of distribution ber on top and bottom layer	✓	-	✓
		[Wall] Size and pitch of horizontal and vertical rebar, splicing position, anchoring style and lenth.	✓	-	✓
		[Stair case] Size and number of main bar and distribution bar, anchoring style and length, size and number of tip bar	✓	-	✓
	Fabrication Drawing	Size and Number of each shuttering panes.	✓	-	✓
	Shorring arrangement	Materials, shoring type, setting level	✓	-	✓
Shuttering arrangement	Setting position, and level, size, reinforcing style, etc	✓	-	✓	

\* Shop drawing item on the above is not all, so that other kind of shop drawing shall be prepared, if necessary.

\* When the information to make a shop drawing is not enough on reference document, other regulation and/or stipulation such as BNBC, BVR, and others.

When the construction supervisor receives construction drawings from the contractor, he/she should check the contents for the following points and give approval to see if he/she judges them to be appropriate. In addition, if there are any doubts about the contents, it is advisable to point them out and provide advice and suggestions as necessary.

✧ Points to note when checking the contents of construction drawings

- ✓ The dimensions shown as correct and the method of showing them to be clear.
- ✓ It shall be created for each construction area and each work such as excavation, form-work installation, rebar work and so on site and has to be covered all necessary and sufficient information for the construction work
- ✓ To be indicated the measurement standards for dimensions clearly
- ✓ To confirm that installation methods and material specifications have complied with the requirements of the design documents etc.

4) Other work (execution) plans

In addition to the Working procedure (Methodology) and/or Construction drawings (Shop drawing), there are other plans that must be prepared in advance for construction. In particular, a construction supervisor must check the rebar bending schedule and/or concrete mix plan.

- ◇ Rebar bending schedule shall be referred 2.4.2.3, 1) “Rebar work!” and Table 2-17
- ◇ Concrete mixing plan shall be referred 2.2.1 “Concrete” and 2.4.1.3 “Water content in concrete”

The most important thing about any preparatory document is that they are thoroughly communicated to all workers and that the actual construction work is carried out based on these plans.

### 3.1.3.2 Construction work implementation

Once a construction plan has been created and the planned content has shared thorough awareness to relevant parties have been informed, the actual construction work will begin.

In construction beginning, preparations are made and carried out based on the plan, and the construction manager makes preparations and carries out the work based on the following items, and the construction supervisor checks the situation. If there are any discrepancies with the plan at this time, it is important for the construction supervisor to point them out and provide appropriate advice and suggestions to support the construction manager.

- ◇ Material preparation status according to the plan
- ◇ Personnel, equipment, and heavy machinery based on the plan
- ◇ Number of construction days following the plan

After construction begins, the construction manager will check the daily progress, weekly and monthly progress, etc. in detail, and will implement improvements to the plan as necessary. If necessary, the construction supervisor will point out problems with the construction period, quality, or safety, and provide advice and suggestions to the construction manager.

### 3.1.3.3 Checking the construction status

After construction begins, we closely monitor the construction status and progress, checking daily to ensure that the building is completed safely and to the required quality within the planned construction period. Construction status will be checked to ensure quality, progress, and safety of the work. It is important to closely check what problems there are by comparing them with the plan. Specifically, we check the progress, quality and safety of the daily construction situation, as well as the resulting weekly and monthly progress, and consider whether or not the plan can be achieved.

#### 1) Daily Progress

The points to look for in daily situation checks are:

- ◇ Personnel issues: Are the number of personnel, working hours, and worker skills appropriate?
- ◇ Work preparation issues: Are there any delays in arranging the materials, equipment, and heavy machinery to be used?
- ◇ Work environment: Is the work environment properly maintained (work passages, work scaffolding, material storage areas, etc.)

The contractor will check and record these points.

## 2) Weekly Progress

The points to look at when checking the weekly construction progress are:

- ◇ Weather issues: Whether or not conditions that hinder construction, such as rain or strong winds, occur ?
- ◇ Interrelationship issues between tasks: Whether or not the procedures (work order) for each task in a series of tasks are carried out according to plan ?
- ◇ Work environment: Whether or not other events that hinder construction progress occur ?

Delays and problems that were not visible in the daily progress can become problems if they accumulate over a week. In this way, we strive to detect problems early by taking an overview of the work situation throughout the week.

## 3) Monthly Progress

Just like with weekly progress checks, monthly progress checks also show that problems such as delays in the process or declines in quality that could not be detected in a one-week check can accumulate over the course of a month and cause serious construction problems to become apparent. Therefore, it is necessary and important to take an overview of the work status and construction results over the course of a month and strive to detect problems early.

### 3.1.3.4 Improvement of construction plan (action)

The construction manager must devise appropriate measures for the problems identified during each observation period and improve the original construction plan to safely complete the building of the required quality within the contracted construction period. It is important that the construction supervisor cooperates with the construction manager and provides appropriate advice and suggestions based on the construction status that the construction supervisor has confirmed. Points to consider for each confirmation content:

- ◇ Appropriateness of the planning procedure?
- ◇ Appropriateness of the planned assumptions for work efficiency?
- ◇ Were there any delays in arranging materials or delays in delivery? Etc.

If any of the above problems are discovered during each period, the appropriateness of the measures listed below must be immediately considered and reasonable change measures must be proposed.

- ◇ Whether to improve the skills of workers or increase the number of workers
- ◇ Whether to change or add equipment and heavy machinery

- ◇ Whether to change work procedures
- ◇ Whether to extend work hours
- ◇ Whether there is room for improving the work environment

It is important to thoroughly consider each possibility, its advantages and disadvantages, and to come up with the optimal improvement plan. Construction supervisors are expected to contribute to the formulation of improvement plans by using their knowledge as supervisors to provide specific suggestions, advice, and suggestions.

## 3.2 Site supervising work

As has been repeatedly explained, the on-site supervision work involves supervising the construction work of the contractor, understanding the contents of the construction work, and providing appropriate guidance, advice, and suggestions to contribute to the completion of the contracted work with the quality required in the design documents. In this article, we will explain in terms of specific when, what, and how. The specific work of construction supervision involves inspecting the construction status based on the design documents and pointing out, advising and proposing corrections as necessary (Construction inspection), recording the status of construction supervision implemented to achieve the required construction quality (Supervising records) for use in maintenance, renovation, expansion and other problem-solving, and reporting to the client and managing ministries and agencies as appropriate (Supervising reports).

### 3.2.1 Site inspection

#### 3.2.1.1 Checking of construction work (Check List)

Checking during the construction work is to check the quality of materials used, how they are handled, the assembly method, and the assembled state, and to confirm that they conform to the specifications in the design documents. The main items to be confirmed for rebar, formwork, and concrete and the confirmation timing are as shown in the table below.

Furthermore, although the final construction status will be judged as to whether it is adequate or not through a site inspection, checking the construction during construction is an important step in preventing rework and ensuring that the construction is promptly approved as adequate at the site inspection.

##### 1) Rebar checking point

In rebar construction, it is important that the rebar is processed based on the bending schedule and assembled at the installation location according to the construction drawings. Furthermore, it is important too that the rebar is arranged at appropriate intervals so that the concrete can be poured reliably, and that the rebar is firmly fixed so that the rebar position is not disturbed until the concrete is poured.

**Table 3-2 Checking List for Rebar Work**

Checking Subject	Implementation period	Checking point	Reference document	Inspection Style		
				Measurement	Report/ Certificate	Photo/ Visual check
Rebar Materials	Receiving materials	Required grade	Mill sheet/Tensile test report		✓	-
	Receiving materials	Required size and volume	Delivery receipt/ Mesuring record		✓	-
	Receiving materials	Delivered/Handling condition: Bent, warp, rust or Dirtiness	-			✓
Rebar Fabrication	Before installation	Column Main bar: Diameter, length and number	Bending schedule	✓	✓	-
	Before installation	Column Main bar: Length of end hook (Top only)	Bending schedule	✓	✓	-
	Before installation	Column Main bar: Bending angle of end hook (Top only)	Bending schedule	✓	✓	-
	Before installation	Girder/Beam Main bar: Diameter, length, number and the shape	Bending schedule	✓	✓	-
	Before installation	Girder/Beam Main bar: Length of hook (anchoring and others)	Bending schedule	✓	✓	-
	Before installation	Hoop/Stirrup: Diameter, dent size and numbers	Bending schedule	✓	✓	-
	Before installation	Hoop Stirrup: Hook length and the bent angle	Bending schedule	✓	✓	-
	Before installation	Sub hoop/stirrup: Diameter, size, shape, hook length/angle and the number	Bending schedule	✓	✓	-
	Before installation	Web bar and Tie bar: Diameter, size, shape, number, angle	Bending schedule	✓	✓	-
	Before installation	Slab: Diameter, length shape, hook length/angle, number	Bending schedule	✓	✓	-
	Before installation	Stairs: Diameter, length shape, hook length/angle, number	Bending schedule	✓	✓	-
	Before installation	Wall and others: Diameter, length, shapes, hook length/angle, number	Bending schedule	✓	✓	-
Rebar Arrangement Installation	After installation	Column Main bar: Size, number and splice position	Shop drawing (Rebar arrangement)	✓	-	✓
	After installation	Stirrup position	Shop drawing (Rebar arrangement)	✓	-	✓
	After installation	Girder/Beam Main bar: Size, number, Splice position	Shop drawing (Rebar arrangement)	✓	-	✓
	After installation	Girder/Beam Main bar: Anchored position and the condition	Shop drawing (Rebar arrangement)	✓	-	✓
	After installation	Hoop/ Stirrup: Diameter, installed pitch	Shop drawing (Rebar arrangement)	✓	-	✓
	After installation	Hoop and Stirrup: 1st installed position	Shop drawing (Rebar arrangement)	✓	-	✓
	After installation	Hoop and Stirrup: Installed condition at panel zone	Shop drawing (Rebar arrangement)	✓	-	✓
	After installation	Web bar: Diameter and installed layer	Shop drawing (Rebar arrangement)	✓	-	✓
	After installation	Tie bar: Diameter and installed number and pitch	Shop drawing (Rebar arrangement)	✓	-	✓
	After installation	Slab Main bar/ Distribution bar: Diameter, Installed layer and pitch	Shop drawing (Rebar arrangement)	✓	-	✓
	After installation	Slab Main bar/ Distribution bar: Start position of the arrangement	Shop drawing (Rebar arrangement)	✓	-	✓
	After installation	Slab Main bar/ Distribution bar: Anchor position and length	Shop drawing (Rebar arrangement)	✓	-	✓
	After installation	Stairs: Diameter, pitch, anchoring, splice position	Shop drawing (Rebar arrangement)	✓	-	✓
	After installation	Wall/Others: Diameter, pitch, anchoring	Shop drawing (Rebar arrangement)	✓	-	✓
	After installation	Wall/Others: Number of layers, splice position	Shop drawing (Rebar arrangement)	✓	-	✓
	After installation	Concrete spacer: Size, set position and number	Shop drawing (Rebar arrangement)	✓	-	✓
	After installation	Temporary position keeper: The condition	Shop drawing (Rebar arrangement)	✓	-	✓
	After installation	Beam re-bar position inside the column re-bar	Shop drawing (Rebar arrangement)	✓	-	✓

2) Formwork checking point

Formwork construction (formwork and shoring) must support the weight of the concrete being poured, rebar and other materials, workers and equipment, and also withstand the lateral pressure of the poured concrete. Furthermore, concrete pouring must be planned to have sufficient strength to withstand vibrations for compaction. For this reason, prior consideration, material selection, and assembly according to the construction drawings are important, and are key points in construction confirmation.

**Table 3-3 Checking List for Formwork**

Checking Subject	Implementation period	Checking point	Reference document	Inspection Style		
				Measurement	Report/ Certificate	Photo/ Visual check
Shoring	After delivery	Material condition: Damage (Rust, bent, twist, scratch, others)	-	-	-	✓
	Before installation	Planned Arrangement: Shoring strength	Shoring calculation	-	✓	-
	After installation	Constructed condition: Level, line, looseness	-	✓	-	✓
Shuttering Materials	After installation	Plywood condition: Peeling the surface	-	-	-	✓
	Before fabrication	Plywood condition: Recycle times	-	-	✓	✓
	Before fabrication	Shutter panel: Recycle times	-	-	✓	✓
	Before installation	Steel panel: Flatness, Bent, twist	-	✓	-	✓
	Before installation	Timber/GS Pipe: Straightness, Bent, Twist, Damages	-	✓	-	✓
	Before installation	Shutter leakage	-	✓	-	✓
Formwork construction	Before fabrication	Formwork arrangement/design: Parts strength	Formwork calculation	-	✓	-
	After fabrication	Shuttering panel: Size, number	Shop draing (Panel arrangement)	✓	✓	-
	After installation	Column: Size (X/Y)	Shop draing (Panel arrangement)	✓	✓	✓
	After installation	Column: Setting location and the top level	Shop draing (Panel arrangement)	✓	✓	✓
	After installation	Column: diagonal, axis	Shop draing (Panel arrangement)	✓	-	✓
	After installation	Column: Installed condition: Plumbing, Twist, and incline	Shop draing (Panel arrangement)	✓	✓	✓
	After installation	Column: Supported condition (Tighten and /or loose)	Shop draing (Panel arrangement)	✓	-	✓
	After installation	Girder/Beam: Size (BxD)	Shop draing (Panel arrangement)	✓	✓	✓
	After installation	Girder/Beam: Horizontality	Shop draing (Panel arrangement)	✓	✓	✓
	After installation	Girder/Beam: Bottom and Top level	Shop draing (Panel arrangement)	✓	✓	✓
	After installation	Girder/Beam: Deflection (Curvature, Twist, Bent)	Shop draing (Panel arrangement)	✓	✓	-
	After installation	Girder/Beam: Setting condition/ Rigid or Loose	Shop draing (Panel arrangement)	✓	-	✓
	After installation	Slab: Horizontality	Shop draing (Panel arrangement)	✓	✓	-
	After installation	Slab: Setting level	Shop draing (Panel arrangement)	✓	✓	-
	After installation	Slab: Setting condition/ Rigid or Loose	-	✓	✓	-
	After installation	Stair, Wall and others: Size, location, level, dimension (Thickness)	Shop draing (Panel arrangement)	✓	✓	-
	After installation	Stair, Wall and others: Setting condition (Rigid or Loose)	-	✓	-	✓
	Before concreting	Shuttering condition: Cleanness	-	-	✓	✓
	Before concreting	Shuttering condition: Sprinkling water	-	-	✓	✓
	Before concreting	Shuttering condition: Covering clear covering	-	-	✓	✓
Removal of fomwork	After concreting	[Removal] Side shuttering panel: Terms of curing concrete	Design document	-	✓	✓
	After concreting	[Removal] Bottom shuttering panel: Terms of curing concrete	Crusing test report	-	✓	✓
	After concreting	[Removal] Dismantle condition: Without any impact to concrete	-	-	✓	✓
	After concreting	[Removal] Dismantle Shoring: Curing terms of concrete	-	-	✓	✓

3) Concrete checking points

In concrete construction, it is important that concrete mixed according to a mix plan is poured properly within the allowable time, and that appropriate measures are taken during the curing period after pouring. There are many points that greatly affect construction quality, including points that affect the strength of the structure.

**Table 3-4 Checking List for Concrete Work**

Checking Subject	Implementation period	Checking point	Reference document	Inspection Style		
				Measurement	Report/ Certificate	Photo/ Visual check
Concrete material	Before Mixing/Order	Mixing design: Mixing ratio, selecting additive materials	Concrete mixing design	-	-	✓
	After delivered/Mixed	Ready mixed/Site mixed: Mixed condition/ Slump test, Flow checking	-	✓	✓	✓
	After delivered/Mixed	Ready mixed/Site mixed: Coarse aggregate size and shape, fine aggregate F.M	-	✓	✓	✓
	After delivered/Mixed	Ready mixed/Site mixed: Cement type and condition, water quality	-	✓	✓	✓
	After delivered/Mixed	Ready mixed/Site mixed: Temperature	-	✓	✓	✓
	After delivered	Ready Mixed Concrete/Delivery condition: Transportation time	Delicery receipt	✓	✓	-
	After mixed	Site mixed concrete: Mixing (Measuring, Mixing time)	Mixing record	✓	✓	✓
Pouring concrete	After delivered	Pouring time after delivery of Ready mixed concrete	-	✓	✓	-
	During casting time	Usage of equipment (vibrator/ steel trowel)	Manyual Book	-	✓	✓
	During casting time	Casting condition: Handling of a tip of concrete hose	Manyual Book	-	✓	✓
	During casting time	Downtime in each layer of concrete pouring	Manyual Book	✓	✓	✓
Curing concrete	Curing time	Curing condition: Sprinkle water and/or curing compound	Manyual Book	-	✓	✓
	Curing time	Protection against Blow window and/or Rain	Manyual Book	-	✓	✓
	Curing time	Protecting against any impact	Manyual Book	-	✓	✓

#### 4) Checking point of Fire prevention work

Materials used in fire prevention construction must be certified by public institutions, and various regulations are in place for construction. These facilities are often difficult to check during inspections after completion, so it is important to make sure that the right materials are used and installed properly during construction.

**Table 3-5 Checking List for Fire prevention Work**

Checking Subject	Implementation period	Checking point	Reference document	Inspection Style		
				Measurement	Report/ Certificate	Photo/ Visual check
Fire Prevention Material	After receiving	Smoke detector/ Heat sensor: Product certificate	Design document	-	✓	-
	After receiving	Wall one- or two-hour rating	Design document	-	✓	-
	After receiving	Control panel: Product certificate	Design document	-	✓	-
	After receiving	Cable and accessory (Condit material): Fireproof certified product	Design document		✓	-
	After receiving	Cable and accessory (Condit material): Fireproof certified product	Design document		✓	-
	After receiving	Sprinkler accessory (Connector, joint and others Product) certificate:	Design document		✓	-
Fire Prevention Installation	After installation	Setting position: Detector/sensor/alarm	Shop drawing	✓	✓	-
	After installation	Cabling condition: Connection, joint and others	-	-	✓	✓
	After installation	Cabling treatment of penetration for fire prevention section	Manual	-	✓	✓
	After installation	Wall penetration of pipe, cable, duct and others	Manual	-	✓	✓
	After installation	Slab penetration of pipe, cable, duct and others	Manual	-	✓	✓
	After installation	Treatment for gap around fire prevent door	Manual	-	✓	✓
Application	After completion	Application of completion	Design document, BNBC	-	✓	-

#### 5) Checking points of the other works

The checking points 1) to 4) are general for rebar work, formwork work, concrete work and disaster prevention work, but pile work and other general building work and M&E work are as shown below. However, this does not cover steel structural work and other building work and finishing work.

**Table 3-6 Checking List for Building Work**

Checking Subject	Implementation period	Checking point	Reference document	Inspection Style		
				Measurement	Report/ Certificate	Photo/ Visual check
Working location	Before commencement	Building Use and Zone category of the Land	BNBC	-	✓	-
	Before commencement	Construction permission	Permitted document	-	✓	-
	Before commencement	Actual construction position for the building	Design drawing/shop drawing	✓	-	-
	Before commencement	Actual Set-back distance from front road and/or adjacent border	Design drawing/shop drawing	✓	-	-
Pile Preparation	Before piling	Marking the piling position	Shop drawing	✓	-	-
	Before piling	Stock condition of the pile, Rebar, and other	-	-	-	✓
	Before piling	Confirmed the condition of bearing layer at pile tip position	Design drawing/Boring data	-	✓	✓
	Before piling	Assembled condition rebar cage	Shop drawing	✓	✓	✓
	Before driving	Setting condition of piling machine	Manual	-	✓	✓
		Joint pile	Machine & Materials prepared	BNBC	-	✓
Driving Pile	After driving	Driving condition (Hammering number, Electrical resistance, Others)	-	✓	✓	-
	After driving	Driven pile depth	-	✓	✓	-
	After driving	Level of the pile head position	-	✓	✓	-
		After driving test	Pit, Pile driving analyzer, load test	BNBC	✓	✓
Bored pile	After bored	Bored condition (size, depth, plumbing)	Shop drawing	✓	✓	-
	After bored	Removal of slime at the bored hole	-	-	✓	✓
	After bored	Casting material (Concrete strength, slump)	Design document	-	✓	-
	After bored	Casting method (Using tremie pipe)	Manual	-	✓	✓
	After bored	Casting concrete level (pile top level:1.0mm approx.)	Shop drawing	✓	✓	-
Piling result	After piling	Treatment of pile head (Cutting, Chipping)	-	-	✓	✓
	After piling	Executed pile position (Deviation)	Shop drawing	✓	✓	-
	After piling	Loading test, Pit, Pile driving analyzer	Design document	-	✓	-
	After piling	Sonic test (Boring pile)	Design document	-	✓	-
Earth work	Before execution	[Excavation] Excavated area	Shop drawing	✓	✓	-
	After execution	[Excavation] Excavated depth	Shop drawing	✓	✓	-
	Before laying	[Graveling materials] Grade, Particle, Type	Design document	✓	✓	-
	After excavation	[Graveling] Grading condition (excavated sub-grade condition)	Manual	✓	✓	✓
	After laying	[Graveling] Gravel and/or Crush stone material (Size/ Thickness)	Shop drawing	✓	✓	✓
	After compacting	[Graveling] Compaction of Gravel/ Crush stone	Manual	-	✓	✓
	After execution	[Backfilling] Thickness of each filling layer	Manual	✓	-	✓
After execution	[Backfilling] Result of compaction	Manual	-	✓	✓	

**Table 3-7 Checking List for M & E Work**

Checking Subject	Implementation period	Checking point	Reference document	Inspection Style		
				Measurement	Report/ Certificate	Photo/ Visual check
Plumbing work	After delivery	[Water supply] Piping materials	Shop drawing	-	✓	-
	After execution	[Water supply] Piping route	Shop drawing	-	✓	-
	Before execution	[Water supply] Pipe size	Shop drawing	✓	✓	-
	After execution	[Water supply] Piping condition such as joint and support	-	-	✓	✓
	After execution	Easily apply Repair and maintenance	-	-	✓	✓
	After execution	[Water supply] Arrangement of air-vent	Shop drawing	-	✓	✓
	After execution	[Water supply] Arrangement of gate valve, non-return valve, other valves	Shop drawing	-	✓	✓
	After execution	[Water supply] Piping treatment of penetration for fire prevention section	Manual	-	-	✓
	Before execution	[Drainpipe] Piping material	Shop drawing	-	✓	-
	After execution	[Drainpipe] Piping slope	Shop drawing	-	✓	✓
	After execution	[Drainpipe] Piping route	Shop drawing	-	✓	-
	After execution	[Drainpipe] Pipe size	Shop drawing	✓	✓	-
	After execution	[Drainpipe] Piping condition such as Joint, support, others	Manual	-	✓	✓
	After execution	[Drainpipe] Arrangement of Cleaning port	Shop drawing	-	-	✓
After execution	[Drainpipe] Piping treatment of penetration for fire prevention section	Manual	-	-	✓	
Air-intake & Air-ventilation	After execution	Arrangement of the setting position	Shop drawing	✓	-	✓
	Before execution	Size/Area of Air-intake	Shop drawing	-	✓	-
	Before execution	Size/Area of Air-ventilation	Shop drawing	-	✓	-
	After execution	Route of Air-intake line	Shop drawing	-	✓	-
	Before execution	Size of Air-intake duct (spiral and/or squire)	Shop drawing	✓	✓	-
	Before execution	Size of Air-ventilation duct (spiral and/or squire)	Shop drawing	✓	✓	-
	After execution	Ducting treatment of penetration for fire prevention section	Manual	-	-	✓
Erectrical Work	Before execution	Position of electrical conduit	Discussion with Designer	-	✓	-
	Before execution	Cable size and type as required design document	Design document	-	✓	-
	After execution	Cabling route as design document	Shop drawing	-	✓	-
	After execution	Cable connection to be rigid	Manual	-	✓	✓
	After execution	Cable condition under a little more than exact distance	Manual	-	-	✓
	After execution	Ordinal cable arrangement	Manual	-	-	✓

### 3.2.1.2 Execution of construction inspections (Inspection Items)

Construction inspection is a confirmation task carried out at each construction stage to check whether the construction results at the construction site are completed according to the specifications stipulated in the design documents. In other words, it is to check whether the specified grade of materials is used, whether it is installed as required by the drawings, and whether it is installed in the manner stipulated in BNBC and other standards, etc., and whether the quality of the construction is in line with the design documents, which is one of the very important tasks of construction supervision.

#### 1) Purpose of Construction inspection

Construction inspections are carried out at the end of each construction stage to confirm the completion of that stage. While construction checking carried out during each construction stage is aimed at preventing construction defects at the construction inspections time, construction inspections are important milestones in construction where the inspection results at each stage are finally confirmed and approval is given to proceed to the next stage of construction, or instructions are given for corrections or countermeasures, etc., as necessary.

#### 2) Construction inspection items and contents

Construction inspections of rebar, formwork, and concrete are carried out at the end of each construction stage, and their items, contents, and implementation times are as shown in the table below. Furthermore, the results of these inspections must be kept as construction inspection records and must be available for presentation when necessary.

- ◇ Inspection of rebar work: The work shall be checked the points shown on Table 3-8 “Inspection contents for Rebar.

**Table 3-8 Inspection List for Rebar work**

Category	Title	Checking contents	Implementation period
Rebar work-1	Reinforcement inspection for pile cap	*Rebar size and number (arranged pitch), *Rebar bend and strait *Fixing condition, each other rebar	Before concreting
Rebar work-2	Column (Base ~ First Splicing)	*Concrete covering size (Concrete spacer) *Diameter, number and length of Main bar *Foot shape of the Main bar *Rebar bend and straight, angle *Size, diameter and shape of Hoop *Number and spacing of Hoop *Concrete covering size (Concrete spacer) *Fixing condition of each bar	After completion of placing / Before installing Formwork
Rebar work-3	Underground Beam	*Number and diameter of main bar *Rebar spacing of main bar *Area, shape and length of anchoring *Shape and length of splicing *Size and diameter of stirrup *Rebar bend and straight, angle *Reinforcing space of stirrup *Diameter, layer and spacing of web bar, tie bar *Concrete covering size (Concrete spacer) *Fixing condition of each bar	After completion of placing / Before concreting
Rebar work-4	Grade slab	*Diameter, length and shape of end position for Main bar *Diameter, length and shape of end position for Distribution bar *Rebar bend and straight, angle *Number (Spacing) of Main bar at Top and Bottom layers *Number (Spacing) of Distribution bar at Top and Bottom layers *Concrete covering size (bar stand size) for Top and Bottom layers *Fixing condition of each bar	After completion of placing / Before concreting
Rebar work-5	Column (First Splicing ~ Final Splicing)	*Diameter and number of Main bars *Size, diameter and shape of Hoop (Including Panel zone) *Rebar bend and straight, angle *Number and spacing of Hoop *Splicing style and length *Concrete covering size (Concrete spacer) *Fixing condition of each bar	After completion of placing / Before installing Formwork
Rebar work-6	Column (Top section)	*Diameter and number of Main bars *Top level of Main bar *Rebar bend and straight, angle *Size, diameter and shape of Hoop (Including Panel zone) *Size, diameter and shape of Hoop (Including Panel zone) *Reinforcing space of tie (pitch) *Number and spacing of Hoop *Splicing style and length	After completion of placing / Before installing Formwork

Category	Title	Checking contents	Implementation period
Rebar work-7	Beam (In Each floor)	*Number and diameter of main bar *Rebar spacing of main bar *Area, shape and length of anchoring *Rebar bend and straight, angle *Shape and length of splicing *Size and diameter of stirrup *Reinforcing space of stirrup (pitch) *Diameter, layer and spacing of web bar, tie bar *Concrete covering size (Concrete spacer) *Fixing condition of each bar	After completion of placing / Before concreting
Rebar work-8	Wall (In each floor)	*Diameter, length and shape of end position for vertical bar *Anchoring style, shape and the length of vertical bar *Splicing style and length of vertical bar *Diameter, length and shape of end position for horizontal bar *Rebar bend and straight, angle *Anchoring style, shape and the length of horizontal bar *Splicing style and length of horizontal bar *Diameter and size of tie bar *Layer and positions for tie bar *Number, style, and diameter of opening reinforcement bar *Concrete covering size (Concrete spacer) *Fixing condition of each bar	After completion of placing / Before installing Formwork
Rebar work-9	Slab (In each floor)	*Diameter, length and shape of end position for Main bar *Rebar bend and straight, angle *Diameter, length and shape of end position for Distribution bar *Anchoring style, shape and the length of Main bar	After completion of placing/ Before concreting
Rebar work-9	Slab (In each floor)	*Anchoring style, shape and the length of Distribution bar *Number (Spacing) of Main bar at Top and Bottom layers *Rebar bend and straight, angle *Number (Spacing) of Distribution bar at Top and Bottom layers *Number, style, and diameter of Opening reinforcement bar *Concrete covering size (bar stand size) for Top and Bottom layers *Fixing condition of each bar	After completion of placing / Before concreting
Rebar work-10	Stair (In each floor)	*Diameter, length and shape of end position for Main bar *Diameter, length and shape of end position for Distribution bar *Diameter, shape, and size of stairway bar *Rebar bend and straight, angle *Installation spacing of stairway bar (pitch/number) *Size, length and shape of tip bar *Concrete covering size (Concrete spacer) *Fixing condition of each bar	After completion of bottom formwork
Rebar work-11	Miscellaneous rebar (Palalet, Canopy, Others)	*Diameter, length, shape and number of main bars *Anchoring style, length and shape of main bar *Rebar bend and straight, angle *Diameter, length, shape and number of distribution bar *Concrete covering size (concrete spacer) *Fixing condition of each bar	After completion of placing / Before concreting

- ◇ Inspection of formwork: The work shall be checked the points shown on Table 3-9  
 “Inspection contents for Formwork.

**Table 3-9 Inspection List for Formwork**

Category	Title	Checking contents	Implementation period
Formwork-1	Shuttering Panel/Plywood/Timber	*Damage (Hole, Peel Scratch, Bent, Twist, Curbed etc.)	Before usage
Formwork-2	Pile cap/Spread foundation	*Size (X*Y*D)	After completion of installation / Before concreting
		*Plumbing of shuttering panel	
		*Length and type of tie-rod	
		*Fixing of the foot of shuttering panel	
		*Fixing of the diagonal bracing for mat or raft	
		*Fixing of corner	
		*Vertical and horizontal reinforcing pipe (timber)	
		*Fixing condition of each panel	
		*Fixing of form-tie	
*Setting condition of support materials			
Formwork-3	Column (In each portion)	*Size (X*Y)	After completion of installation / Before concreting
		*Plumbing of shuttering panel	
		*Length and type of tie-rod (X/Y)	
		*Fixing of the foot of shuttering panel	
		*Fixing of corner	
		*Vertical and horizontal reinforcing pipe (timber)	
		*Fixing condition of each panel	
		*Fixing of form-tie	
		*Ensure airtight	
*Setting condition of support materials			
Formwork-4	Underground Beam	*Size (B*D)	After completion of installation / Before concreting
		*Plumbing of side shuttering panel	
		*Fixing of foot of shuttering panel	
		*Length and type of tie-rod	
		*Fixing condition in each panel	
		*Connecting condition to Pile cap and/or Column	
		*Vertical and horizontal reinforcing pipe (timber)	
		*Fixing of form-tie	
		*Ensure airtight	
*Setting condition of support materials			
Formwork-5	Beam (in each floor)	*Setting level of bottom panel	After completion of installation / Before concreting
		*Size (B*D)	
		*Plumbing of side shuttering panel	
		*Length and type of tie-rod	
		*Fixing condition in each panel	
		*Fixing condition to bottom panel	
		*Connecting condition to column	
		*Constructed condition (Straightness, bent, twist and etc.)	
		*Vertical and horizontal reinforcing pipe (timber)	
*Ensure airtight			
*Fixing of form-tie			
Formwork-6	Grade Slab	*Height of Shuttering panel	After completion of installation
		*Fixing condition in each panel	

Category	Title	Checking contents	Implementation period
Formwork-7	Grade Slab	*Fixing condition of panel foot *Plumbing of shuttering panel *Vertical and horizontal reinforcing pipe (timber) *Setting of diction of support pipe and/or timber	After completion of installation/ Before concreting
Formwork-8	Slab (Including canopy)	*Setting level and flatness for bottom panel (excluding slop slab) *Connecting condition to Beams and/or Columns *Joint condition in each bottom panel *Height of Side shuttering panel (If any) *Setting condition of side panel (Plumbing, straightness, twist), if any <b>*Ensure airtight</b> *Fixing condition of side panel, if any	After completion of installation / Before concreting
Formwork=9	Wall (In each floor)	*Plumbing of shuttering panel *Length and type of tie-rod *Setting location of tie-rod (Pitch and layer) *Joint condition in each shuttering panel *Vertical and horizontal reinforcing pipe (timber) *Setting condition of support pipe and/or timber, if any <b>*Ensure airtight</b> *Fixing of form-tie	After completion of installation / Before concreting
Formwork-10	Stair (In each floor)	*Start and end position of slop for bottom panel *Joint condition in each bottom panel *Thickness of the bottom slab *Plumbing of side shuttering panel, if any *Fixing condition of side panel, if any *Fixing condition of stairway panel <b>*Ensure airtight</b> *Size of Stairway	After completion of installation / Before concreting
Formwork-11	Miscellaneous (Parapet and others)	*Setting condition of side panel (Plumbing, straightness, twist), if any *Joint condition in each panel *Size (Height) *Length and type of tie-rod *Vertical and horizontal reinforcing pipe (timber) <b>*Ensure airtight</b> *Fixing condition of form-tie	After completion of installation / Before concreting

✧ Inspection of Concrete work: The work shall be checked the points shown on Table 3-10 “Inspection contents for Concrete work.

**Table 3-10 Inspection List for Concrete work**

Category	Title	Checking contents	Implementation period
Concrete work-1	Preparation for Casting	*Cleaning *Sprinkle water in pouring area (Wetting the shuttering surface) *Temporary walkway *Preparation of tools (vibrator, steel trowel, Lamp, etc.) <b>*Covering check</b>	Before commencement of concreting
Concrete work-2	Concrete test/sampling	*Concrete Slump test (Slump flow test) *Checking concrete tempter *Sampling Test piece	Arrival on site
Concrete work-3	Concreting	*Downtime of in each layer (completion of one layer to next layer) *Laying condition of concrete *Vibrating condition *Tamping condition *Protection against rainfall (under rain) *Executing of trawl condition (wooden and/or steel)	During concreting
Concrete work-4	Curing	*Protection against blowing window (After casting) *Protection against impacting/ shock (After casting) *Keeping wet condition *Keeping the curing time due to stipulated term	After concreting

### 3) Inspection sheet

Construction inspections are carried out for the items listed in the previous section, but it is extremely difficult and unrealistic that the Supervisor inspects all positions and record actual inspection results for all items in terms of time. For example, the shape and number of reinforcing bars of structural members such as pillars and beams change depending on the stress that the frame bears, which is so complicated. Therefore, construction supervisors are required to carefully check the parts that are important for structural strength and approve if they are within the allowable error range but point out the problem to the contractor and give instructions for redoing or reworking if there are differences from the drawings that exceed the allowable range. In this case, it is important to make a careful judgment, including checking with the designer.

Basically, the contractor should prepare a construction checking record and present it to the Supervisor, who should then reconfirm some important parts with the contractor to make sure there are no errors with the recorded contents.

It is a reasonable checking style for both.

In addition, it is important to use an inspection sheet when carrying out construction inspections and to keep a record of the inspection results.

It is reasonable to use Attachment C "Inspection Sheet" for the inspection sheet for rebar work, formwork work, and concrete work. The inspection sheet has items such as required values, construction values, allowable errors, and inspection results, but please fill in the required values and allowable errors after checking the drawings and specifications in advance as preparation before the inspection. If you are unclear about the allowable errors, it is important to check with the designer in advance.

For reference, we have provided below an inspection sheet for beam rebar.

**Table 3-11 Sample of Inspection Sheet for Beam Rebar**

<b>Construction Inspection Records</b>									
Project Name: <b>XXX Building Project</b>									
Inspection Title: <b>Rebar Inspection (Beam)</b>									
Beam Name: _____					Location: _____				
					Sheet No.: _____				
					Inspection Date: _____				
					Supervisor Name: _____				
No.	Confirmation			Onspection result		Judgement			
	Items	Contents	Required	Result	Tolerance	Good	Acceptable	Reject	
1	Upper Min-bar	Diameter (End position)							
		Number (End position)							
		Diameter (Center position)							
		Number (Center Position)							
		Anchoring Length							
		Anchoring Condition							
		Splicing length							
2	Bottom Min-bar	Diameter (End position)							
		Number (End position)							
		Diameter (Center position)							
		Number (Center Position)							
		Anchoring Length							
		Anchoring Condition							
		Splicing length							
3	Stirrup	Diameter							
		Number (Pitch/Spacing) End position							
		Number (Pitch/Spacing) Center position							
4	Web bar	Diameter							
		Number of Layer (Pitch/Spacing)							
5	Tie Bar	Diameter							
		Number (Pitch/Spacing)							
6	Arrangement & Others	Fising Condition (Binding)							
		Streghtness (Bend, Curb, Twist)							
		Concrete covering (Both side) Spacer							
		Concrete covering (Bottom side) Spacer							
		Concrete covering (Top side) Spacer							

**Notes:** \*When inspecting, fill in the sheet with the project name, sheet number for each project, inspection date, and inspector name.  
 \*The tolerance values in the table are showing tolerances in Japan as reference. Actual tolerances must be discussed and confirmed with the designer.

Both Ends (a-Section)

Center (b-Section)

Side view of Beam

AL: Anchoring length  
 SL: Splicing length  
 \*1: Approx. 100mm into another zone

### 3.2.2 Supervising Record

Construction supervision records are important for checking after construction what kind of supervision was performed and what the results of that supervision were, and can be very useful when carrying out future renovations, etc. Furthermore, as explained above, in the event of a disaster, it will be a very important document to prove that the cause was not due to the original construction, and it will help avoid construction risks not only for construction supervisors but also for contractors.

Simply put, construction supervision records are records of the confirmation work carried out during construction, so that it means that they will be stored together with the check sheets and inspection sheets explained above, inspection reports for materials used, manufacturer warranties, and appropriate photographic records of the construction status.

The documents that should be kept as construction supervision records are as follows:

- Material Certificate such as Rebar mill sheet
- Test report such as Tensile test for rebar, Concrete Crushing Test result
- Material Delivery receipt
- Other required report
- Work procedure (Methodology)
- Construction photograph

The above report shall be submitted to the Supervisor by Constructor

In addition,

- Inspection sheet in each inspection
- Issued instruction sheet
- Checking photograph
- Any other record for the construction, if any.

Again, these construction records will not only be useful in the future but will also be extremely useful in showing the construction status of the contractors and construction supervisors during construction inspections carried out by RAJUK, and will serve as important evidence of the high construction quality by the contractors and construction supervisors.

### 3.2.3 Site construction record

At the construction site, how construction is carried out is determined on a daily basis through the PDCA (Plan, Do, Check, Act) work cycle. Contractors prepare plans such as work procedures and mix plans, and by examining the contents, they anticipate risks in advance and avoid construction risks. This is the Plan phase of the PDCA cycle. Then, they carry out the actual construction (Do), check the construction daily (Check), and, if necessary, make improvements such as increasing the number of workers or adding heavy machinery (Action). This construction quality management activity is a task that shows the contractor's work attitude.

In other words, the records of these activities are also important materials for the contractor to dispel doubts about the construction quality in the future, such as in the event of a disaster. Construction records are created by the contractor, but as a construction supervisor, it is important to properly create and store construction records, fully explain the significance and benefits of keeping them, gain understanding, and actually request that they be submitted as a construction report.

The following documents are normally included in the construction record:

- Material Certificate such as Rebar mill sheet
- Test report such as Tensile test for rebar, Concrete Crushing Test result
- Material Delivery receipt
- Other required report
- Work procedure (Methodology)
- Shop drawing such as formwork arrangement, rebar arrangement and etc.
- Construction photograph
- Manpower record
- Weather report on site
- Daily Working time
- Schedule sheet such as overall, monthly and weekly

Finally, to summarize the supervision work at the construction site, it starts with the storage status of the contractor's design documents, preparation of plans such as construction drawings and construction instructions, and advance confirmation of material test results and performance tables, etc., followed by confirmation of the daily work content (checklist) at the construction site that has been confirmed so far, and then inspections (inspection items) at each construction stage and, to record the inspection results on an inspection sheet. A report will be created along with each of these confirmation documents and documents showing the implementation status such as photos, and these will be prepared as records so that they can be presented to the owner or inspector (RAJUK) if necessary.

## Chapter 4 WORK PROCEDURE FOR REFERENCE

This chapter provides some examples of construction instructions that can be used as reference for construction supervisors. Please use them as a reference when discussing with the contractor and confirming the construction procedures planned by the contractor.

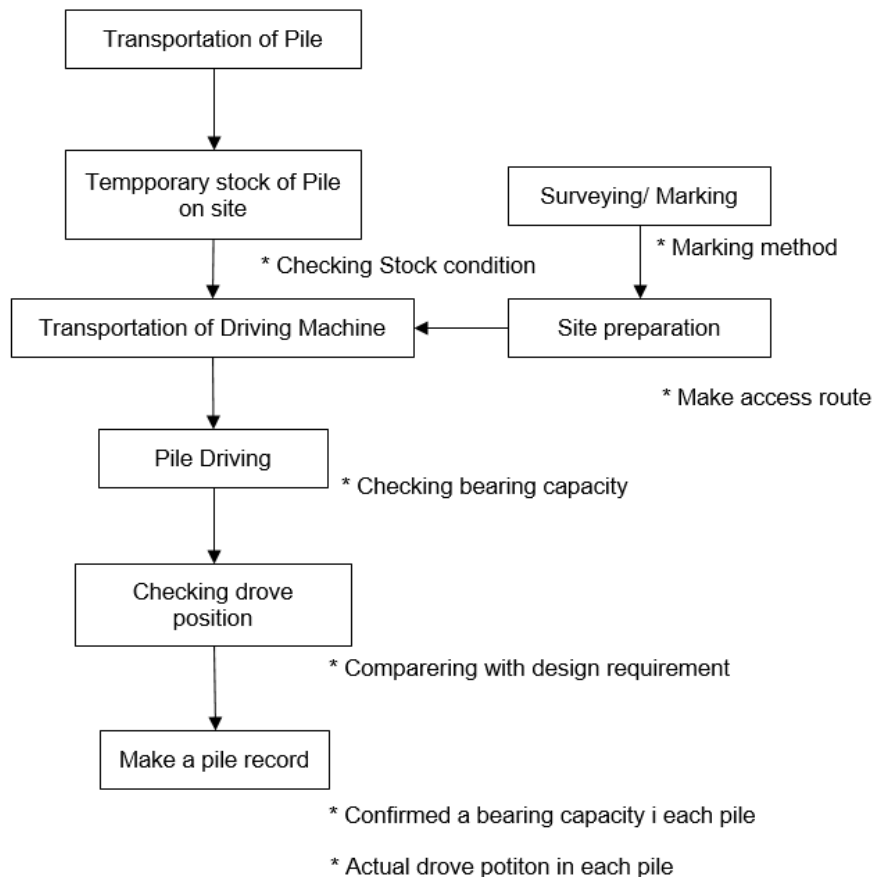
### 4.1 Driving Pile work

There are many kinds of types of pile according to the materials and/or construction method. Especially, Concrete pile can be classified into Pre-fabricated piles and Pile cast in place, and pre-fabricated pile has a RC pile, PC pile, PHC pile and others, and each pile type and driving method shall be decided according to structural design.

Herein, the RC pile in the group of Pre-fabricated pile and Bore pile will be explained.

#### 4.1.1 Working flow

The Working flow of PC pile work is below.

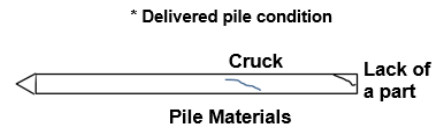


**Figure 4-1 Working flow PC Pile work**

#### 4.1.2 Working point on the working steps

##### 4.1.2.1 Damage of delivery, Handling and/or Stock

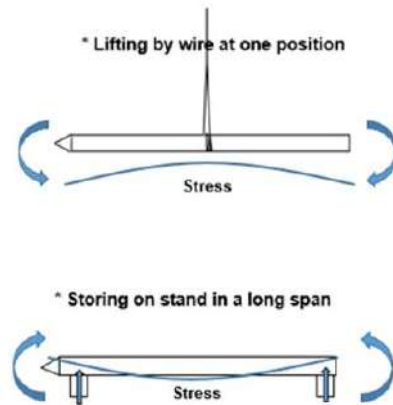
PC piles are manufactured in factories and transported on trailers to the construction site, but it is important that we thoroughly check to ensure that they are not damaged during transportation or unloading on site.



**Figure 4-2 Damages on the delivered pile**

##### 4.1.2.2 Stress on Pile

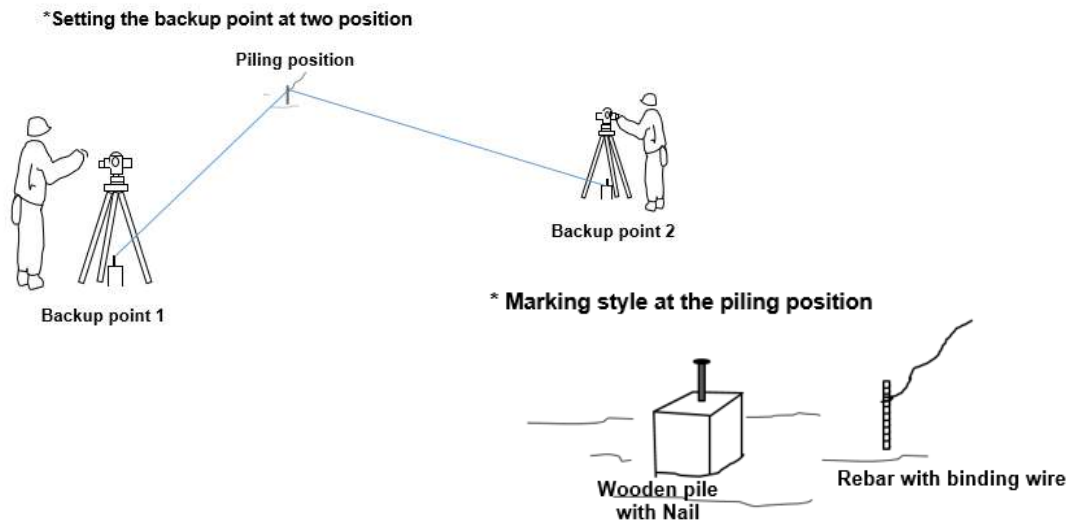
The piles that are delivered to the site are temporarily stored at the construction site, but it is important to handle them carefully so as not to damage them when lifting them with a crane or in storage conditions.



**Figure 4-3 Incorrect handling of pile**

##### 4.1.2.3 Marking piling position

The piling position shall be marked the wooden stakes with nails, rebar with marking wire, etc. normally, and that the backup point shall be set at least two positions as following illustrations.



**Figure 4-4 Marking style and Two-way backup point**

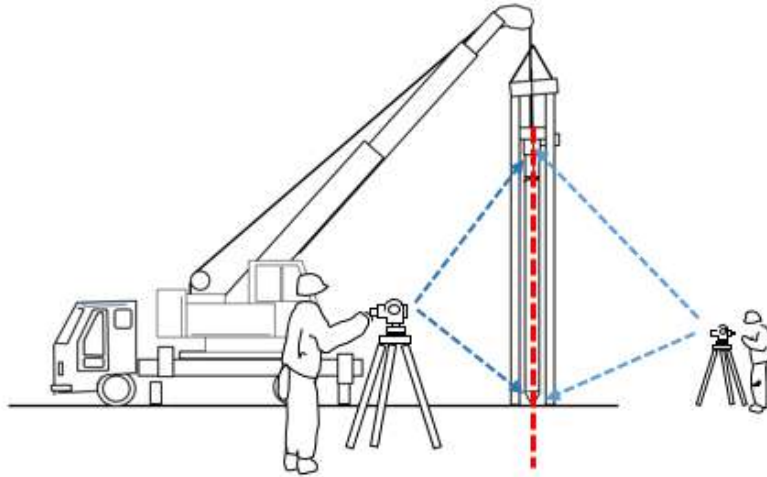
##### 4.1.2.4 Access route/ Sequence of driving pile

The driven pile shall not be given any stress, therefore, the piling machine and/or any other support equipment need a correct access route and/or driving sequence. In other words, the pile driving procedure must plan an access route that pile drivers or other heavy machinery would not need to pass over the installed pile positions.

#### 4.1.2.5 The plumbing of the pile and Piling leader

The pile shall be driven in plumb to avoid any bending stress. For this reason, during pile driving operations, it is necessary to constantly check that the pile driver's tower is maintained vertically from two directions.

##### **\*Checking plumbing of the pile (Verticality)**



**Figure 4-5 Two direction checking Pile driver's tower**

#### 4.1.2.6 Checking Bearing capacity

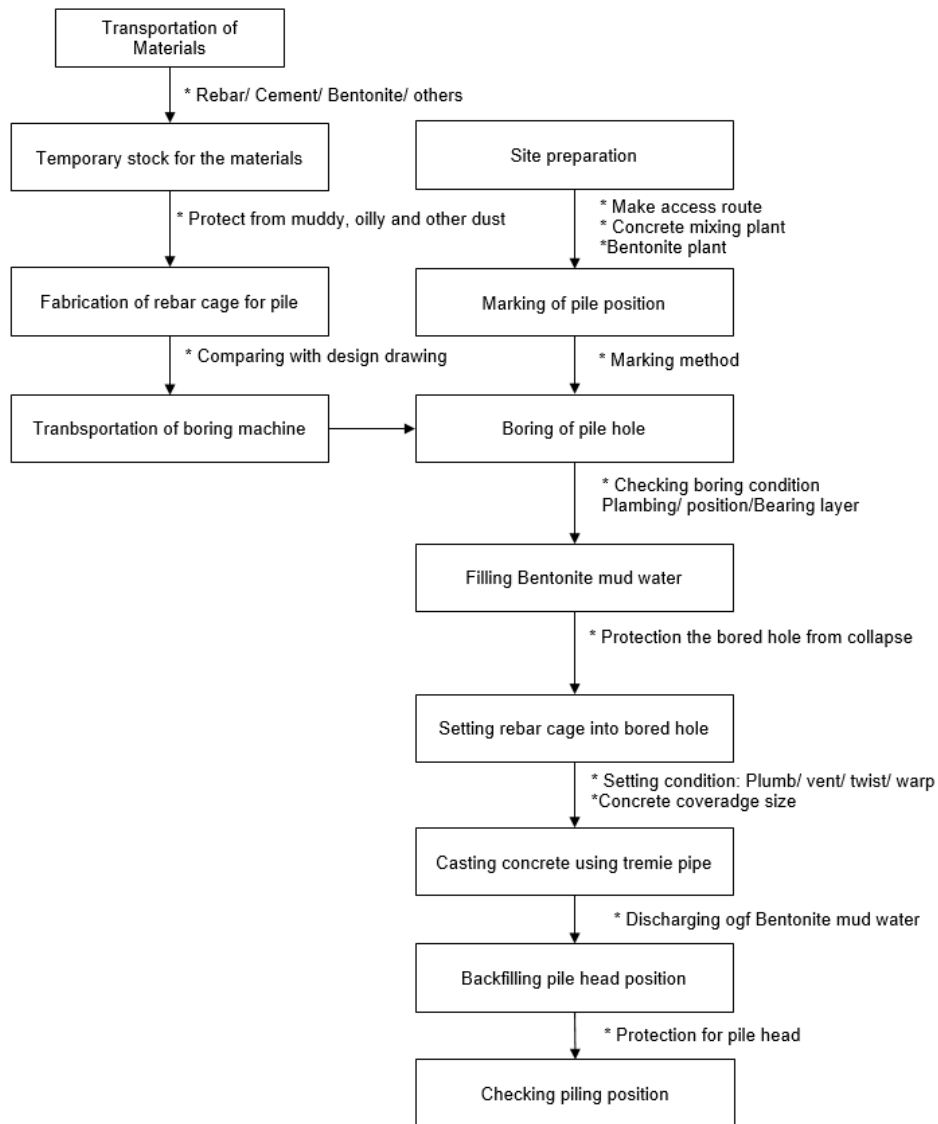
It shall be confirmed by checking load current of press fitting machine, settlement of pile at final driving and other method

### 4.2 Pile cast in place (Bore-pile)

There are several types for "Cast in Place Pile Method", each of which is classified by methods for preventing pile holes from collapse, and/or Type of Drilling Machine for pile holes, but it is important to choose a construction method that suits the situation around the construction site and the situation at the pile construction site. Herein briefly explains the "Earth Drill method".

#### 4.2.1 Working flow

The Working flow of Cast in place Pile/Bore pile work is below.



**Figure 4-6 Working flow of Cast in place pile/ Bore pile**

#### 4.2.2 Working point

The sketch on the left side is showing imaging “Bore-pile”

The bore pile is bored a hole at the required pile position. And a fabricated rebar cage would be installed and then concrete would be cast into the bored hole.

Therefore, there are many points for the quality of the pile as below.

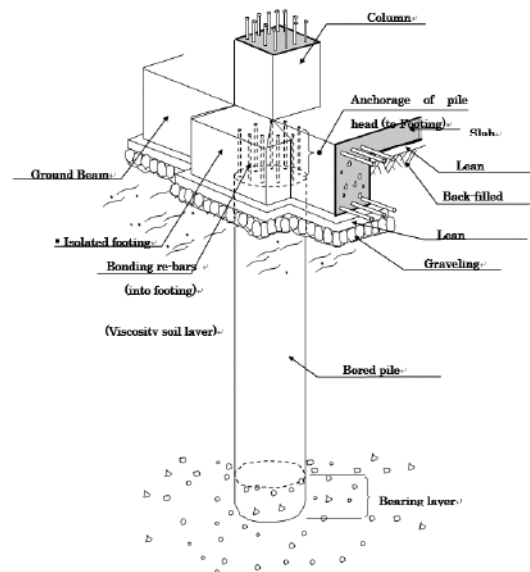
##### 4.2.2.1 Temporary stock condition of materials

The materials such as rebar, cement, sand, aggregate, shall be stocked correctly.

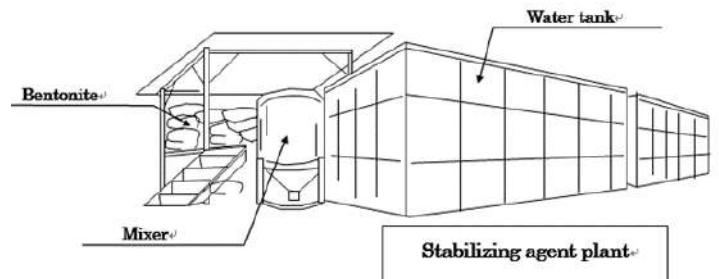
- 1) Rebar: It shall not be bent, dirt, rust
- 2) Cement: It shall not be moist condition, but dried condition.
- 3) Sand and Aggregate: It shall not mix with mud and any dust or impurities, and it shall keep suitable moisture contents.

##### 4.2.2.2 Preparation of Batching plant/ Bentonite plant/ Access route

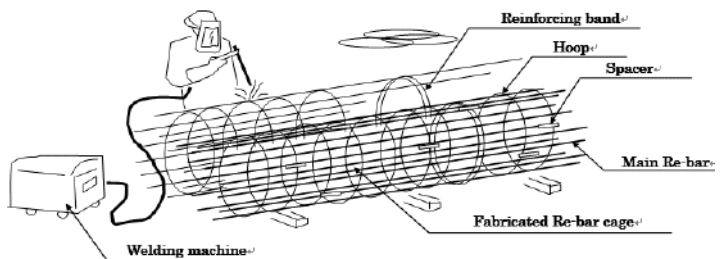
In the earth drill method, bentonite liquid is often used to prevent pile holes from collapsing. When using bentonite liquid, a bentonite manufacturing plant must be installed on-site, and when using steel casings, a storage area for the casings is required. In addition, a place to manufacture rebar cages is required on-site. For this reason, heavy machinery must not avoid running over piles that have already been driven only, but the order in which piles are driven must be determined, including the establishment of these many work areas.



**Figure 4-7 Imaging sketch of Pile Foundation**



**Figure 4-8 Illustration of Vent Nite Plant**



**Figure 4-8 Illustration of Assembling rebar cage**

#### 4.2.2.3 Marking of piling center position

It shall be as well as Pre-fabricated pile work.  
Refer to 4.1.2.3 “Marking piling position”

#### 4.2.2.4 Drilling of hole for piles

Kelly bar shall be kept in plumb, and the bored hole shall penetrate into the bearing layer at least one meter and/more.

Furthermore, the reached bearing layer must be checked to be designed soil layer by depth and the soil condition.

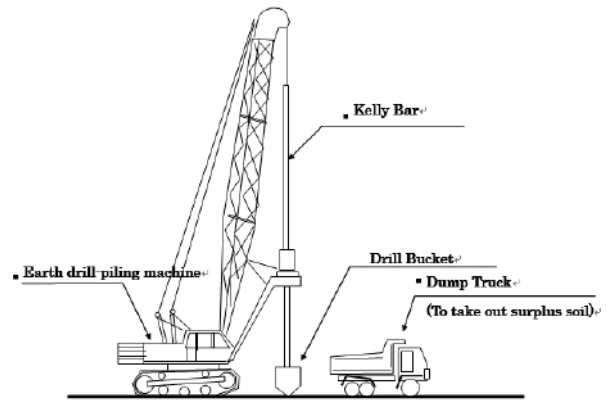


Figure 4-9 Illustration of Drilling work

#### 4.2.2.5 Concrete casting into bored hole

Casting concrete has to use a tremie pipe, and that it shall not interrupt until completion of casting. Furthermore, the pile concrete shall be cast with additional length, which shall be 600mm~1200mm more, which is depended on the pipe Dia-meter.

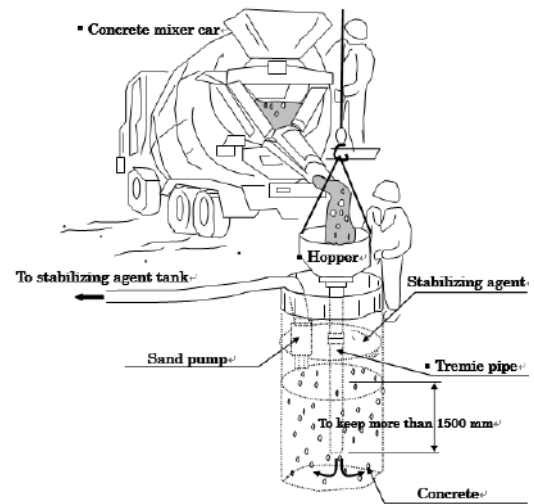


Figure 4-10 Illustration of Casting concrete using tremie pipe

#### 4.2.2.6 Curing the pile head

The position has to be backfilled to avoid any damage.

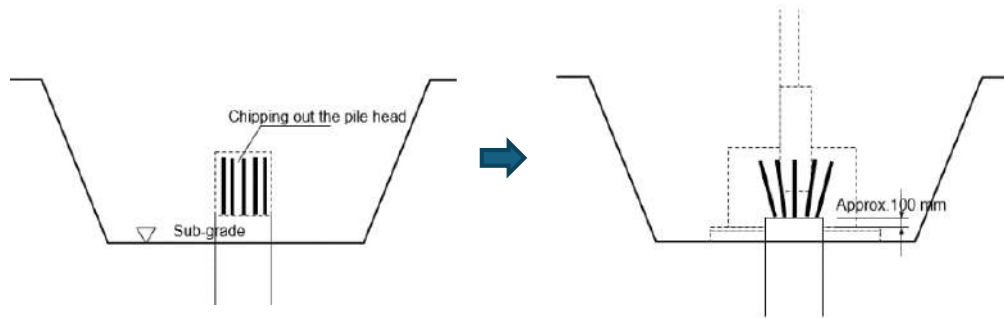


Figure 4-11 Illustration of Backfilling

#### 4.2.2.7 Checking of piling position and pile condition (After excavation and chipping)

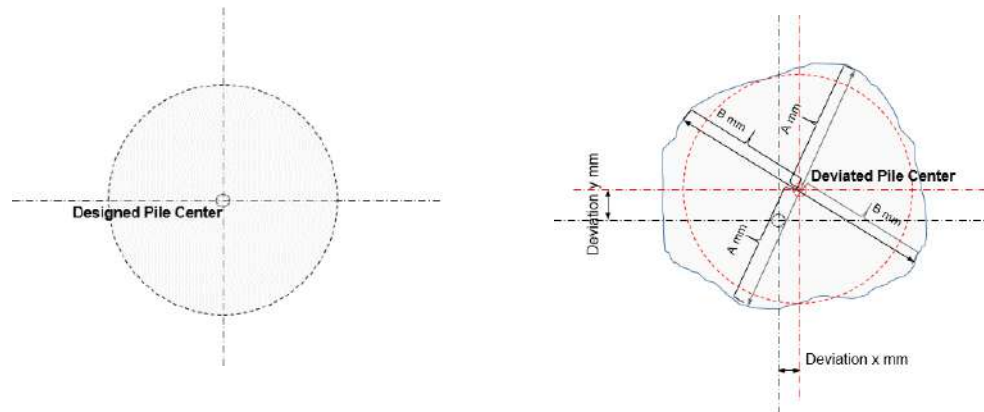
After the piles are driven in, the area around the piles is excavated for the foundation

construction. The driven pile head is chipped up to a specified height (Bottom of foundation + 100 mm), and the deviation of the driven position must be measured.



**Figure 4-12 Illustration of Checking pile head treatment**

Furthermore, the pile position has to be checked the deviation.



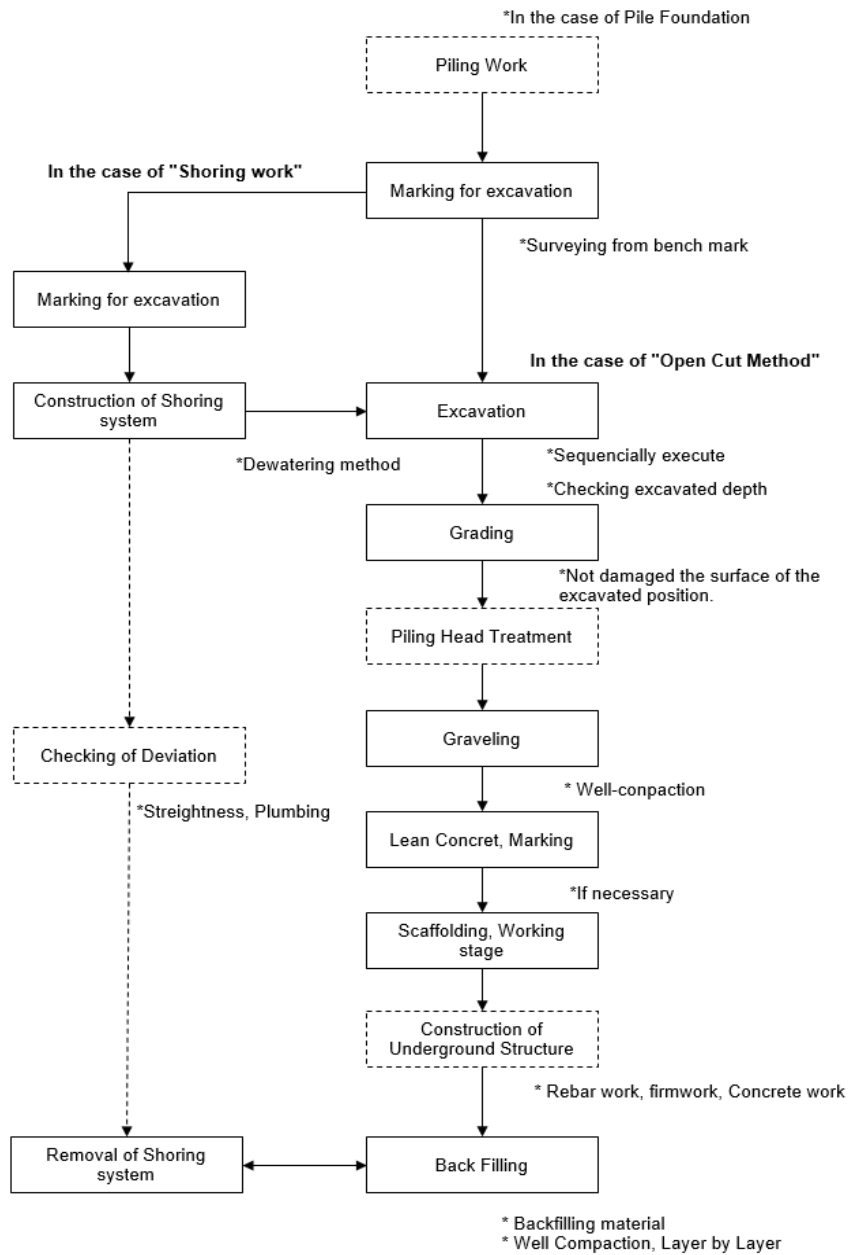
**Figure 4-13 Illustration of Checking pile position**

### 4.3 Earth work

Earth work influences the building quality, such as uneven settlement and/or some damage for the building structure. Therefore, the outline of “Earth work” and important point will be explained

### 4.3.1 Working Flow

The Working flow of Cast in place Pile/Bore pile work is below.



**Figure 4-14 Working flow of Earth work**

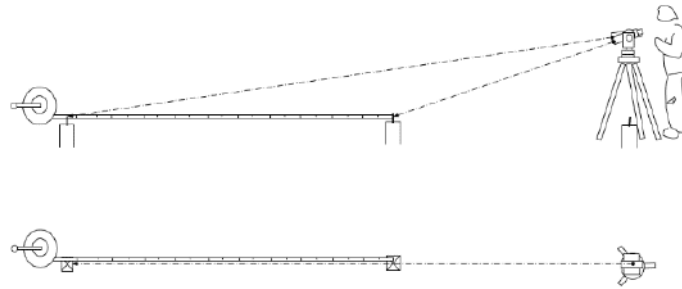
### 4.3.2 Working point of Earth work

#### 4.3.2.1 Surveying and Marking

Firstly, Standard line and Benchmark shall be set on site. And then, each excavating line and excavated depth shall be marked using the standard line and benchmark. And the mark shall be protected from any damage. The illustration below shows two careful points of surveying work

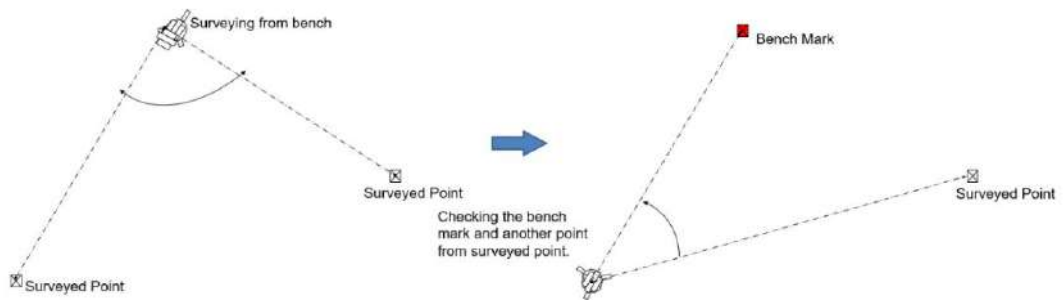
After setting the standard line, surveying and marking for the other line shall be not carried out using total station but it shall be offset measurement to avoid surveying error.

- \* Transit shall be used for confirmation of the straightness.
- \* The distance is measured by measuring tape, and that the tape shall be set in level and straight.



**Figure 4-14 Measuring in Straight**

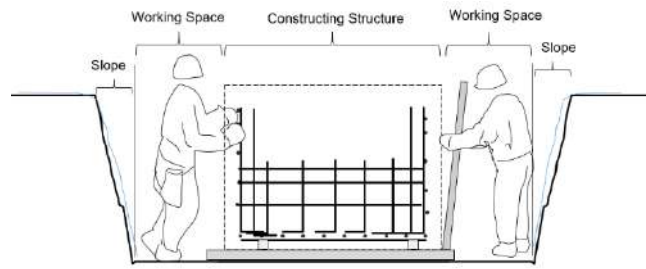
When using a total station, survey the original point directly from the point obtained as the survey point and reconfirm the original point.



**Figure 4-15 Confirmation of surveyed point**

#### 4.3.2.2 Working Space

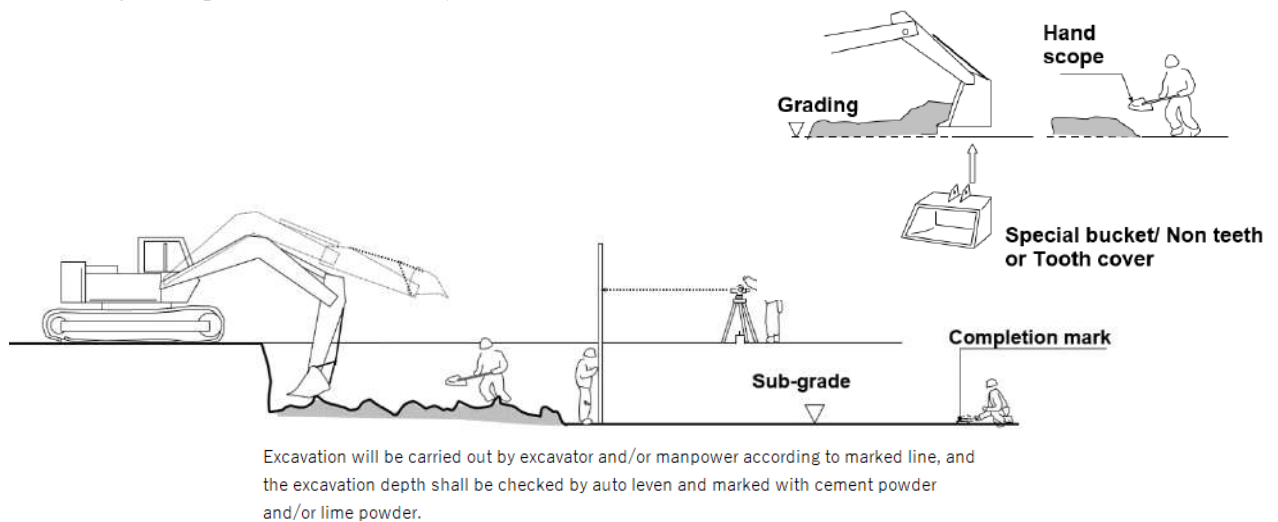
The first step in earthworks is excavation work. When deciding the extent of excavation, it is necessary to add the size of the actual structure to the space for work. The size of the workspace varies depending on the construction method and the content of the work, but a minimum of 600 to 1000 mm is required.



**Figure 4-16 Excavation area**

#### 4.3.2.3 Excavation work

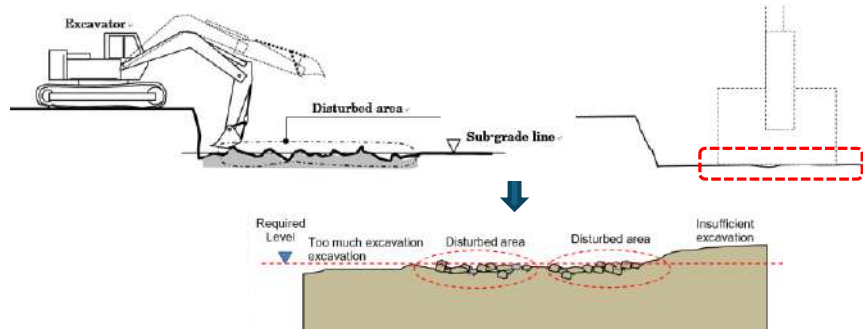
Excavation work must be done carefully without destroying the ground. For this reason, when using machinery, it is best not to dig directly to the planned excavation surface, but to excavate to a shallower depth of about 100 to 200 mm and then proceed to the planned depth while checking the depth with a level survey.



**Figure 4-17 Excavation work**

#### 4.3.2.4 Recovering of damaged sub-grade

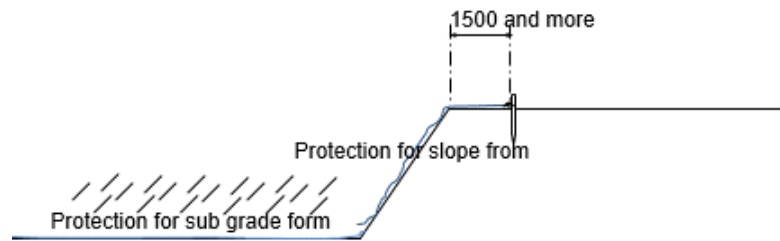
In the unlikely event that the ground is damaged or if a part is excavated too deeply, the disturbed soil will be removed and filled in with good quality soil, then thoroughly compacted to repair the damage and integrate it with the original ground. The same applies to repairing areas that have become muddy due to rainwater, etc.



**Figure 4-18 Repairing of damaged ground**

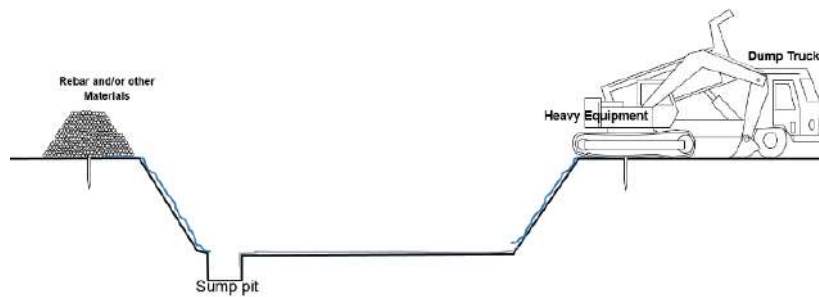
4.3.2.5 Protection of Excavated area (Shoulder and Sub-grade)

After excavation work is completed, the excavation area must be protected from any disturbances to the surface or slope collapses.



\* Plastic sheet cover: the excavated slope shall be covered by plastic sheet to protect collapsing, and that the finished sub grade shall be covered also to protect from rain water. The covering length at slope sholder shall be 1500mm and more.

**Figure 4-19 Protection against rainfall**



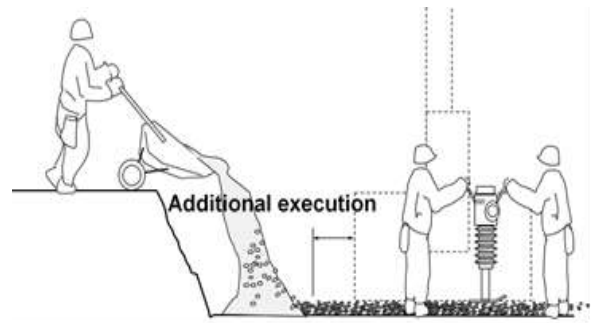
\*Heavy equipment and/or other heavy weight materials shall not park or stock at the shoulder position of excavated area

**Figure 4-20 Prevention of collapse**

#### 4.3.2.6 Graveling work

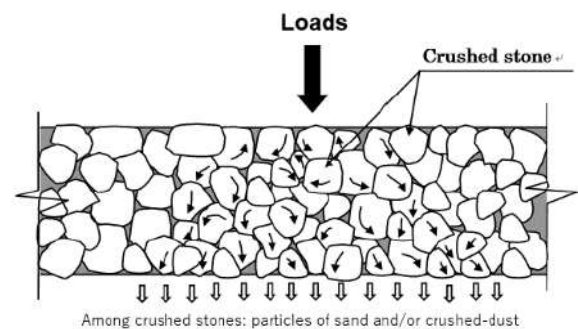
##### 1) Graveling area

The range of crushed stones to be laid is determined by taking into consideration the size of the structure, the installation space for the formwork, and other allowance spaces. Usually, the area to be laid is set up 50 to 100 mm larger than the structure. Furthermore, the extent space for the crushed stone to be laid must be wider than the thickness of the stone specified in the design documents.



##### 2) Compaction

The crushed stone and gravel to be laid are firmly compacted so that they interlock with each other, and the gaps between the particles are filled with sand or other materials to strengthen the ground. This allows loads to be distributed over a wider area.



**Figure 4-22 Distribution of Loads**

Please refer to the right side illustration.

#### 4.3.2.7 Backfilling work

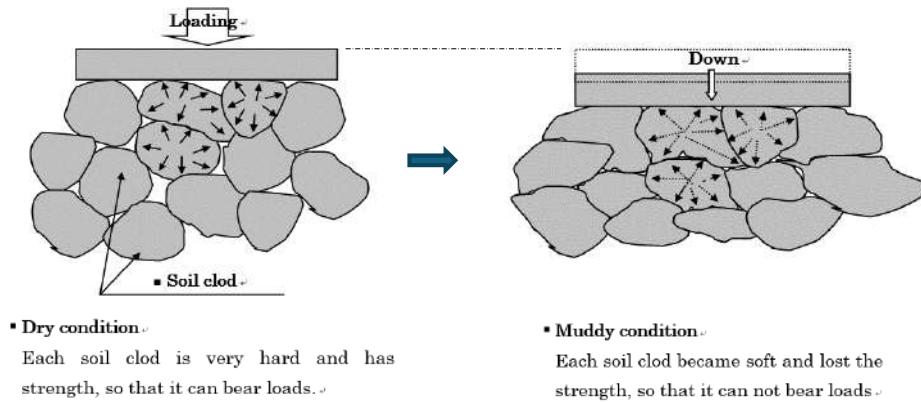
The backfill material used for backfilling must be selected appropriately to obtain good construction results. Backfilling material must not be in an inappropriate state such as mud or lumps. When Backfilling work is carried out using the soil, it is necessary to check the appropriate moisture state in advance and properly handle the dryness and lumps.

##### 1) Backfill soil

Furthermore, It is so difficult to compact the back filled soil that keeping suitable moisture content and reasonable countermeasure.

For example, If backfilling is done with hard clay clod during the dry season, the dry clod, losing strength, then it will absorb water when the rainy season comes, causing the soil to sink. Therefore, Backfilling work has to be carried out to prevent with a suitable method.

Clay and laterite are very hard in dry condition, but if it become muddy in wet condition and it would be soft.



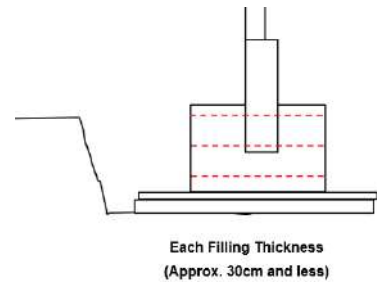
**Figure 4-23 Settlement of Clod**

2) Sand backfilling,

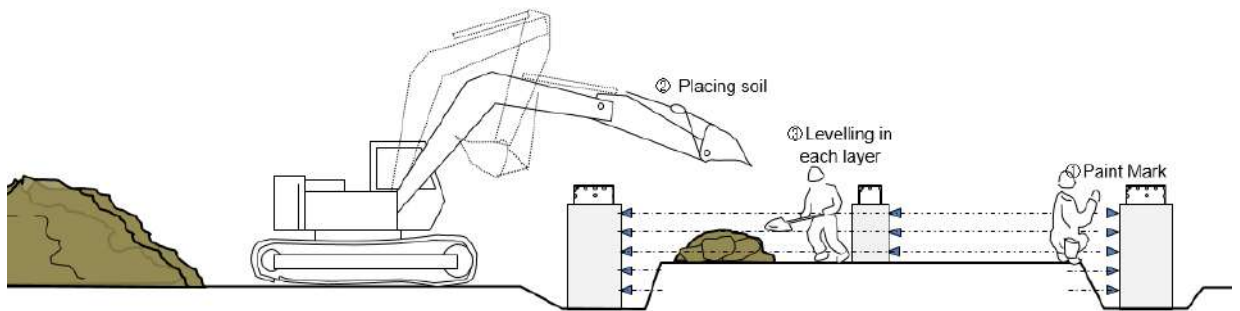
In the case of using sand for backfilling, the backfilling work shall be executed with sprinkling water to get rigid.

3) Backfilling thickness

The backfilling work has to be executed with layer by layer to keep a well compaction, which thickness of layer shall be 30 centimeters (cm) and less. Because compacting impact will achieve certainly until 30 centimeter and less. In addition, each layer has to be well compacted by suitable equipment such as vibration-roller, tamping hammer, and others. The illustration below shows backfill work



**Figure 4-24 Marking of backfilling layer**



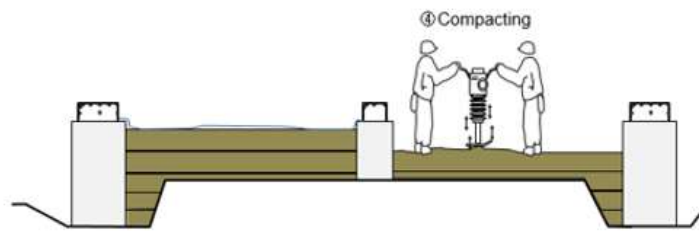
- ① Backfilling layer shall be marked using paint or others, and that each layer shall be 300mm thickness and less
- ② The filling soil will be placed by excavator or other equipment, and that the placing soil work shall be carried out with checking of the filling thickness in each layer
- ③ Placed soil shall be graded by manpower in each layer
- ④ Placed soil shall be compacted using compacting equipment such as a engine compactor, wooden tamper, and others, until required density

4) Checking compaction

Checking compaction is a process to check whether the work of "compaction," which compacts the ground, has been done properly in supervision for construction work. Insufficient compaction can cause land subsidence and cracks, so it is extremely

important in terms of quality control.

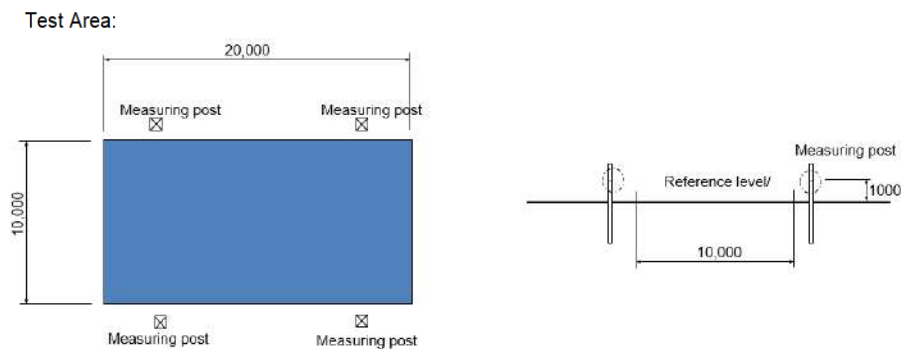
Methods for checking include visually checking the flatness, cracks, and unevenness of the compacted surface, conducting on-site density tests to measure the density after compaction, and installing a settlement gauge to measure the amount of settlement caused by compaction. There are various measurement methods, which are also introduced in BNBC. In any case, it is important for the construction supervisor to consult with the contractor and designer and check the compaction status using a method appropriate for the construction site.



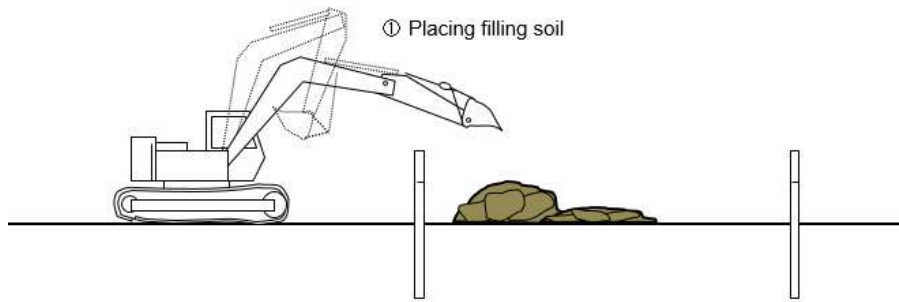
#### 5) Test execution

Compacted condition shall be checked the required condition on the design specification at layer by layer; however, it makes many working downtimes so that test compaction would be executed to get a control value that is how many times compacting equipment passing through the test area and can achieve the required density. In actual backfilling time, the site execution time will be shortened as a result that the compact condition would be confirmed using the control value.

The illustration below shows the procedure of test compaction.



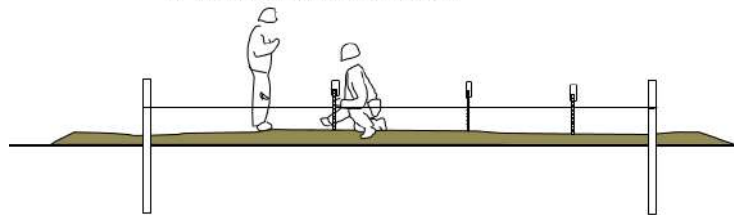
## Test compaction



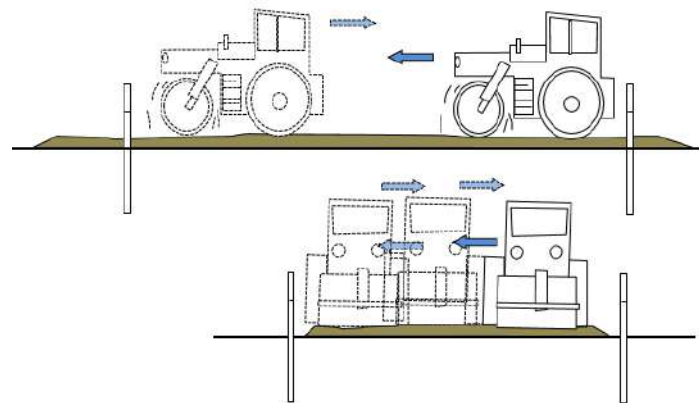
② Grading with dozer blade roughly



③ Checking measuring filling layer

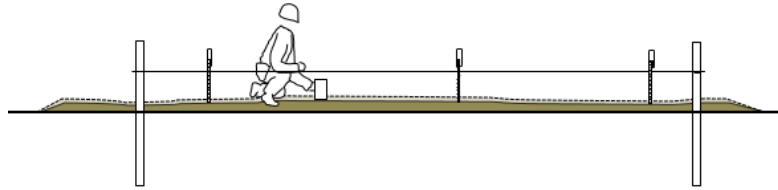


④ Compacting by Roller, 5 time, 7thims, 10 times and 15



1 round compaction shall be counted as 1 time.

⊙: Sampling for density test and measuring settlement thickness at after 5 times, 7times,10 times and 15 times compaction . Each sample shall be inspected at site laboratory to get suitable compacting times.



**This testing data such as thickness of placing layer, density test result in each sample, settlement thickness in each sampling time, compacting speed of roller, utilized equipment name and capacity has to be recorded**

**Tested heavy equipment such as doser, compaction roller and filling material has not to be changed on site execution. If it is necessary to change the equipment, test compaction has to be executed again**

## Chapter 5 ANNEX

5.1 Annex A: Check list for supervision

5.2 Annex B: Inspection List for supervision

5.3 Annex C: Inspection Sheet for supervision

5.4 Annex D: Sample of constructed condition on site

**CHECK LIST for Supervision**

August, 2024

**DCQR**

## 5.1 ANNEX A

Checking Subject	Implementation period	Checking point	Reference document	Inspection Style		
				Measurement	Report/ Certificate	Photo/ Visual check
Working location	Before commencement	Building Use and Zone category of the Land	BNBC	-	✓	-
	Before commencement	Construction permission	Permitted document	-	✓	-
	Before commencement	Actual construction position for the building	Design drawing/shop drawing	✓	-	-
	Before commencement	Actual Set-back distance from front road and/or adjacent border	Design drawing/shop drawing	✓	-	-
Pile Preparation	Before piling	Marking the piling position	Shop drawing	✓	-	-
	Before piling	Stock condition of the pile, Rebar, and other	-	-	-	✓
	Before piling	Confirmed the condition of bearing layer at pile tip position	Design drawing/Boring data	-	✓	✓
	Before piling	Assembled condition rebar cage	Shop drawing	✓	✓	✓
	Before driving	Setting condition of piling machine	Manual	-	✓	✓
	Joint pile	Machine & Materials prepared	BNBC	-	✓	✓
Driving Pile	After driving	Driving condition (Hammering number, Electrical resistance, Others)	-	✓	✓	-
	After driving	Driven pile depth	-	✓	✓	-
	After driving	Level of the pile head position	-	✓	✓	-
	After driving test	Pit, Pile driving analyzer, load test	BNBC	✓	✓	-
Bored pile	After bored	Bored condition (size, depth, plumbing)	Shop drawing	✓	✓	-
	After bored	Removal of <b>slime</b> at the bored hole	-	-	✓	✓
	After bored	Casting material (Concrete strength, slump)	Design document	-	✓	-
	After bored	Casting method (Using tremie pipe)	Manual	-	✓	✓
	After bored	Casting concrete level (pile top level: 1.0mm approx.)	Shop drawing	✓	✓	-
Piling result	After piling	Treatment of pile head (Cutting, Chipping)	-	-	✓	✓
	After piling	Executed pile position (Deviation)	Shop drawing	✓	✓	-
	After piling	Loading test, Pit, Pile driving analyzer	Design document	-	✓	-
	After piling	Sonic test (Boring pile)	Design document	-	✓	-
Earth work	Before execution	[Excavation] Excavated area	Shop drawing	✓	✓	-
	After execution	[Excavation] Excavated depth	Shop drawing	✓	✓	-
	Before laying	[Graveling materials] Grade, Particle, Type	Design document	✓	✓	-
	After excavation	[Graveling] Grading condition (exacted sub-grade condition)	Manual	✓	✓	✓
	After laying	[Graveling] Gravel and/or Crush stone material (Size/ Thickness)	Shop drawing	✓	✓	✓
	After compacting	[Graveling] Compaction of Gravel/ Crush stone	Manual	-	✓	✓
	After execution	[Backfilling] Thickness of each filling layer	Manual	✓	-	✓
	After execution	[Backfilling] Result of compaction	Manual	-	✓	✓
Rebar Materials	Receiving materials	Required grade	Mill sheet/Tensile test report	-	✓	-
	Receiving materials	Required size and volume	Delivery receipt/ Mesuring record	-	✓	-
	Receiving materials	Delivered/Handling condition: Bent, warp, rust or Dirtiness	-	-	-	✓
Rebar Fabrication	Before installation	Column Main bar: Diameter, length and number	Bending schedule	✓	✓	-
	Before installation	Column Main bar: Length of end hook (Top only)	Bending schedule	✓	✓	-
	Before installation	Column Main bar: Bending angle of end hook (Top only)	Bending schedule	✓	✓	-
	Before installation	Girder/Beam Main bar: Diameter, length, number and the shape	Bending schedule	✓	✓	-
	Before installation	Girder/Beam Main bar: Length of hook (anchoring and others)	Bending schedule	✓	✓	-
	Before installation	Hoop/Stirrup: Diameter, dent size and numbers	Bending schedule	✓	✓	-
	Before installation	Hoop Stirrup: Hook length and the bent angle	Bending schedule	✓	✓	-
	Before installation	Sub hoop/stirrup: Diameter, size, shape, hook length/angle and the number	Bending schedule	✓	✓	-
	Before installation	Web bar and Tie bar: Diameter, size, shape, number, <b>angle</b>	Bending schedule	✓	✓	-
	Before installation	Slab: Diameter, length shape, hook length/angle, number	Bending schedule	✓	✓	-
	Before installation	<b>Stairs</b> : Diameter, length shape, hook length/angle, number	Bending schedule	✓	✓	-
	Before installation	Wall and others: Diameter, length, shapes, hook length/angle, number	Bending schedule	✓	✓	-

## 5.1 ANNEX A

Checking Subject	Implementation period	Checking point	Reference document	Inspection Style		
				Measurement	Report/Certificate	Photo/Visual check
Rebar Arrangement Installation	After installation	Column Main bar: Size, number and splice position	Shop drawing (Rebar arrangement)	✓	-	✓
	After installation	Stirrup position	Shop drawing (Rebar arrangement)	✓	-	✓
	After installation	Girder/Beam Main bar: Size, number, Splice position	Shop drawing (Rebar arrangement)	✓	-	✓
	After installation	Girder/Beam Main bar: Anchored position and the condition	Shop drawing (Rebar arrangement)	✓	-	✓
	After installation	Hoop/ Stirrup: Diameter, installed pitch	Shop drawing (Rebar arrangement)	✓	-	✓
	After installation	Hoop and Stirrup: 1st installed position	Shop drawing (Rebar arrangement)	✓	-	✓
	After installation	Hoop and Stirrup: Installed condition at panel zone	Shop drawing (Rebar arrangement)	✓	-	✓
	After installation	Web bar: Diameter and installed layer	Shop drawing (Rebar arrangement)	✓	-	✓
	After installation	Tie bar: Diameter and installed number and pitch	Shop drawing (Rebar arrangement)	✓	-	✓
	After installation	Slab Main bar/ Distribution bar: Diameter, Installed layer and pitch	Shop drawing (Rebar arrangement)	✓	-	✓
	After installation	Slab Main bar/ Distribution bar: Start position of the arrangement	Shop drawing (Rebar arrangement)	✓	-	✓
	After installation	Slab Main bar/ Distribution bar: Anchor position and length	Shop drawing (Rebar arrangement)	✓	-	✓
	After installation	Stairs: Diameter, pitch, anchoring, splice position	Shop drawing (Rebar arrangement)	✓	-	✓
	After installation	Wall/Others: Diameter, pitch, anchoring	Shop drawing (Rebar arrangement)	✓	-	✓
	After installation	Wall/Others: Number of layers, splice position	Shop drawing (Rebar arrangement)	✓	-	✓
	After installation	Concrete spacer: Size, set position and number	Shop drawing (Rebar arrangement)	✓	-	✓
	After installation	Temporary position keeper: The condition	Shop drawing (Rebar arrangement)	✓	-	✓
		After installation	Beam re-bar position inside the column re-bar	Shop drawing (Rebar arrangement)	✓	-
Shoring	After delivery	Material condition: Damage (Rust, bent, twist, scratch, others)	-	-	-	✓
	Before installation	Planned Arrangement: Shorting strength	Shoring calculation	-	✓	-
	After installation	Constructed condition: Level, line, looseness	-	✓	-	✓
Shuttering Materials	After installation	Plywood condition: Peeling the surface	-	-	-	✓
	Before fabrication	Plywood condition: Recycle times	-	-	✓	✓
	Before fabrication	Shutter panel: Recycle times	-	-	✓	✓
	Before installation	Steel panel: Flatness, Bent, twist	-	✓	-	✓
	Before installation	Timber/GS Pipe: Straightness, Bent, Twist, Damages	-	✓	-	✓
	Before installation	Shutter leakage	-	✓	-	✓
Formwork construction	Before fabrication	Formwork arrangement/design: Parts strength	Formwork calculation	-	✓	-
	After fabrication	Shuttering panel: Size, number	Shop draing (Panel arrangement)	✓	✓	-
	After installation	Column: Size (X/Y)	Shop draing (Panel arrangement)	✓	✓	✓
	After installation	Column: Setting location and the top level	Shop draing (Panel arrangement)	✓	✓	✓
	After installation	Column: diagonal, axis	Shop draing (Panel arrangement)	✓	-	✓
	After installation	Column: Installed condition: Plumbing, Twist, and incline	Shop draing (Panel arrangement)	✓	✓	✓
	After installation	Column: Supported condition (Tighten and /or loose)	Shop draing (Panel arrangement)	✓	-	✓
	After installation	Girder/Beam: Size (BxD)	Shop draing (Panel arrangement)	✓	✓	✓
	After installation	Girder/Beam: Horizontality	Shop draing (Panel arrangement)	✓	✓	✓
	After installation	Girder/Beam: Bottom and Top level	Shop draing (Panel arrangement)	✓	✓	✓
	After installation	Girder/Beam: Deflection (Curvature, Twist, Bent)	Shop draing (Panel arrangement)	✓	✓	-
	After installation	Girder/Beam: Setting condition/ Rigid or Loose	Shop draing (Panel arrangement)	✓	-	✓
	After installation	Slab: Horizontality	Shop draing (Panel arrangement)	✓	✓	-
	After installation	Slab: Setting level	Shop draing (Panel arrangement)	✓	✓	-
	After installation	Slab: Setting condition/ Rigid or Loose	-	✓	✓	-
	After installation	Stair, Wall and others: Size, location, level, dimension (Thickness)	Shop draing (Panel arrangement)	✓	✓	-
	After installation	Stair, Wall and others: Setting condition (Rigid or Loose)	-	✓	-	✓
	Before concreting	Shuttering condition: Cleaness	-	-	✓	✓
	Before concreting	Shuttering condition: Sprinkling water	-	-	✓	✓
		Before concreting	Shuttering condition: Covering clear covering	-	-	✓
Removal of formwork	After concreting	[Removal] Side shuttering panel: Terms of curing concrete	Design document	-	✓	✓
	After concreting	[Removal] Bottom shuttering panel: Terms of curing concrete	Crusing test report	-	✓	✓
	After concreting	[Removal] Dismantle condition: Without any impact to concrete	-	-	✓	✓
	After concreting	[Removal] Dismantle Shoring: Curing terms of concrete	-	-	✓	✓
Concrete material	Before Mixing/Order	Mixing design: Mixing ratio, selecting additive materials	Concrete mixing design	-	-	✓
	After delivered/Mixed	Ready mixed/Site mixed: Mixed condition/ Slump test, Flow checking	-	✓	✓	✓
	After delivered/Mixed	Ready mixed/Site mixed: Coarse aggregate size and shape, fine aggregate F.M	-	✓	✓	✓
	After delivered/Mixed	Ready mixed/Site mixed: Cement type and condition, water quality	-	✓	✓	✓
	After delivered/Mixed	Ready mixed/Site mixed: Temperature	-	✓	✓	✓
	After delivered	Ready Mixed Concrete/Delivery condition: Transportation time	Delicery receipt	✓	✓	-
Pouring concrete	After mixed	Site mixed concrete: Mixing (Measuring, Mixing time)	Mixing record	✓	✓	✓
	After delivered	Pouring time after delivery of Ready mixed concrete	-	✓	✓	-
	During casting time	Usage of equipment (vibrator/ steel trowel)	Manyual Book	-	✓	✓
	During casting time	Casting condition: Handling of a tip of concrete hose	Manyual Book	-	✓	✓
	During casting time	Downtime in each layer of concrete pouring	Manyual Book	✓	✓	✓
Curing concrete	Curing time	Curing condition: Sprinkle water and/or curing compound	Manyual Book	-	✓	✓
	Curing time	Protection against Blow window and/or Rain	Manyual Book	-	✓	✓
	Curing time	Protecting against any impact	Manyual Book	-	✓	✓

5.1 ANNEX A

Checking Subject	Implementation period	Checking point	Reference document	Inspection Style		
				Measurement	Report/ Certificate	Photo/ Visual check
Fire Prevention Material	After receiving	Smoke detector/ Heat sensor: Product certificate	Design document	-	✓	-
	After receiving	Wall one- or two-hour rating	Design document	-	✓	-
	After receiving	Control panel: Product certificate	Design document	-	✓	-
	After receiving	Cable and accessory (Condit material): Fireproof certified product	Design document		✓	-
	After receiving	Cable and accessory (Condit material): Fireproof certified product	Design document		✓	-
	After receiving	Sprinkler accessory (Connector, joint and others Product) certificate:	Design document		✓	-
Fire Prevention Installation	After installation	Setting position: Detector/sensor/alarm	Shop drawing	✓	✓	-
	After installation	Cabling condition: Connection, joint and others	-	-	✓	✓
	After installation	Cabling treatment of penetration for fire prevention section	Manual	-	✓	✓
	After installation	Wall penetration of pipe, cable, duct and others	Manual	-	✓	✓
	After installation	Slab penetration of pipe, cable, duct and others	Manual	-	✓	✓
	After installation	Treatment for gap around fire prevent door	Manual	-	✓	✓
After installation	Fitting/ Fixing condition	Manual	-	✓	✓	
Application	After completion	Application of completion	Design document, BNBC	-	✓	-
Plumbing work	After delivery	[Water supply] Piping materials	Shop drawing	-	✓	-
	After execution	[Water supply] Piping route	Shop drawing	-	✓	-
	Before execution	[Water supply] Pipe size	Shop drawing	✓	✓	-
	After execution	[Water supply] Piping condition such as joint and support	-	-	✓	✓
	After execution	Easily apply Repair and maintenance	-	-	✓	✓
	After execution	[Water supply] Arrangement of air-vent	Shop drawing	-	✓	✓
	After execution	[Water supply] Arrangement of gate valve, non-return valve, other valves	Shop drawing	-	✓	✓
	After execution	[Water supply] Piping treatment of penetration for fire prevention section	Manual	-	-	✓
	Before execution	[Drainpipe] Piping material	Shop drawing	-	✓	-
	After execution	[Drainpipe] Piping slope	Shop drawing	-	✓	✓
	After execution	[Drainpipe] Piping route	Shop drawing	-	✓	-
	After execution	[Drainpipe] Pipe size	Shop drawing	✓	✓	-
	After execution	[Drainpipe] Piping condition such as Joint, support, others	Manual	-	✓	✓
	After execution	[Drainpipe] Arrangement of Cleaning port	Shop drawing	-	-	✓
After execution	[Drainpipe] Piping treatment of penetration for fire prevention section	Manual	-	-	✓	
Air-intake & Air-ventilation	After execution	Arrangement of the setting position	Shop drawing	✓	-	✓
	Before execution	Size/Area of Air-intake	Shop drawing	-	✓	-
	Before execution	Size/Area of Air ventilation	Shop drawing	-	✓	-
	After execution	Route of Air-intake line	Shop drawing	-	✓	-
	Before execution	Size of Air-intake duct (spiral and/or squire)	Shop drawing	✓	✓	-
	Before execution	Size of Air-ventilation duct (spiral and/or squire)	Shop drawing	✓	✓	-
	After execution	Ducting treatment of penetration for fire prevention section	Manual	-	-	✓
Erectrical Work	Before execution	Position of electrical conduit	Discussion with Desiger	-	✓	-
	Before execution	Cable size and type as required design document	Design document	-	✓	-
	After execution	Cabling route as design document	Shop drawing	-	✓	-
	After execution	Cable connection to be rigid	Manual	-	✓	✓
	After execution	Cable condition under a little more than exact distance	Manual	-	-	✓
	After execution	Ordinal cable arrangement	Manual	-	-	✓

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**INSPECTION LIST for Supervision**  
Rebar/Formwork/Concrete

August, 2024

DCQR

## 5.2 ANNEX B

Category	Title	Checking contents	Implementation period
Rebar work-1	Reinforcement inspection for pile cap	*Rebar size and number (arranged pitch), *Rebar bend and strait *Fixing condition, each other rebar	Before concreting
Rebar work-2	Column (Base ~ First Splicing)	*Concrete covering size (Concrete spacer) *Diameter, number and length of Main bar *Foot shape of the Main bar *Rebar bend and straight, angle *Size, diameter and shape of Hoop *Number and spacing of Hoop *Concrete covering size (Concrete spacer) *Fixing condition of each bar	After completion of placing / Before installing Formwork
Rebar work-3	Underground Beam	*Number and diameter of main bar *Rebar spacing of main bar *Area, shape and length of anchoring *Shape and length of splicing *Size and diameter of stirrup *Rebar bend and straight, angle *Reinforcing space of stirrup *Diameter, layer and spacing of web bar, tie bar *Concrete covering size (Concrete spacer) *Fixing condition of each bar	After completion of placing / Before concreting
Rebar work-4	Grade slab	*Diameter, length and shape of end position for Main bar *Diameter, length and shape of end position for Distribution bar *Rebar bend and straight, angle *Number (Spacing) of Main bar at Top and Bottom layers *Number (Spacing) of Distribution bar at Top and Bottom layers *Concrete covering size (bar stand size) for Top and Bottom layers *Fixing condition of each bar	After completion of placing / Before concreting
Rebar work-5	Column (First Splicing ~ Final Splicing)	*Diameter and number of Main bars *Size, diameter and shape of Hoop (Including Panel zone) *Rebar bend and straight, angle *Number and spacing of Hoop *Splicing style and length *Concrete covering size (Concrete spacer) *Fixing condition of each bar	After completion of placing / Before installing Formwork
Rebar work-6	Column (Top section)	*Diameter and number of Main bars *Top level of Main bar *Rebar bend and straight, angle *Size, diameter and shape of Hoop (Including Panel zone) *Size, diameter and shape of Hoop (Including Panel zone) *Reinforcing space of tie (pitch) *Number and spacing of Hoop *Splicing style and length	After completion of placing / Before installing Formwork
Rebar work-7	Beam (In Each floor)	*Number and diameter of main bar *Rebar spacing of main bar *Area, shape and length of anchoring *Rebar bend and straight, angle *Shape and length of splicing *Size and diameter of stirrup *Reinforcing space of stirrup (pitch) *Diameter, layer and spacing of web bar, tie bar *Concrete covering size (Concrete spacer) *Fixing condition of each bar	After completion of placing / Before concreting
Rebar work-8	Wall (In each floor)	*Diameter, length and shape of end position for vertical bar *Anchoring style, shape and the length of vertical bar *Splicing style and length of vertical bar *Diameter, length and shape of end position for horizontal bar *Rebar bend and straight, angle *Anchoring style, shape and the length of horizontal bar *Splicing style and length of horizontal bar *Diameter and size of tie bar *Layer and positions for tie bar *Number, style, and diameter of opening reinforcement bar *Concrete covering size (Concrete spacer) *Fixing condition of each bar	After completion of placing / Before installing Formwork
Rebar work-9	Slab (In each floor)	*Diameter, length and shape of end position for Main bar *Rebar bend and straight, angle *Diameter, length and shape of end position for Distribution bar *Anchoring style, shape and the length of Main bar	After completion of placing/ Before concreting
Rebar work-9	Slab (In each floor)	*Anchoring style, shape and the length of Distribution bar *Number (Spacing) of Main bar at Top and Bottom layers *Rebar bend and straight, angle *Number (Spacing) of Distribution bar at Top and Bottom layers *Number, style, and diameter of Opening reinforcement bar *Concrete covering size (bar stand size) for Top and Bottom layers *Fixing condition of each bar	After completion of placing / Before concreting

## 5.2 ANNEX B

Category	Title	Checking contents	Implementation period
Rebar work-10	Stair (In each floor)	*Diameter, length and shape of end position for Main bar *Diameter, length and shape of end position for Distribution bar *Diameter, shape, and size of stairway bar <b>*Rebar bend and straight, angle</b> *Installation spacing of stairway bar (pitch/number) *Size, length and shape of tip bar *Concrete covering size (Concrete spacer) *Fixing condition of each bar	After completion of bottom formwork
Rebar work-11	Miscellaneous rebar (Palalet, Canopy, Others)	*Diameter, length, shape and number of main bars *Anchoring style, length and shape of main bar <b>*Rebar bend and straight, angle</b> *Diameter, length, shape and number of distribution bar *Concrete covering size (concrete spacer) *Fixing condition of each bar	After completion of placing / Before concreting
Formwork-1	Shuttering Panel/Plywood/Timber	*Damage (Hole, Peel Scratch, Bent, Twist, Curbed etc.)	Before usage
Formwork-2	Pile cap/Spread foundation	*Size (X*Y*D) *Plumbing of shuttering panel *Length and type of tie-rod *Fixing of the foot of shuttering panel <b>*Fixing of the diagonal bracing for mat or raft</b> *Fixing of corner *Vertical and horizontal reinforcing pipe (timber) *Fixing condition of each panel *Fixing of form-tie *Setting condition of support materials	After completion of installation / Before concreting
Formwork-3	Column (In each portion)	*Size (X*Y) *Plumbing of shuttering panel *Length and type of tie-rod (X/Y) *Fixing of the foot of shuttering panel *Fixing of corner *Vertical and horizontal reinforcing pipe (timber) *Fixing condition of each panel *Fixing of form-tie <b>*Ensure airtight</b> *Setting condition of support materials	After completion of installation / Before concreting
Formwork-4	Underground Beam	*Size (B*D) *Plumbing of side shuttering panel *Fixing of foot of shuttering panel *Length and type of tie-rod *Fixing condition in each panel *Connecting condition to Pile cap and/or Column *Vertical and horizontal reinforcing pipe (timber) *Fixing of form-tie <b>*Ensure airtight</b> *Setting condition of support materials	After completion of installation / Before concreting
Formwork-5	Beam (in each floor)	*Setting level of bottom panel *Size (B*D) *Plumbing of side shuttering panel *Length and type of tie-rod *Fixing condition in each panel *Fixing condition to bottom panel *Connecting condition to column *Constructed condition (Straightness, bent, twist and etc.) *Vertical and horizontal reinforcing pipe (timber) <b>*Ensure airtight</b> *Fixing of form-tie	After completion of installation / Before concreting
Formwork-6	Grade Slab	*Height of Shuttering panel *Fixing condition in each panel	After completion of installation
Formwork-7	Grade Slab	*Fixing condition of panel foot *Plumbing of shuttering panel *Vertical and horizontal reinforcing pipe (timber) *Setting of diction of support pipe and/or timber	After completion of installation/ Before concreting

## 5.2 ANNEX B

Category	Title	Checking contents	Implementation period
Formwork-8	Slab (Including canopy)	*Setting level and flatness for bottom panel (excluding slop slab) *Connecting condition to Beams and/or Columns *Joint condition in each bottom panel *Height of Side shuttering panel (If any) *Setting condition of side panel (Plumbing, straightness, twist), if any <b>*Ensure airtight</b> *Fixing condition of side panel, if any	After completion of installation / Before concreting
Formwork-9	Wall (In each floor)	*Plumbing of shuttering panel *Length and type of tie-rod *Setting location of tie-rod (Pitch and layer) *Joint condition in each shuttering panel *Vertical and horizontal reinforcing pipe (timber) *Setting condition of support pipe and/or timber, if any <b>*Ensure airtight</b> *Fixing of form-tie	After completion of installation / Before concreting
Formwork-10	Stair (In each floor)	*Start and end position of slop for bottom panel *Joint condition in each bottom panel *Thickness of the bottom slab *Plumbing of side shuttering panel, if any *Fixing condition of side panel, if any *Fixing condition of stairway panel <b>*Ensure airtight</b> *Size of Stairway	After completion of installation / Before concreting
Formwork-11	Miscellaneous (Parapet and others)	*Setting condition of side panel (Plumbing, straightness, twist), if any *Joint condition in each panel *Size (Height) *Length and type of tie-rod *Vertical and horizontal reinforcing pipe (timber) <b>*Ensure airtight</b> *Fixing condition of form-tie	After completion of installation / Before concreting
Concrete work-1	Preparation for Casting	*Cleaning *Sprinkle water in pouring area (Wetting the shuttering surface) *Temporary walkway *Preparation of tools (vibrator, steel trowel, Lamp, etc.) <b>*Covering check</b>	Before commencement of concreting
Concrete work-2	Concrete test/sampling	*Concrete Slump test (Slump flow test) *Checking concrete tempter *Sampling Test piece	Arrival on site
Concrete work-3	Concreting	*Downtime of in each layer (completion of one layer to next layer) *Laying condition of concrete *Vibrating condition *Tamping condition *Protection against rainfall (under rain) *Executing of trawl condition (wooden and/or steel)	During concreting
Concrete work-4	Curing	*Protection against blowing window (After casting) *Protection against impacting/ shock (After casting) *Keeping wet condition *Keeping the curing time due to stipulated term	After concreting
Rebar work-1	Underground Beam	*Number and diameter of main bar <b>*Rebar bend and straight, angle</b> *Rebar spacing of main bar *Area, shape and length of anchoring *Shape and length of splicing *Size and diameter of stirrup *Reinforcing space of stirrup *Diameter, Layer and Spacing of Web bar, tie bar *Concrete covering size (Concrete spacer) *Fixing condition of each bar <b>*Rebar bend and straight, angle</b>	After completion of placing / Before concreting
Rebar work-2	Grade Slab	*Diameter, length and shape of end position for Main bar *Diameter, length and shape of end position for Distribution bar *Number (Spacing) of Main bar at Top and Bottom layers *Number (Spacing) of Distribution bar at Top and Bottom layers *Concrete covering size (bar stand size) for Top and Bottom layers *Fixing condition of each bar	After completion of placing / Before concreting
Rebar work-3	Column (First Splicing ~ Final Splicing)	*Diameter and number of Main bars <b>*Rebar bend and straight, angle</b> *Size, diameter and shape of Hoop (Including Panel zone) *Number and spacing of Hoop *Splicing style and length *Concrete covering size (Concrete spacer) *Fixing condition of each bar	After completion of placing / Before installing Formwork

## 5.2 ANNEX B

Category	Title	Checking contents	Implementation period
Rebar work-4	Column (Top section)	*Diameter and number of Main bars *Rebar bend and straight, angle *Top level of Main bar *Size, diameter and shape of Hoop (Including Panel zone) *Size, diameter and shape of Hoop (Including Panel zone) *Number and spacing of Hoop *Splicing style and length	After completion of placing / Before installing Formwork
Rebar work-5	Beam (In Each floor)	*Number and diameter of main bar *Rebar spacing of main bar *Rebar bend and straight, angle *Area, shape and length of anchoring *Shape and length of splicing *Size and diameter of stirrup *Reinforcing space of stirrup (pitch) *Diameter, layer and spacing of Web bar, tie bar *Concrete covering size (Concrete spacer) *Fixing condition of each bar	After completion of placing / Before concreting
Rebar work-6	Wall (In each floor)	*Diameter, length and shape of end position for vertical bar *Rebar bend and straight, angle *Anchoring style, shape and the length of vertical bar *Splicing style and length of vertical bar *Diameter, length and shape of end position for horizontal bar *Anchoring style, shape and the length of horizontal bar *Splicing style and length of horizontal bar *Diameter and size of tie bar *Layer and positions for tie bar *Number, style, and diameter of Opening reinforcement bar *Concrete covering size (Concrete spacer) *Fixing condition of each bar	After completion of placing / Before installing Formwork
Rebar work-7	Slab (In each floor)	*Diameter, length and shape of end position for Main bar *Rebar bend and straight, angle *Diameter, length and shape of end position for Distribution bar *Anchoring style, shape and the length of Main bar *Anchoring style, shape and the length of Distribution bar *Number (spacing) of Main bar at Top and Bottom layers *Number (spacing) of Distribution bar at Top and Bottom layers *Number, style, and diameter of Opening reinforcement bar *Concrete covering size (bar stand size) for Top and Bottom layers *Fixing condition of each bar	After completion of placing/ Before concreting
Rebar work-8	Stair (In each floor)	*Diameter, length and shape of end position for Main bar *Rebar bend and straight, angle *Diameter, length and shape of end position for Distribution bar *Diameter, shape, and size of stairway bar *Installation spacing of stairway bar (pitch/ number) *Size, length and shape of tip bar *Concrete covering size (Concrete spacer) *Fixing condition of each bar	After completion of bottom formwork
Rebar work-9	Miscellaneous rebar (Palalet, Canopy, Others)	*Diameter, length, shape and number of main bars *Rebar bend and straight, angle *Anchoring style, length and shape of main bar *Diameter, length, shape and number of distribution bar *Concrete covering size (concrete spacer) *Fixing condition of each bar	After completion of placing / Before concreting
Formwork-1	Shuttering panel/Plywood/Timber	*Damage (Hole, Peel Scratch, Bent, Twist, Curved etc.)	Before usage
Formwork-2	Pile cap/ Spread foundation	*Size(X*Y*D) *Plumbing of shuttering panel *Length and type of tie-rod *Fixing of the foot of shuttering panel *Fixing of corner *Vertical and horizontal reinforcing pipe (timber) *Fixing condition of each panel *Ensure airtight *Fixing of form-tie *Setting condition of support materials	After completion of installation / Before concreting

## 5.2 ANNEX B

Category	Title	Checking contents	Implementation period
Formwork-3	Column (In each portion)	*Size (X*Y) *Plumbing of shuttering panel *Ensure airtight *Length and type of tie-rod (X/Y) *Fixing of the foot of shuttering panel *Fixing of corner *Vertical and horizontal reinforcing pipe(timber) *Fixing condition of each panel *Fixing of form-tie *Setting condition of support materials	After completion of installation / Before concreting
Formwork-4	Underground Beam	*Size (B*D) *Plumbing of side shuttering panel *Fixing of foot of shuttering panel *Length and type of tie-rod *Fixing condition in each panel *Connecting condition to Pilecap and/or Column *Vertical and horizontal reinforcing pipe(timber) *Fixing of form-tie *Ensure airtight *Setting condition of support materials	After completion of installation / Before concreting
Formwork-5	Beam (in each floor)	*Setting level of bottom panel *Size (B*D) *Plumbing of side shuttering panel *Length and type of tie-rod *Fixing condition in each panel *Fixing condition to bottom panel *Connecting condition to column *Constructed condition (Straightness, bent, twist etc.) *Ensure airtight *Vertical and horizontal reinforcing pipe (timber) *Fixing of form-tie	After completion of installation / Before concreting
Formwork-6	Grade Slab	*Height of Shuttering panel *Fixing condition in each panel	After completion of installation
Concrete work-1	Preparation for Casting	*Cleaning *Sprinkle water in pouring area (Wetting the shuttering surface) *Temporary walkway *Covering check *Preparation of tools (vibrator, steel trowel, Lamp, etc.)	Before commencement of concreting
Concrete work-2	Concrete test/sampling	*Concrete Slump test (Slump flow test) *Checking concrete tempter *Sampling Test piece	Arrival on site
Concrete work-3	Concreting	*Downtime of in each layer (completion of one layer to next layer) *Laying condition of concrete *Vibrating condition *Tamping condition *Protection against rainfall (under rain) *Executing of trawl condition (wooden and/or steel)	During concreting
Concrete work-4	Curing	*Protection against blowing window (After casting) *Protection against impacting/ shock (After casting) *Keeping wet condition *Keeping the curing time due to stipulated term	After concreting

**INSPECTION SHEET for Supervision**

Jul-25

**DCQR**









# 5.3 ANNEX C

## Construction Inspection Records

Project Name: \_\_\_\_\_

Inspection Title: Rebar Inspection(Pile Cap and/or Base foundation)

Sheet No.: \_\_\_\_\_

Inspection Date: \_\_\_\_\_

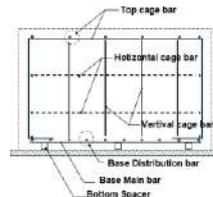
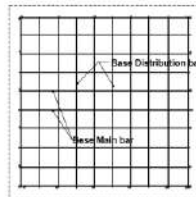
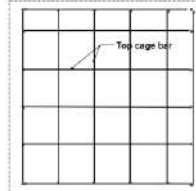
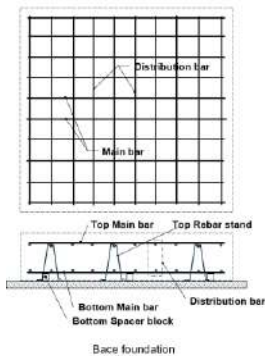
Beam Name: \_\_\_\_\_

Location: \_\_\_\_\_

Supervisor Name: \_\_\_\_\_

No.	Confirmation			Onspection result			Judgement		
	Items	Contents	Required	Result	Tolerance	Good	Acceptable	Reject	
Basement	Diameter of Upper Main bar	Upper Main bar condition (Bend, warp and twist)							
		Number of Upper Main bar (Spacing/ Pitch)							
		Splicing zone and splicing length							
		Top Spacer (Top covering concrete size)							
	Diameter of Upper Distribution bar	Upper Distribution bar condition (Bend, warp and twist)							
		Number of Upper Distribution bar (Spacing/ Pitch)							
		Splicing zone and splicing length							
		Diameter of Bottom Main bar							
	Bottom Main bar condition (Bend, warp and twist)	Bottom Main bar condition (Bend, warp and twist)							
		Number of Bottom Main bar (Spacing/ Pitch)							
		Splicing zone and splicing length							
		Bottom Spacer (Bottom covering concrete size)							
	Diameter of Bottom Distribution bar	Bottom Distribution bar condition (Bend, warp and twist)							
		Number of Bottom Distribution bar (Spacing/ Pitch)							
		Splicing zone and splicing length							
		Fixing condition of binding wire							
	Cage bar	Diemeter of Top cage bar	Number of Top cage bar/ Pitch, Space (X)						
			Number of Top cage bar/ Pitch, Space (Y)						
Arranged condition of top cage bar (Bent, wsrp, twist)									
Diemeter of vertical cage bar									
Number of vertical cage bar/ Pitch, Space (X)		Arranged condition of top cage bar (Bent, wsrp, twist)							
		Diemeter of vertical cage bar							
		Number of vertical cage bar/ Pitch, Space (X)							
		Arranged condition of top cage bar (Bent, wsrp, twist)							
Fixing condition of binding wire									

**Notes:** \*When inspecting, fill in the sheet with the project name, sheet number for each project, inspection date, and inspector name.  
 \*The tolerance values in the table are showing tolerances in Japan as reference. Actual tolerances must be discussed and confirmed with the designer.  
 \*In case of some bars not designed, the related above column do not need to fill.



Pile Cap foundation

# 5.3 ANNEX C

## Construction Inspection Records

Project Name: XXX Building Project

Inspection Title: Rebar Inspection (Column)

Sheet No.:

Inspection Date:

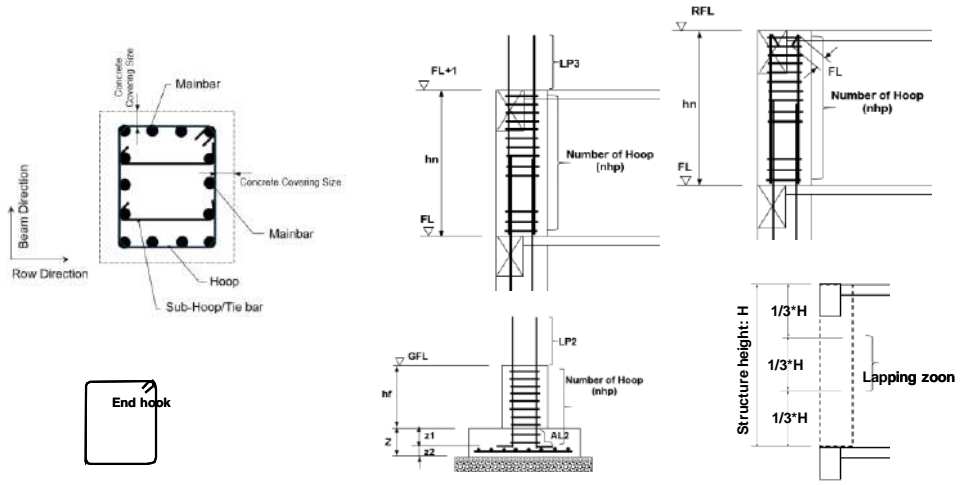
Supervisor Name:

Beam Name:

Location:

No.	Confirmation			Onspection result		Judgement			
	Items	Contents	Required	Result	Tolerance	Good	Acceptable	Reject	
1	Main Bar	Diameter (Raw Direction)							
		Number (Raw Direction)							
		Diameter (Beam Direction)							
		Number (Beam Direction)							
		Anchoring Length							
		Anchoring Condition							
		Splicing length							
2	Hoop	Diameter							
		Number (Pitch/Spacing) End position							
		Number (Pitch/Spacing) Center position							
3	Sub-Hoop	Diameter (Row Direction)							
		Number, Row Direction (Pitch/Spacing) End position							
		Diameter (Beam Direction)							
4	Tie Bar	Diameter (Row Direction)							
		Number, Row Direction (Pitch/Spacing)							
		Diameter (Beam Direction)							
		Number, Beam Direction (Pitch/Spacing)							
6	Arrangement & Others	Fising Condition (Binding)							
		Streghtness (Bend, Curb, Twist)							
		Concrete covering (Row Direction) Spacer							
		Concrete covering (Beam Direction) Spacer							

**Notes:** \*When inspecting, fill in the sheet with the project name, sheet number for each project, inspection date, and inspector name.  
 \*The tolerance values in the table are showing tolerances in Japan as reference. Actual tolerances must be discussed and confirmed with the designer.



# 5.3 ANNEX C

## Construction Inspection Records

Project Name: XXX Building Project

Inspection Title: Rebar Inspection (Beam)

Sheet No.:

Inspection Date:

Beam Name:

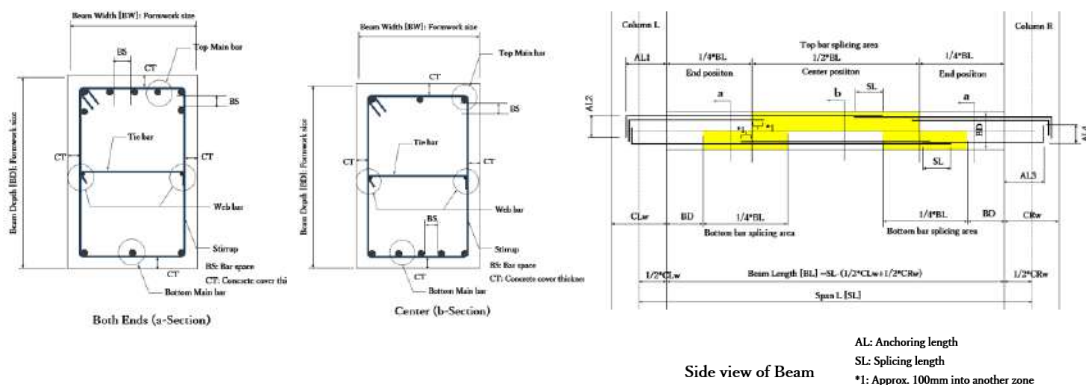
Location:

Supervisor Name:

No.	Confirmation			Onspection result			Judgement		
	Items	Contents	Required	Result	Tolerance	Good	Acceptable	Reject	
1	Upper Min-bar	Diameter (End position)							
		Number (End position)							
		Diameter (Center position)							
		Number (Center Position)							
		Anchoring Length							
		Anchoring Condition							
		Splicing length							
		Splicing Location							
2	Bottom Min-bar	Diameter (End position)							
		Number (End position)							
		Diameter (Center position)							
		Number (Center Position)							
		Anchoring Length							
		Anchoring Condition							
		Splicing length							
		Splicing Location							
3	Stirrup	Diameter							
		Number (Pitch/Spacing) End position Number (Pitch/Spacing) Center position							
4	Web bar	Diameter							
		Number of Layer (Pitch/Spacing)							
5	Tie Bar	Diameter							
		Number (Pitch/Spacing)							
6	Arrangement & Others	Fising Condition (Binding)							
		Streghtness (Bend, Curb, Twist							
		Concrete covering (Both side) Spacer							
		Concrete covering (Bottom side) Spacer Concrete covering (Top side) Spacer							

**Notes:** \*When inspecting, fill in the sheet with the project name, sheet number for each project, inspection date, and inspector name.

\*The tolerance values in the table are showing tolerances in Japan as reference. Actual tolerances must be discussed and confirmed with the designer.





# Construction Inspection Records

Project Name: \_\_\_\_\_

Inspection Title: **Slab Rebar Inspection**

Sheet No.: \_\_\_\_\_

Inspection Date: \_\_\_\_\_

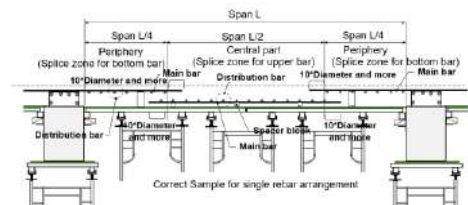
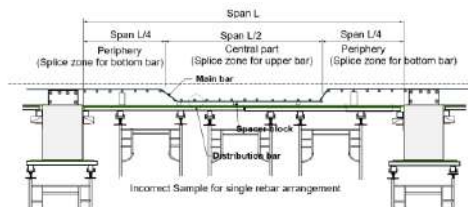
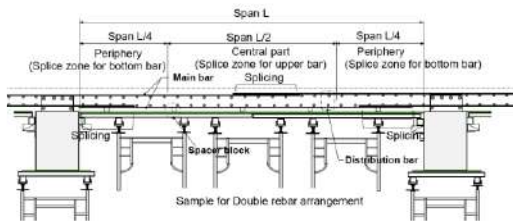
Beam Name: \_\_\_\_\_

Location: \_\_\_\_\_

Supervisor Name: \_\_\_\_\_

No.	Confirmation			Inspection result			Judgement		
	Items	Contents	Required	Result	Tolerance	Good	Acceptable	Reject	
1	Double bar arrangement	Diameter of Upper Main bar							
		Upper Main bar condition (Bend, warp and twist)	-						
		Number of Upper Main bar (Spacing/ Pitch)							
		Splicing zone and splicing length	-						
		Top Spacer (Top covering concrete size)	20						
		Fixing condition of binding wire							
		Diameter of Upper Distribution bar							
		Upper Distribution bar condition (Bend, warp and twist)	-						
		Number of Upper Distribution bar (Spacing/ Pitch)							
		Splicing zone and splicing length	-						
		Fixing condition of binding wire							
		Diameter of Bottom Main bar							
		Bottom Main bar condition (Bend, warp and twist)							
		Number of Bottom Main bar (Spacing/ Pitch)							
Splicing zone and splicing length									
Bottom Spacer (Bottom covering concrete size)									
Fixing condition of binding wire									
Diameter of Bottom Distribution bar									
Bottom Distribution bar condition (Bend, warp and twist)									
Number of Bottom Distribution bar (Spacing/ Pitch)									
Splicing zone and splicing length									
Fixing condition of binding wire									
2	Single bar Arrangement	Diameter of Main bar							
		Main bar condition (Bend, warp and twist)							
		Main bar arrangement condition (the stop position)							
		Concrete covering size at upper position							
		Concrete covering size at lower position							

**Notes:** \*When inspecting, fill in the sheet with the project name, sheet number for each project, inspection date, and inspector name.  
 \*The tolerance values in the table are showing tolerances in Japan as reference. Actual tolerances must be discussed and confirmed with the designer.












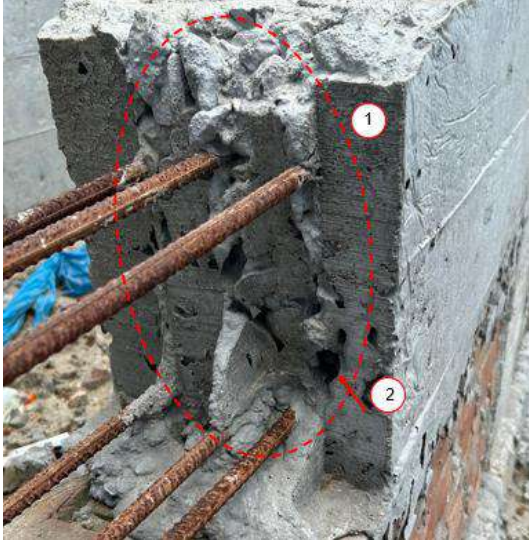

**5.4 ANNEX D**

**Samples of constructed condition on site**

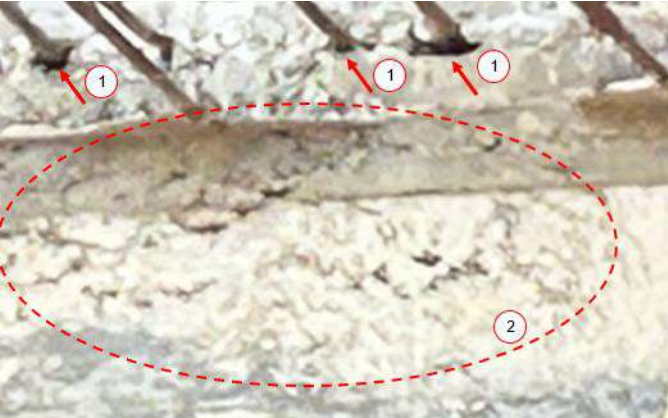

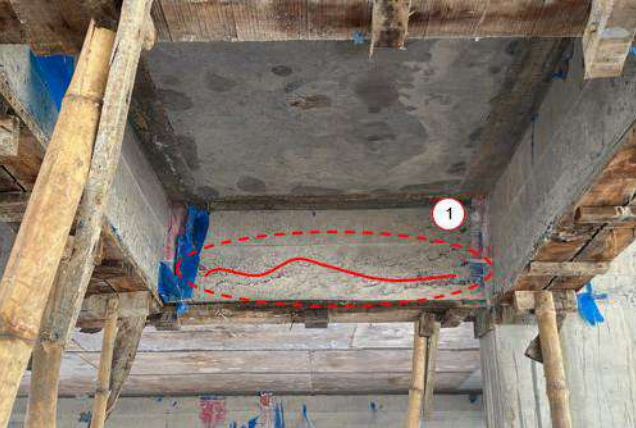
July 2025

RAJUK/DCQR

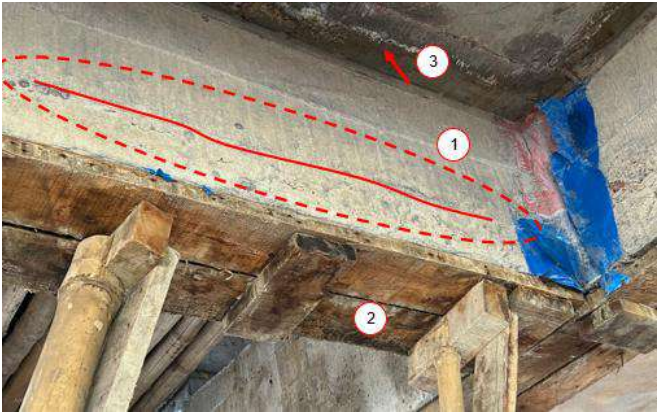
## 5.4 ANNEX D

Actual Working Condition	Point/Factor	Cause
	<p>① Honeycomb *Insufficient vibrating *Concrete separation (Wrong placing/Laying)</p> <p>② Incorrect space *Wrong concrete stop</p>	<p>Concreting</p> <p>Concreting</p>
	<p>① Unacceptable construct joint *Incorrect concrete condition</p> <p>② Concrete Cavities *Insufficient vibrating *Incorrect shuttering</p>	<p>Concrete-Material</p> <p>Concreting</p>
	<p>① Concrete Cavity (Porous concrete) *Insufficient Vibrating *Strength of shuttering</p>	<p>Concreting</p>

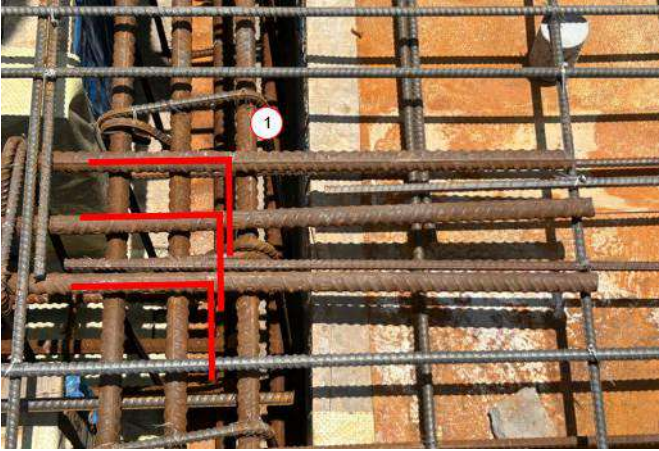
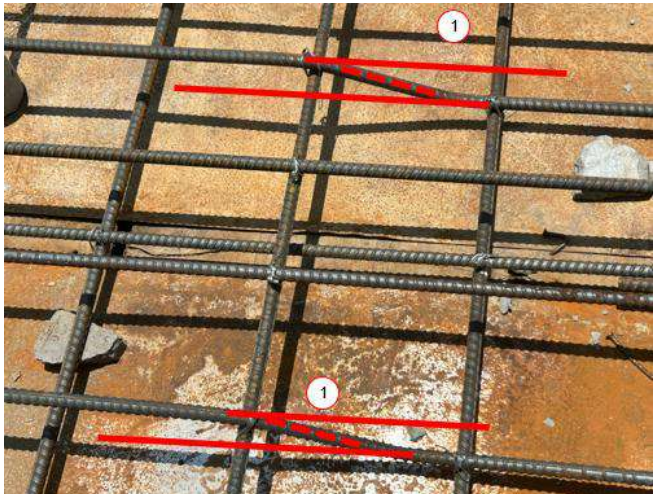

## 5.4 ANNEX D

Actual Working Condition	Point	Reference
	<p>① Chink (Gap)            *Insufficient Vibrating            *Incorrect water-cement ratio(Too much water)</p> <p>② Porous concrete (Not rigid)            *Insufficient Vibrating            *Not enough shuttering strength</p>	<p>Concreting            Concrete-Material</p> <p>Concreting            Formwork</p>
	<p>① Unacceptable working condition            *Lack of cleaning            *Incorrect material handling</p>	<p>Site Arrangement</p>
	<p>① Cold Joint            *Too much interval of casting            *Insufficient Vibrating</p>	<p>Concreting</p>

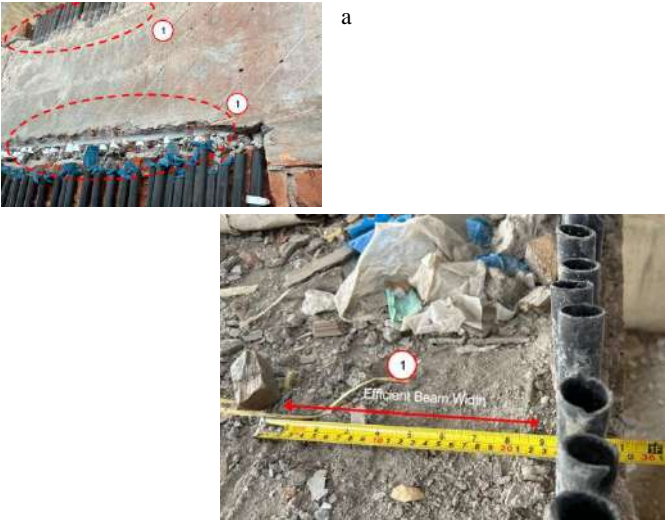
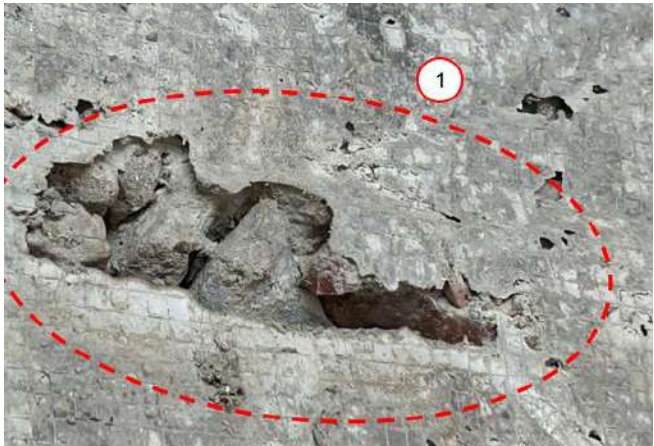
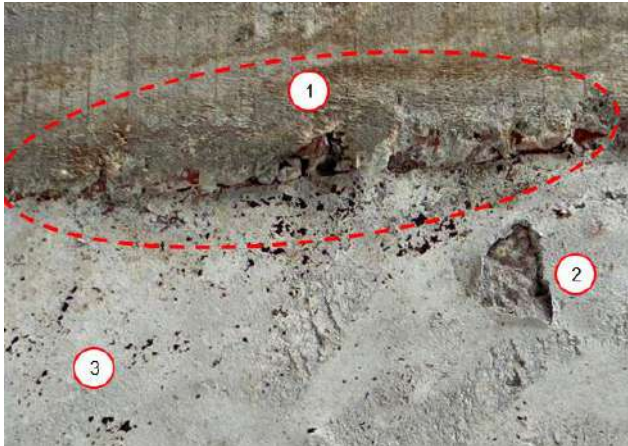
## 5.4 ANNEX D

Actual Working Condition	Point	Reference
	<p>① Cold Joint *Too much interval of casting *Insufficient Vibrating</p> <p>② Low quality shuttering panel *Impact to concrete</p> <p>③ Impurities on concrete surface (Degradation of concrete) *Insufficient Vibrating *Using incorrect shuttering</p>	<p>Concreting</p> <p>Formwork/ Shuttering materials Concreting</p> <p>Formwork/ Shuttering materials</p>
	<p>① Low quality concrete spacer *Impact to structural strength</p>	<p>Concrete Spacer</p>
	<p>① Impurities on concrete surface (Degradation of concrete) *Insufficient Vibrating *Using incorrect shuttering</p>	<p>Concreting</p> <p>Formwork/ Shuttering materials</p>



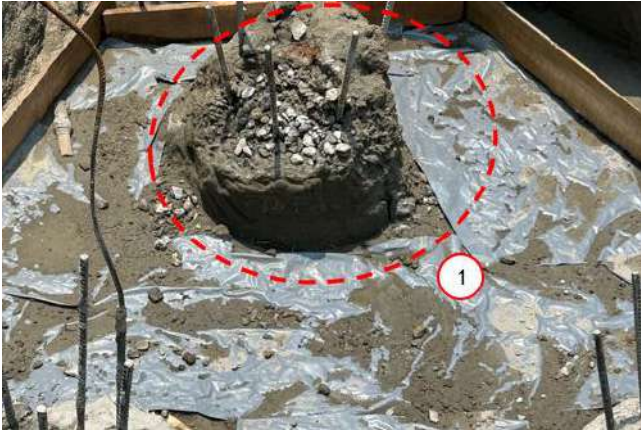
## 5.4 ANNEX D

Actual Working Condition	Point	Reference
	<p>① Wrong anchoring Miss fabrication *Miss bending schedule</p>	<p>Rebar fabrication</p>
	<p>① Wrong fabrication Miss Bending schedule</p>	<p>Rebar fabrication</p>
	<p>① Huge Concrete Cavity *Insufficient Vibrating *Too much casting interval *Insufficient strength of shuttering panel</p> <p>② Exposure of rebar *Wrong bending schedule *Miss fabrication</p>	<p>Concreting Formwork  Rebar Work</p>


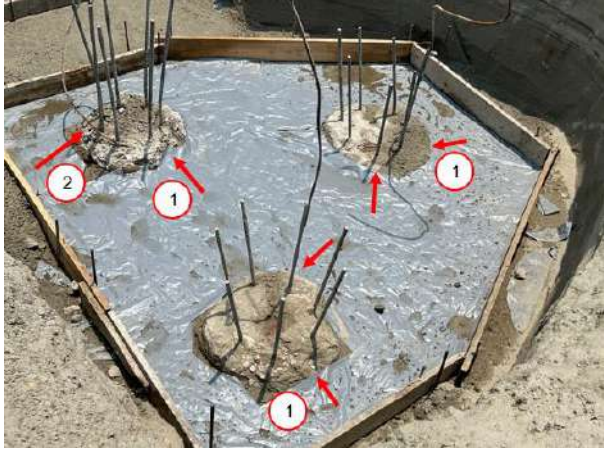
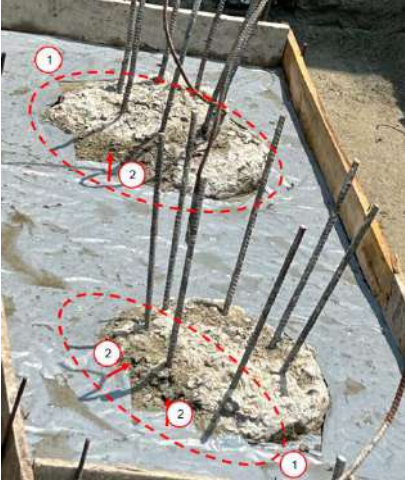
## 5.4 ANNEX D

Actual Working Condition	Point	Reference
 <p style="text-align: right;">a</p>	<p>① Wrong Embedded Pipe</p> <ul style="list-style-type: none"> <li>*Lack of Beam Width</li> <li>*Lack of consideration</li> </ul>	<p>Electrical design</p>
	<p>① Concrete Cavity</p> <ul style="list-style-type: none"> <li>*Insufficient Vibrating</li> <li>*Insufficient Tamping</li> <li>*Too much casting interval</li> </ul>	
	<p>① Incorrect Concrete Joint</p> <ul style="list-style-type: none"> <li>*Insufficient cleaning</li> <li>*Insufficient Vibrating</li> </ul> <p>② Concrete Cavity</p> <ul style="list-style-type: none"> <li>*Insufficient Vibrating/ Tamping</li> </ul> <p>③ Porous Concrete</p> <ul style="list-style-type: none"> <li>*Insufficient Vibrating/ Tamping</li> </ul>	<p>Concreting</p> <p>Concreting</p> <p>Concreting</p>



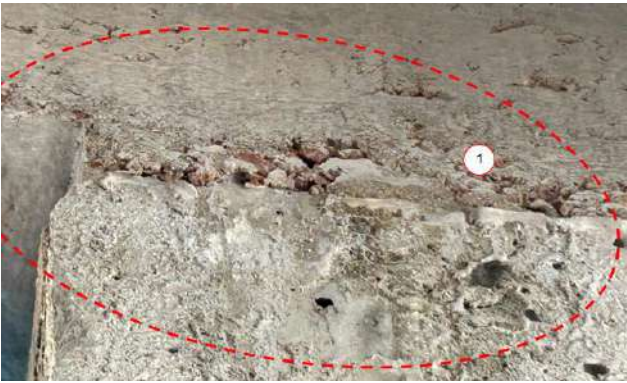
**5.4 ANNEX D**

Actual Working Condition	Point	Reference
	<p>① Low quality shuttering material. *Impact to concreting and concrete.</p>	<p>Shuttering Materials</p>
	<p>① Insufficient Filling Materials *Impact to Fire Prevention</p>	<p>Plumbing Work</p>
	<p>① Impure Pile Concrete *Incorrect pile concrete *Insufficient removal of slime</p>	<p>Bore Pile</p>

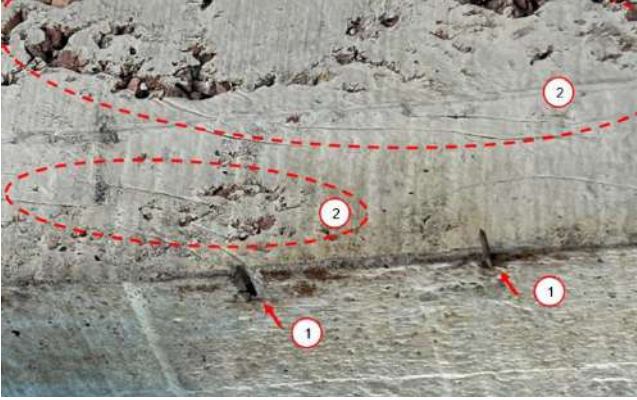
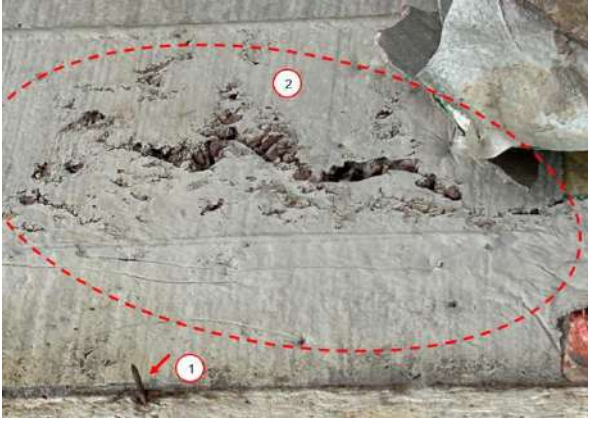

## 5.4 ANNEX D

Actual Working Condition	Point	Reference
	<p>① Lack of Pile Head *Insufficient connection into Pile Cap</p>	Bore Pile
	<p>① Lack of Pile Head *Insufficient Connection into Pile Cap</p> <p>② Impure Concrete *Lost Pile Strength</p>	Bore Pile
	<p>③ Lack of Pile Head *Insufficient Connection into Pile Cap</p> <p>④ Impure Concrete *Lost Pile Strength</p>	Bore Pile

## 5.4 ANNEX D

Actual Working Condition	Point	Reference
	<p>① Incorrect Material Stock            *Unplanned Site arrangement            *Unsafe site condition</p>	<p>Site Arrangement</p>
	<p>① Insufficient Casting concrete            *Unsuitable shuttering</p>	<p>Formwork</p>
	<p>① Incorrect Casted Concrete            *Insufficient cleaning of shuttering panel            *Lack of shuttering strength</p>	

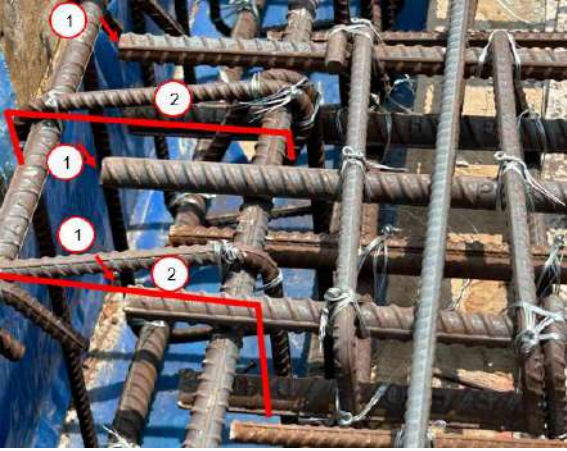
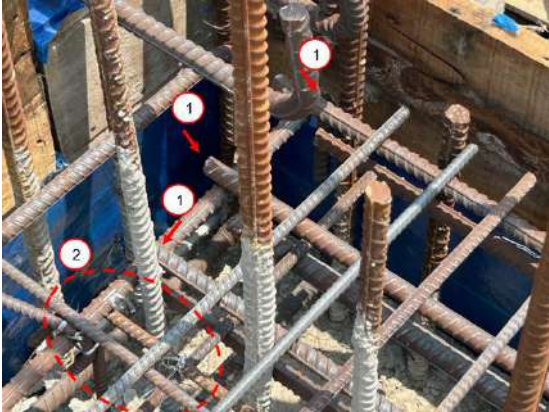

## 5.4 ANNEX D

Actual Working Condition	Point	Reference
	<p>① Remained Nail *Miss-fabrication of shuttering panel</p> <p>② Separated Concrete *Wrong Placing *Insufficient Vibrating *Insufficient sprinkling water on the shuttering panel</p>	<p>Formwork</p> <p>Concreting</p> <p>Preparation of concreting</p>
	<p>① Remained Nail *Miss-fabrication of shuttering panel</p> <p>② Separated Concrete *Wrong Placing *Insufficient Vibrating *Insufficient sprinkling water on the shuttering panel</p>	
	<p>① Porous Concrete *Insufficient Vibrating *Pour Concrete materials</p> <p>*Insufficient strength of shuttering panel *Rebar arrangement in muddle</p>	<p>Concreting</p> <p>Concrete mixing</p> <p>Formwork</p> <p>Rebar work</p>

## 5.4 ANNEX D

Actual Working Condition	Point	Reference
	<p>① Insufficient strength of Slab shoring.</p> <ul style="list-style-type: none"> <li>*Unsuitable materials</li> <li>*Wrong shoring plan</li> </ul>	Formwork
	<p>① Incorrect anchored position</p> <ul style="list-style-type: none"> <li>*Insufficient anchoring strength</li> <li>*Peeling the cover concrete.</li> </ul>	Rebar work (Arrangement)
	<p>① Incorrect Beam Rebar arrangement</p> <ul style="list-style-type: none"> <li>*Miss-bending schedule</li> <li>*Miss-fabrication of rebar</li> </ul> <p>② Not right angle setting of Stirrup against Beam direction</p> <ul style="list-style-type: none"> <li>*Decrease of resistance against sharing force</li> </ul>	<p>Rebar work</p> <p>Fabrication</p> <p>Fabrication</p> <p>Placing</p>



**5.4 ANNEX D**

Actual Working Condition	Point	Reference
	<p>① Incorrect Beam Rebar arrangement *Miss-bending schedule *Miss-fabrication of rebar</p> <p>② Not right angle setting of Stirrup against Beam direction *Decrease of resistance against sharing force</p>	<p>Rebar work Fabrication Fabrication Placing</p>
	<p>① Incorrect Beam Rebar arrangement *Miss-bending schedule *Miss-fabrication of rebar</p> <p>② Rebar arranged in muddle *Rebar placing</p>	<p>Rebar work Fabrication Placing</p>
	<p>① Insufficient concrete cover *Rebar placing</p>	<p>Rebar work</p>

## 5.4 ANNEX D

Actual Working Condition	Point	Reference
	<p>① Wrong anchoring of slab main bar</p> <ul style="list-style-type: none"> <li>*Insufficient connecting strength</li> <li>*Peeling concrete</li> <li>*Miss placing</li> </ul> <p>② Wrong stirrup direction</p> <ul style="list-style-type: none"> <li>*Insufficient resistance against sharing force</li> <li>*Incorrect size</li> </ul>	<p>Rebar work</p> <p>Miss fabrication, or Bending-schedule</p>
	<p>① Wrong stirrup direction</p> <ul style="list-style-type: none"> <li>*Insufficient resistance against sharing force</li> <li>*Incorrect size</li> </ul> <p>② Wrong anchoring of slab main bar</p> <ul style="list-style-type: none"> <li>*Insufficient connecting strength</li> <li>*Peeling concrete</li> <li>*Miss placing</li> </ul>	<p>Rebar work</p> <p>Miss fabrication, or Bending-schedule</p>
	<p>① Missing Hoop</p> <ul style="list-style-type: none"> <li>*Incorrect work procedure</li> </ul>	<p>Rebar work</p> <p>Placing</p>

## 5.4 ANNEX D

Actual Working Condition	Point	Reference
	<p>① Rebar arranged in middle. Placing procedure</p>	<p>Rebar work Arrangement</p>
	<p>① Rebar arranged in middle. Placing procedure</p>	<p>Rebar work Arrangement</p>