Manual
on
Construction Inspection

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

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Preface

With rapid urbanization and increasing infrastructural demands, ensuring building construction quality, safety, and compliance is more important than ever. This Site Inspection Manual is a complete guide for all the participants in the construction process (engineers, supervisors, inspectors, and regulatory authorities) specifically under the Improvement of Design and Construction Quality for Resilience of Private Buildings (DCQR) of RAJUK.

The aim of the manual is to close the gap of theoretical design intent to on-ground execution by providing detailed technical information, practical advice, and systematic inspection processes. It presents the fundamentals of building quality with emphasis on reinforced concrete (RC) structures, it presents basic principles of construction quality assurance and control, and it provides step by step processes of effective site inspection works.

Utilizing the regulatory framework associated with the BNBC and other analogous internationally recognized best practice standards, systemic structure of this manual is to aid consistency in decision making and technical judgement throughout the construction life-cycle phases; and material handling and workmanship; fire life safety; mechanical, electrical and plumbing (MEP) integration and final occupancy certificate; accountability, standardization, and safety there can be assurance at each level.

It is our hope that this manual will be used as more than a procedural guide, but in fact be a building block towards cultivate.

By Chairman, RAJUK

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Chapter 1 General

1.1 Purpose and Importance of the Manual

On-site inspections by RAJUK personnel require specialized knowledge regarding the proper quality of construction work. Therefore, this manual outlines the minimum points to be observed in order to properly conduct on-site inspections.

- Basic knowledge for Reinforcing Concrete structure (Herein after called RC structure)
- Building Quality and Construction Quality
- Procedure the Inspection

The purpose of this manual is to provide basic knowledge about Building Construction and On-site inspection procedures, share necessary technical knowledge, and standardize check points during on-site inspections.

1.2 Definition of Building Quality (Construction)

There are two important points for the above.

1.2.1 To construct the Building as required specification by design document

1.2.1.1 Use of designated materials

Correct materials as specified by design some of which are strength specifications for materials such as rebar and concrete, and other specifications

1.2.1.2 Dimension in each position

Construct to the exact dimensions as designed such as column, Beams, Girders Stair case size and others.

1.2.2 Properly handling and construction of the designated construction materials.

In order to ensure that the specified materials perform as required, they must be handled appropriately, including by proper storage methods, at the construction site.

1.2.2.1 Temporary stock on site

It is very important to protect the materials from dirt and any other impurities including rusting with correct stock condition

1.2.2.2 Correct site fabrication and installation

It is important that specified materials on design drawing such as gravel, cement, sand, concrete, rebar and others have to be used, and fabricated correctly such as size of form work, bending size of rebar and others

1.2.2.3 Suitable execution

The fabricated material has to be installed at the required position unsuitably, some of which are assembling rebar as required size, number and pitch, without warp, twist and bent.

1.3 Duty of Stakeholder for Building Construction

1.3.1 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)

1.3.1.1 Relation of Building construction

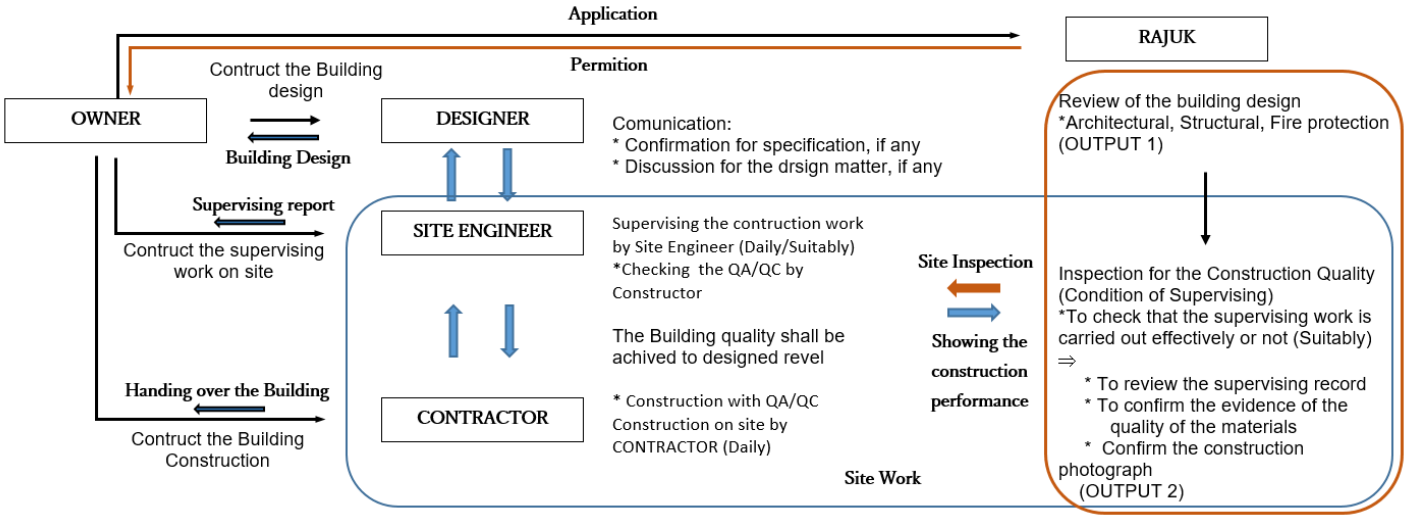


Figure 1-1 Working Relation

1.3.1.2 Duty on each party for Building Quality

1) 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.

2) 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.

3) Duty of RAJUK/ Inspection

To check the construction work, which going on following applicate design and any other requirements and/or construction rules

	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 stipilations.	*Checking of important points on the Building Construction-process *Giving suitable instruction to complete the Building as designed condition, if necessar if any.	*Confirming of the Construction-process and completed condition of The Building, which shall match with the pernmitted condition.(Controlled by owner)
	Residential **Total checking (100%)** ⇐	**Residential/ Periodical** **Randum Checking (Partial)** ⇐	**Suitably** **Suitably Confirming**

Figure 1-2 Duty on each party

Table 1-1 Object of Inspection by

Object of Inspection

Requester	Executor	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 Conctruction	Checklist/ Measuring	Owner Supervisor

1.3.1.3 Site Inspection (Flow chart)

The site inspection is carried out according to the workflow shown below, which consists from two steps mainly.

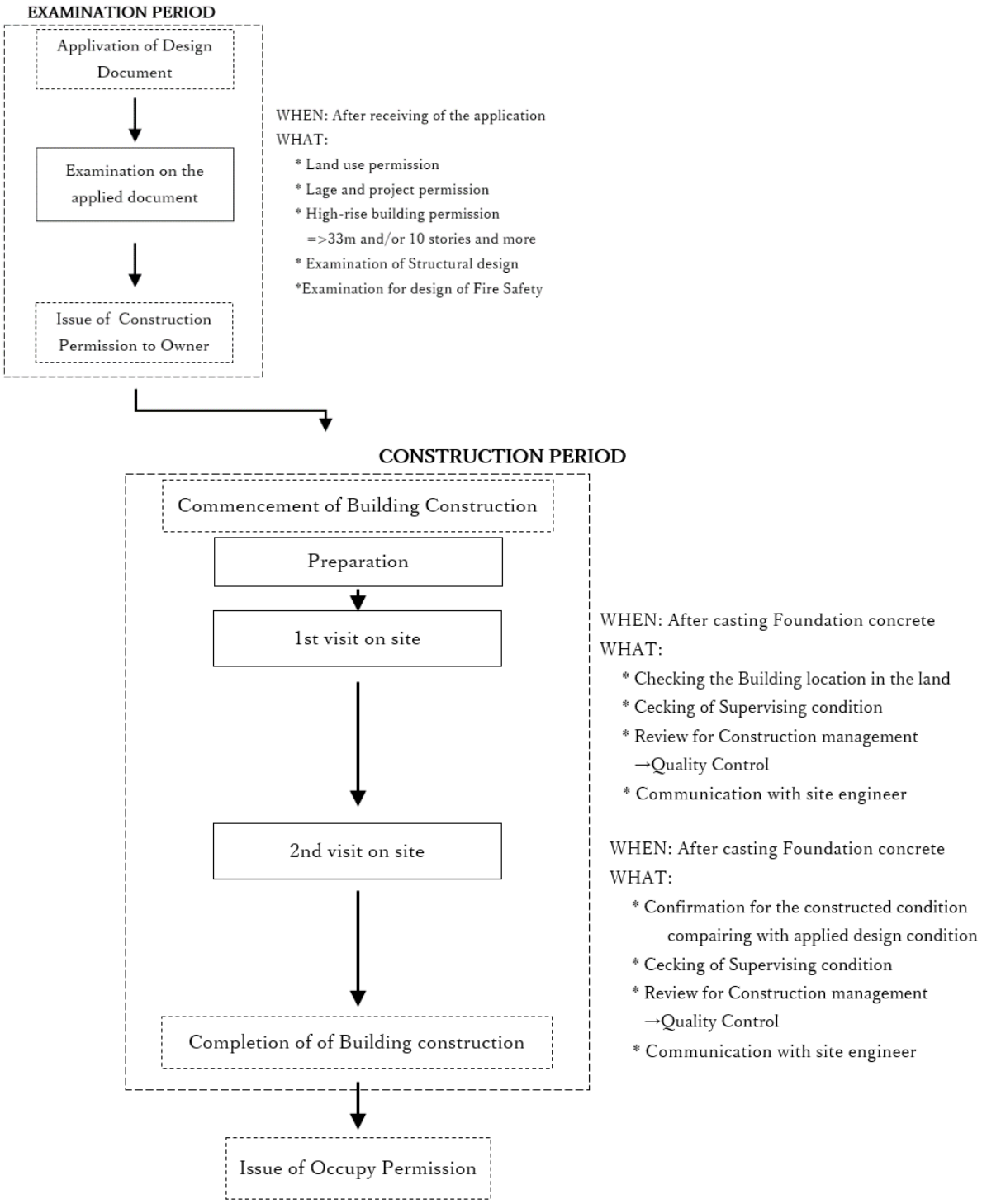


Figure 1-3 Flow-chart for Site Inspection

1.3.1.4 Explanation for each step on the workflow

RUJUK duty can be broadly divided into an examination period before the commencement of construction and an on-site confirmation period after approval oif the construction.

1) Examination period

RAJUK will examine the submitted design the following two points as land clearance;

(a) The purpose of the building has matched with detailed area plan (DAP) or not, which is prepared by Town Planning Section in RAJUK

(b) The planned layout in their land has kept sufficient distance from boundary of neighboring property, which stipulated on BCR 2008.

When the above points have been confirmed, subsequently the construction plan will examine the below points.

(c) In case of planned construction area is 7500m2 and more as residential building, or 5000m2 and more as commercial building, RAJUK will examine as Large and Special Project clearance (LSP)

(d) In case of the planned building height is 33m and more, or the building stories are 10^{th} and more, the appreciated plan will be examined by FSCD and CAAB.

In addition to the above, The below three points will be examined.

(e) The construction plan will be examined by Department of Environment (DOE)

(f) Examination of Structural Calculation

(g) Examination of Fire Safety

2) Construction period

The work carried out by RAJUK as part of the inspection during the construction period consists of inspection preparation and on-site inspection, and the work content at each stage is as below.

(a) Preparation stage: The following points have to be confirmed.

- ✧ Studying contents of permitted design (Design requirements)
- ✧ Structural point
- ✧ Point of Fire Safety
- ✧ Important point for the building quality
- ✧ Confirmation of Checking items on Checklist

(b) First visit on site/ 1^{st} Inspection

After casting concrete for foundation, Confirmed permitted point in design examination, the following points have to be confirmed.

- ✧ Communication with site engineers such as management style, method,
- ✧ Checking site condition: Site Office, Construction document, test report for materials and others, Cleanness, Keeping temporary access , Stock condition for the materials such as rebar, cement, Shuttering and other stocked materials
- ✧ Checking condition of supervising work and site management, What, When, Whom, Where, How.

- ✧ Checking site activities
- ✧ Checking construction record

(c) 2nd Visit on site/ 2nd Inspection

After completion of Building Construction

- ✧ Checking of constructed condition of Building→Distance from boundary around Building
- ✧ Size of staircase (especially the width)
- ✧ Construction conditions for Fire Safety Equipment
- ✧ Checking operation of Fire Safety Equipment
- ✧ Inspection Report

1.3.1.5 Focus Point for Site Inspection

1) Observance of Rules

Specifications required BNBC, any other related rules, required instruction by any officials and others

2) Building construction

Construction has the following points of characteristic, so that in each point it influences Building Quality. Therefore, Suitable working sequence and procedure is required for the Quality

- ✧ Many working steps
- ✧ Many workers
- ✧ Many kinds of materials
- ✧ Complicated relationships on work
- ✧ Long time for construction terms

3) Type of Construction Management

- ✧ In the case of Constructor dispatched engineer, Owner hired supervisor for checking Building Quality
- ✧ In the case of Owner contract constructor, and do not hire supervisor for checking Building Qualities

Chapter 2 BASIC POINT ON BUILDING QUALITY

When Inspection is carried out to achieve the required quality, the basic knowledge for building construction is very important to judge the construction condition. Therefore, some technical points herein will be explained.

2.1 Reinforcing Concrete Structure

Reinforcing Concrete Structure (Herein called after RC Structure) is the most popular structural style due on showing the reasons, and that each point influence to the quality of RC structure directly. Therefore, it is very important to recognize each point at the site inspection time.

2.1.1 High-processible

RC structure is constructed that shuttering panels constructed on site as a structural part such as column, beam, slab and/or any other parts, and rebar would be placed at the required position, and then fresh concrete would be cast in the shuttering case.

2.1.2 Same liner expansion coefficient

Rebar and Concrete have a similar liner expansion coefficient under normal conditions. Therefore, it can move together, which means to protect the separation for Rebar and concrete

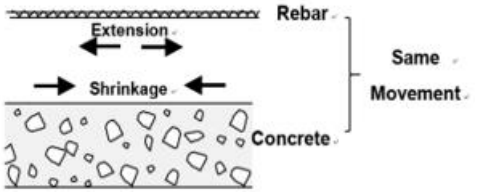


Figure 2-1 Liner expansion Coefficient

2.1.3 Concrete and Steel bar

2.1.3.1 Concrete

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

It is basic point that concrete would be produced by hydrating reaction of cement, 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.

2.3.2 Aggregates

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, alkalies 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.

2.3.5 Admixtures

Admixtures to be used in concrete shall be subject to prior approval by the Building Official and shall comply with Sections 2.4.5.1 to 2.4.5.5.Admixtures shall conform following standards:

BDS EN 934-1	Admixtures for Concrete, Mortar and Grout-Part 1: Common Requirements.
BDS EN 934-2	Admixtures for Concrete, Mortar and Grout-Part 2: Concrete Admixtures Definitions, Requirements, Conformity, Marking and Labelling.

1) Mixing proportion of the compositions

It has to 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 point in shown on the below table simply.

Material	Proportion	Character of Produced concrete
Cement	High	◆ Strength will be higher ◆ Fluidity is going down→Workability for casting will be worse
Water		◆ Fluidity is going up→Workability for casting will be better. →Workability for tamping will be worse. ◆ Shrinkage factor will be bigger→ Appearance of the shrinkage cruck will be easier

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

2.1.3.2 Steel Bar (Herein called after "Rebar")

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

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

In the other hand, when the tensile force affects to bended Rebar, which would straighten and then backed to original condition (Straight).

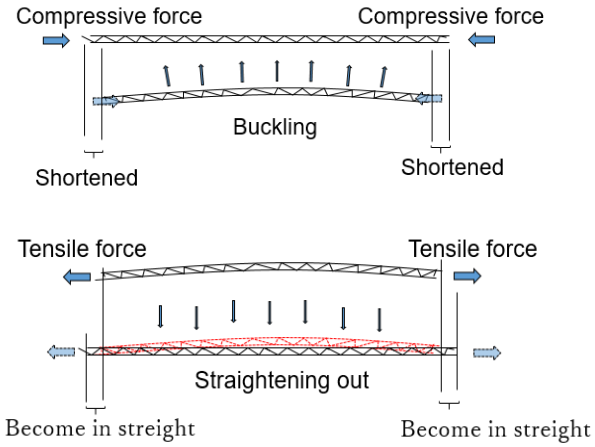


Figure 2-2 Movement of Steel bar

2.1.3.3 Function of Rebar and Concrete

Rebar and Concrete have their own role on RC structure due on its function. Reinforcing bar 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 1/10~1/13 of compressive strength and steel bar has a same strength on tensile and compressive.

In short, Steel bar will bear the tensile stress on Building and Concrete will bear compressive stress.

2.2 Building Quality

Building quality means several points as follows;

- ✧ Lifetime of Building
- ✧ High Usability (Reasonable Planning, Maintenance Free, Comfortable Space, etc.)
- ✧ User's Safety

Especially, User's Safety is 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.

2.2.1 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 vertical loads and Horizontal loads, some of which are dead weight/dead load, live load, seismic load, wind load and other loads by structural calculation.

Furthermore, the building strength has to be take an expected lifetime with reasonable maintenance, and the Building strength, specially Building lifetime will be influenced by a performance of construction work on site. Therefore, site supervising and site-inspection are to check, instruct and confirm the correct construction work on site.

2.2.1.1 Stress on the Building structure

Building structure is affected a stress by External force, which force is Vertical force and Horizontal force. Both forces are below.

1) Vertical force

Dead weight and live load 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 where heavy snowfall is.

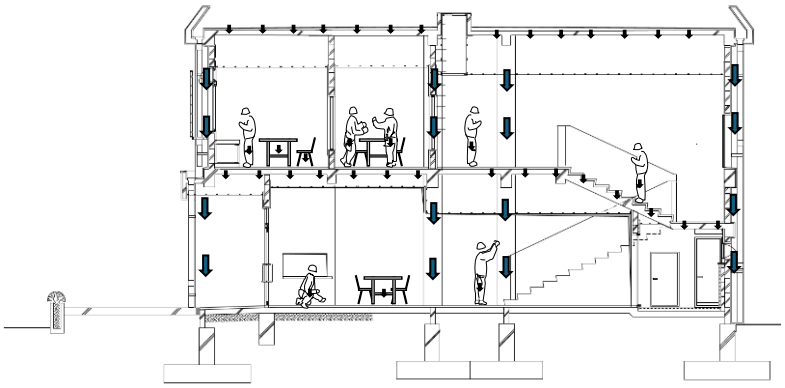


Figure 2-3 Image of Vertical force

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

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

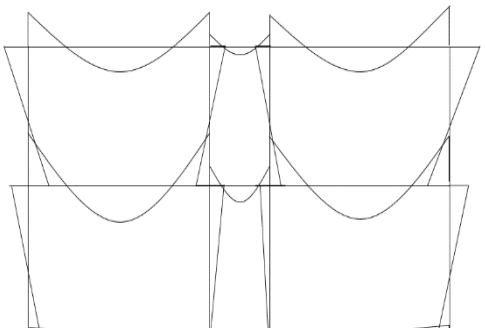


Figure 2-4 Vending Moment on the Frame

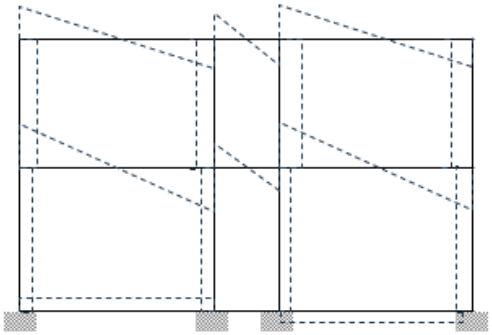


Figure 2-5 Sharing force on the Frame

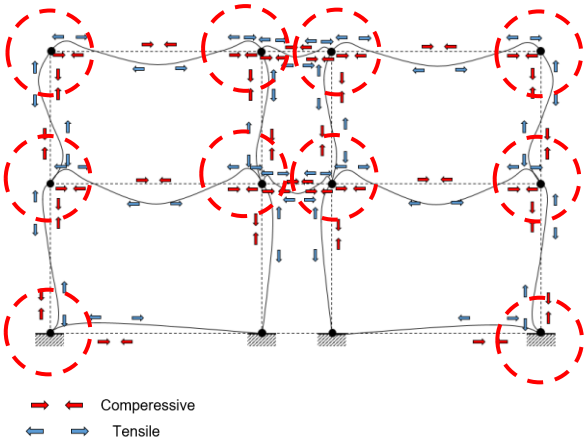
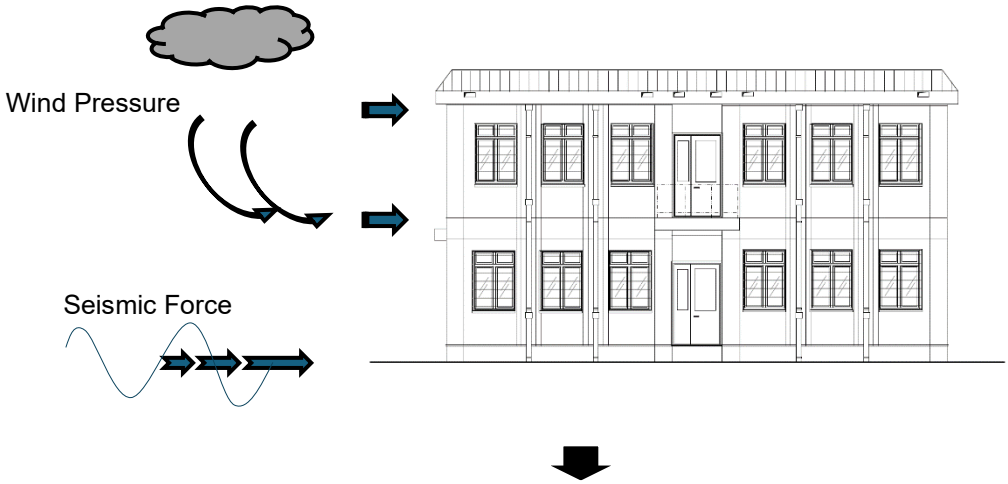


Figure 2-6 Stress on the Frame

2) Horizontal force

Wind pressure caused by storm and any other natural phenomenon affect the building structure and also earthquake as external force. These have not always occurred, but it sometimes attacked the Building as natural hazard.



The below Diagram shows as sample of mages

According to the above mentioned Horizontal force, Moment has appeared on the frame, so that the frame is affected by compressive and tensile stresses at the part by part. Especially, Moment has concentrated at the connection of Beam and Column, and that the position shall bear the much stress as well as under Vertical force showing on the sketch. (A part circled by dot line).

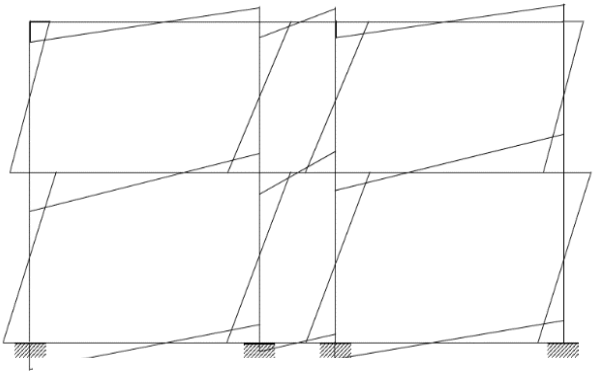


Figure 2-7 Bending Moment Frame (Horizontal Force)

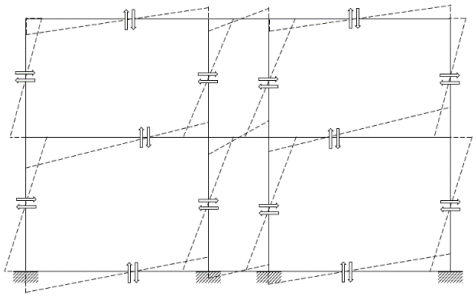


Figure 2-8 Share force on Frame (By Horizontal force)

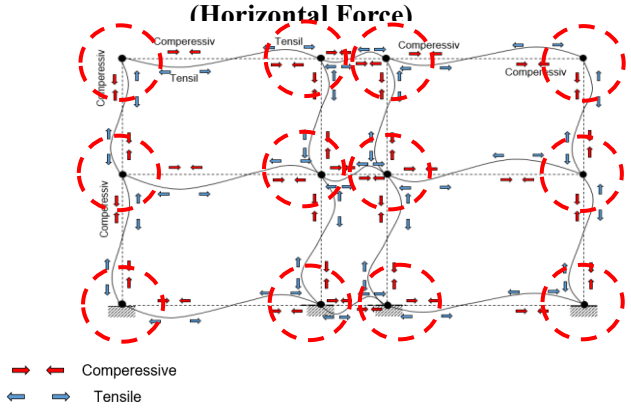


Figure 2-9 Stress on Frame (By Horizontal force)

According to each force, the frame has been affected a compressive and/or tensile stresses on part of the frame.

As result of the above confirmation, the effect of the stress on Building frame in Vertical force and Horizontal force is as shown below normally.

Therefore, the structure shall bear those loads for safety usage of Building and the effect of the stress on Building frame in Vertical force and Horizontal force is below normally.

[Point of Consideration]

- ✧ Many stresses concentrate at the connection of beam and column under Vertical and Horizontal Forces →The connecting position shall be worked carefully -1)
- ✧ At the edge part of Beam, Tensile stress occurs on the upper side of it and compressive stress occurs on the bottom side of it.
- ✧ At the center part of Beam, Tensile stress occurs on the bottom side of it and Compressive stress occurs on the upper side of it.
- ✧ The turning point of tensile and compressive is 1/4 of Beam length (Between both side columns) from column face.

2.2.1.2 Sharing of roles between Concrete and Reinforcing bar for RC structure

As mentioned in "2.1.3.3 Function of Rebar and Concrete", rebar bears the tensile stress

generated in a building, while concrete bears the compressive stress.

In other words, just as we checked the stresses acting on the frame under vertical and horizontal loads above, it is extremely important to imagine the structural frame and consider which stresses, such as compressive stress and tensile stress, will affect the structure for each part.

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

Safety for user of the Building is also important point for Building Quality.

In the case of natural disaster, users need to keep their safety, some of which are Earthquake, Storm, Flood and/or Fire. User of Building shall be protected from that disaster.

Safety for Earthquake and Storm shall be assured by structural design mainly, and Safety for Flood and Fire shall be architectural design, especially Treatment for Fire such as fire prevention, evacuation and fire extinguish herein explained.

2.2.2.1 Fire prevention

Equipping buildings with fire prevention equipment such as smoke detectors, heat detectors, and fire alarms is an extremely effective measure for quickly detecting fires and is an important piece of equipment.

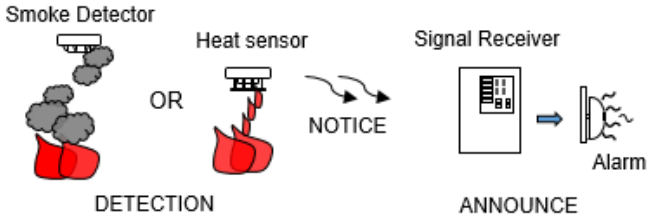


Figure 2-10 Imagine of Fire Prevention

There are several kinds of Fire prevention devise, which shall be designed suitably by designers. The inspector has to refer to the approved plans in accordance with rules and regulations and ensure that the plans are installed correctly in the building as instructed.

2.2.2.2 Evacuation from Fire

In occurrence of Fire, It is necessary that Building user can evacuate form the location of Fire safely and Building shall be designed under consideration for User evacuation from fire. Herein the point of fire threat will be introduced.

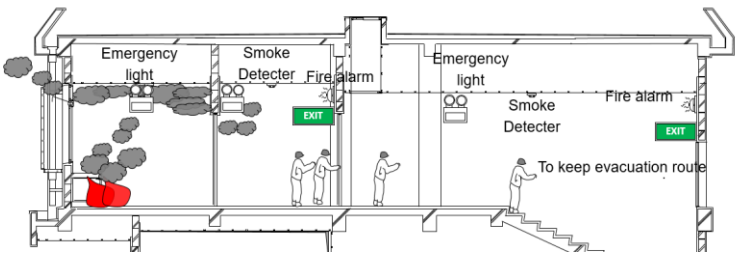


Figure 2-11 Device for evacuation from fire

It is most important point not to lose the evacuation route for Building user, so that the below point shall be considered.

- ✧ Evacuation route has to be two directions at least.
- ✧ Emergency lights have to be equipped to avoid losing light.
- ✧ Emergency exit has to be indicated clearly

In short, It is very important that Fire protection devise shall be installed as required condition by design drawing.

2.2.2.3 Fire fighting

Firefighting equipment has to be installed as required by design documents. Some of the equipment is shown below.

- ✧ Connecting water supplying pipe
- ✧ Fire hose box
- ✧ Sprinkler
- ✧ Portable extinguisher
- ✧ Forming fire extinguishing system
- ✧ Carbon dioxide fire extinguishing system etc.

2.3 Construction points for Building Quality of RC structure

Building Quality will be depended on the design, and Construction work shall be executed following a design document such as design drawing, specifications and any other instruction, and other regulations, rules and stipulations. However, some of behavior on the construction work impact on Building quality.

Therefore, it is main point for Supervising and Site inspection to check, instruct and confirm the working behavior on site, so that there are two focusing points, which is below.

2.3.1 Handling of the construction materials

Construction has to be handled suitably on site to keep the materials' quality and/or the basic function on RC structure. The main careful point on site is as follows;

2.3.1.1 Rebar

- ✧ To confirm the tensile strength by mile sheet and/or sampling tensile strength test.
- ✧ To check the bend, twist and warp: To stock on flat condition and use a reasonable number of sills for stock.
- ✧ To check rust, oil spot and any other spoil: To use vinyl sheet cover, and not to stock on the access route

2.3.1.2 Shuttering materials such as plywood panel and/or steel panel

- ✧ To check the condition such as flatness, strength and maintenance condition: The times

of recycle usage and the condition (bent, twist, warp and/or peeling/plywood only)

- ✧ To avoid bending, twist, and warp: To stock on flat condition and use a suitable number of sills for stock.
- ✧ To protect from rain, strong sunshine and mud: To use vinyl sheet cover, and not to stock on the access route

2.3.1.3 Shoring Materials

- ✧ To check the condition such as bend, twist, warp and other damages, and the maintenance: Visual checking.
- ✧ To check the stock condition: Treatment for muddy, rust and other damages.

2.3.1.4 Concrete material

Strength of concrete will be influenced by volume of cement and strength of the aggregate basically, furthermore the mixing ratio for concrete is also very important, especially Cement-Water ratio has to be controlled as mixing design.

Refer to 2.1.1 Table of [Impact of proportion between Cement and Water]

Concrete material has two options, so that one is Ready Mixed Concrete and another one is Site Mixing Concrete. Each checking points at material arrived on site (before casting on the place) are below.

[In case of Ready Mixed Concrete]

- ✧ The result of the designed mixing ratio shall be confirmed by test mixing and the crushing test (four weeks age).
- ✧ The mixing data shall be checked. (Target strength, volume of cement, Cement-cement ratio, etc.) : To compare with concrete mixing design
- ✧ Checking the slump, flow and concrete temperature
- ✧ Concrete Slump Test: Concrete Slump is term for the workability of the concrete such as fluidity and segregation resistance.

[Concrete slump test is below.]

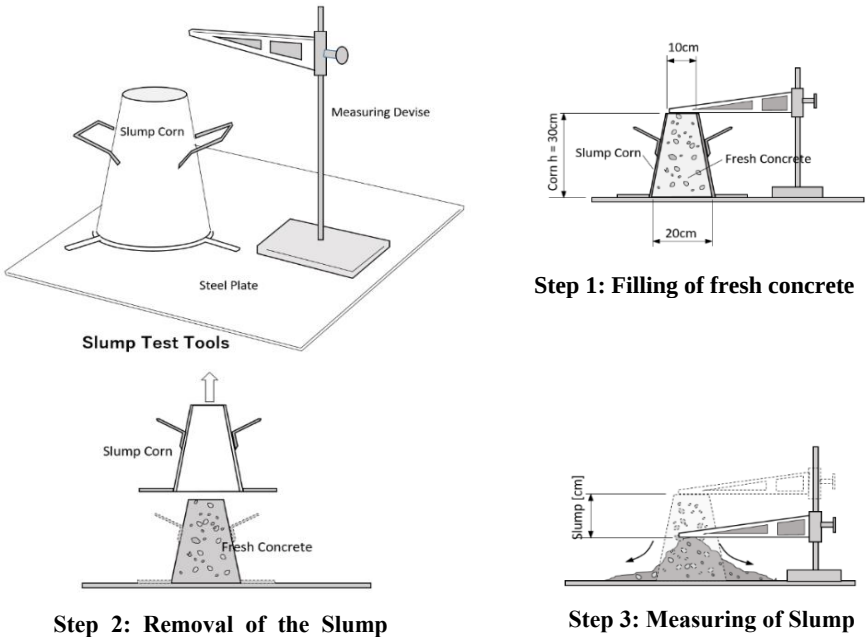


Figure 2-12 Test Devise for Concrete Slump test

✧ 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.

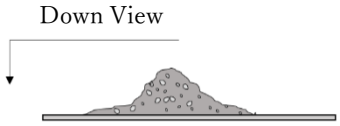


Figure 2-13 Checking Concrete flow (1)

✧ The extent of the concrete after removing of the Slump Co 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.

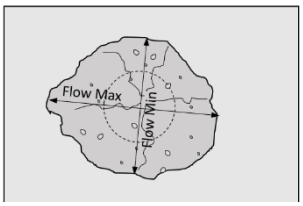


Figure 2-14 Checking Concrete flow (2)

✧ Temperature: To measure using a bar thermometer

The temperature of the Fresh Concrete shall be checked, and the temperature shall be 35℃ and less. If the concrete temperature is more than 35℃, 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.

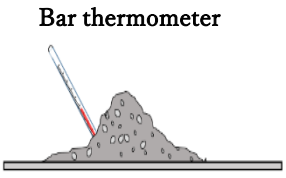


Figure 2-15 Checking concrete Temperature

[Sampling for compressive strength test]

Supplied concrete shall be sampled the planned number of crushing test pieces, which

has two type of test pieces such as cylinder type and cubic type.

Basically, 1 set of test pieces shall be three pieces for one time crushing test, and three sets of crushing test piece, for one week age, two weeks age and four weeks age, are required for 1 lots of concrete.

The volume of one lot of concrete shall be required by design documents such as design drawing, specifications and/or other rules, regulations and stipulations. Furthermore, contractors can sample the concrete more than three sets for one lot to confirm the appeared strength for removal of formwork and other checking.

Type of crushing test piece shall follow to design documents such as design drawing and/or specifications to confirm the designed strength which is designed the strength by cubic test piece and/or cylinder test piece.

[In case of Site Mixed Concrete]

The checking point shall be same as Ready Mixed concrete, and in addition, the below points shall be followed.

- ✧ Measuring method for compositions of the designed concrete such as cement, an aggregate, a fine aggregate and water, and also additive agents, if any. The measuring report shall be prepared, which is one of important confirmation points.
- ✧ Mixing proportions shall be strictly controlled, which is by volume and/or weight, especially water-cement ratio shall not be changed from mixing design.
- ✧ Measuring devise such as case, bucket and/or container shall be fixed during the construction work.

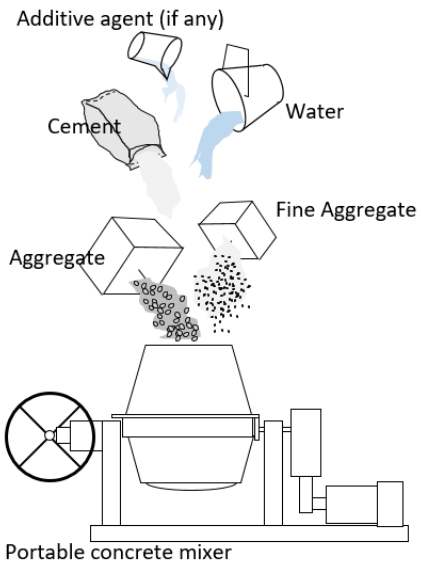


Figure 2-16 Imagine sketch "Concrete mixing"

In addition to the mixing ration, the mixing time and any other mixing conditions are very important, so that the mixing condition for concrete has to be confirmed by trial mix previously and perfectly executed as well as the condition on the trial execution.

✧ A lot of the concrete for sampling test pieces shall be one lot by one batch. Because the condition of concrete mixing has fluctuation in each batching time of concrete.

2.3.2 Working of structural body on site (Rebar work, Formwork, Concrete work)

The behavior on the site activity such as installation, arrangement, placing and any other construction shall follow to construction requirement by construction documents such as design drawing, specification and any other rules, regulation, stipulation and others. Herein important points for the Building Quality on construction work, careful points will be explained.

2.3.2.1 Rebar work (Bending, Placing and Fixing)

BNBC have stipulated on Part 6 chapter8/" Detailing of Reinforcement in Concrete Structures" concerning a rebar bending, placing and fixing. It is quite clear that constructor shall follow the designer's requirement on design documents such as drawing and/or designed specification. Herein some points on site works and the stipulation in Japan would be introduced as reference. Rebar bending and Arrangement (Placing and Fixing) shall be executed as requirement on design documents such as size and number of rebar, position of the rebar (pitch) and placed condition also.

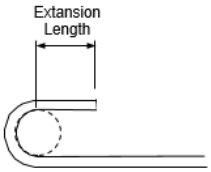
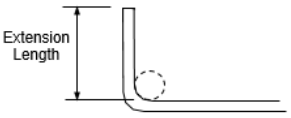
1) Bending

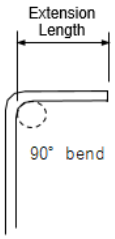
✧ Standard hook

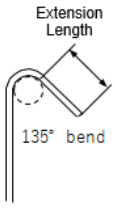
Hook angle and the extension length shall be followed to the stipulations on BNBC.

BNBC stipulations for standard hook is as Table 2-2 on the right, which is prepared following BNBC Part6-8.1.2.1

Table 2-1 Standard hook (BNBC_Part6_8.1.2.1)

	(a) 180° bend	(b) 90° bend
Sketch		
Extension Length	4 bar diameter and more, and 65mm and more	12 bar diameters and more

Sketch	(c) Stirrup and Tie anchorage (i) 16mm diameter bar/ Similar	(ii) 19mm ≦ bar diameter<25mm
	6 bar diameters and more	12 bar diameters and more

Sketch	(iii) 25mm diameter bar/ Similar	(iv) Closed tie/ Continuouse wound tie
	6 bar diameters and more	6 bar diameters and more, and 75mm more

(d) Seismic hook	
Application	**Bending Angle and Extension length**
Seimis hook such as A hook on stirrup, hoop or crosstie	135° and more angle, and 6 bar diameter, and 75mm and more
Circular hoops	90° and more angle, and 6 bar diameter, and 75mm and more, which
* The hooks that engaged the lonitudinal reinforcement and projects into the interior of the stirruo or hoop	

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

Bar Size	Minimum Diameter of Bend
10 mm ≦ d_b ≦ 25mm	$6d_b$
25mm < d_b ≦ 40mm	$8d_b$
40mm < d_b ≦ 57mm	$10d_b$

Furthermore, the minimum bending diameter in each case has been stipulated on BNBC Part6 8.2.2.2 (a), (b), (c), which shows Table 2-4 and Table 2-5.

Table 2-3 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 2-4 BNBC Part6.8.1.2.2 (b),(c)

Stipulation 0n 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	

2) Placing of rebar

Rebar has not to be bent, twist and warp to keep the correct position, so that temporary stand, supporting bar or concrete spacer shall be used as position keeper during placing of bar/before casting concrete.

The placed rebar positions have been stipulated on BNBC Part6_8.1.5

According to BNBC stipulation, Placing tolerances and Concrete cover shall be followed which is as below.

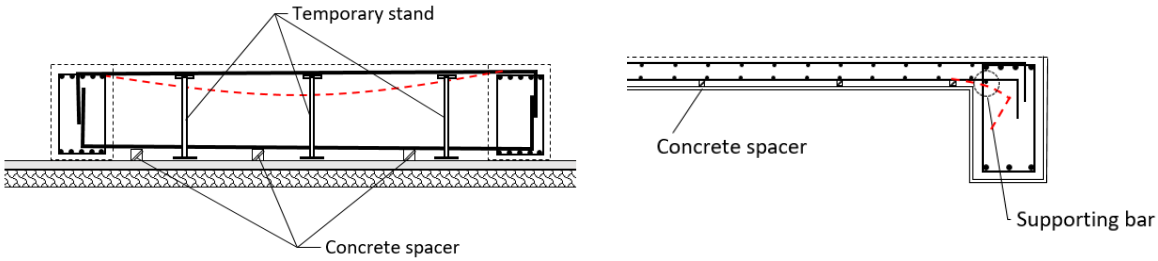


Figure 2-17 Position of rebar spacer

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 ± 50 mm, except at discontinuous ends of brackets and corbels, where tolerance shall be ± 13 mm and at discontinuous ends of other members, where tolerance shall be ±25 mm. The tolerance for concrete cover of Sec 8.1.5.2a shall also apply at discontinuous ends of members.

Table 2-5 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	±10 mm	–10 mm
$d > 200$ mm	±13 mm	–13 mm

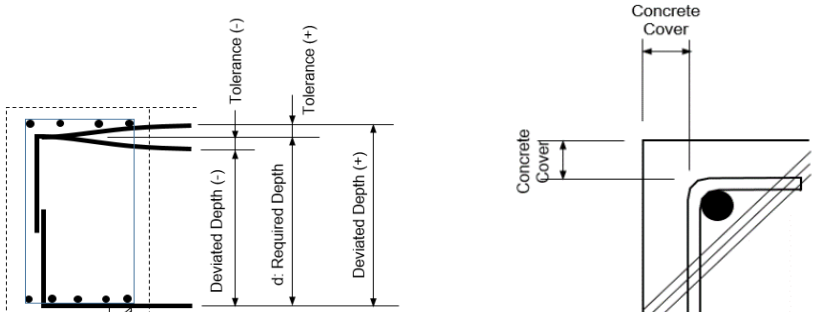


Figure 2-18 Reference Sketch for BNBC Part 6 Table 6.8.2

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.

Furthermore, concrete covers shall be suitable thickness to protect rebar rusting, which is stipulated on BNBC 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 2-6 Concrete covering size on Rebar (BNBC_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/mm²						
		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 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
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		0.5	0.5	0.5	0.45	0.45	0.40	0.40
Minimum cement content, (kg/m³)		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

In Japan, the concrete cover size has been stipulated as minimum values, which table would be shown as reference, and the below table is quoted from JASS 5 of Japanese stipulation.

Table 2-7 Concrete covering size on Rebar (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 concent of supervisor according to the required qyality and cpnstruction method
* In the case of light weight concrete, the value shall be added 10mm

*JASS 5 means Japan Architectural Standard Specification part 5

3) Fixation of rebar (References of Placing rebar-1)

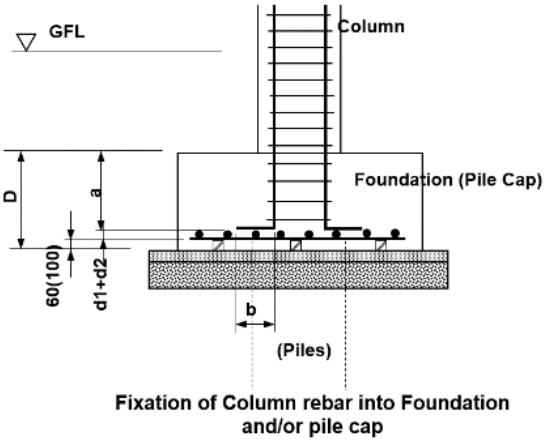
Each rebar has to be fixed in each other according to the structural design model.

*Each sketch shows a range of fixable

✧ 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 walkability for rebar placing.

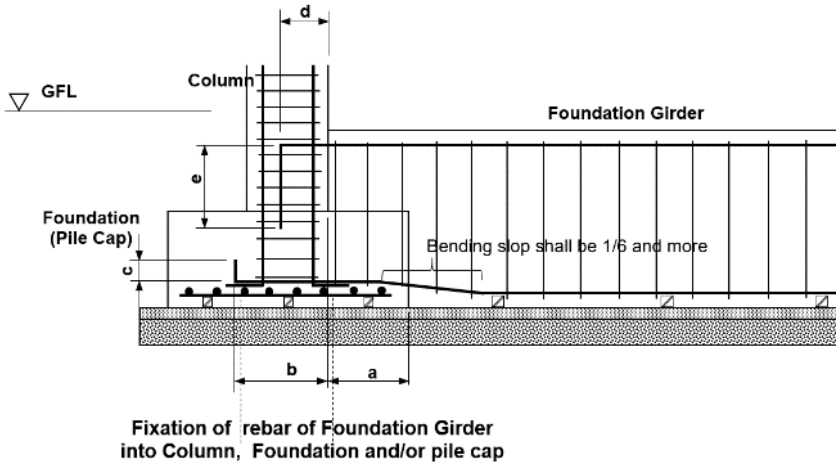


D: Depth of Foundation and/or Pile cap
d1: Diameter of main rebar at bottom of Foundation and/or Pile cap
d2: Diameter of distribution bar at bottom of Foundastion and/or Pile cap

Figure 2-19 Foot of column bar

✧ Rebar of Foundation Girder into Column, Foundation and/or Fixation length

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 : Hoizontal length of Rebar Fixation from column surface
e : Hook length

Figure 2-20 Anchoring Length in Foundation

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

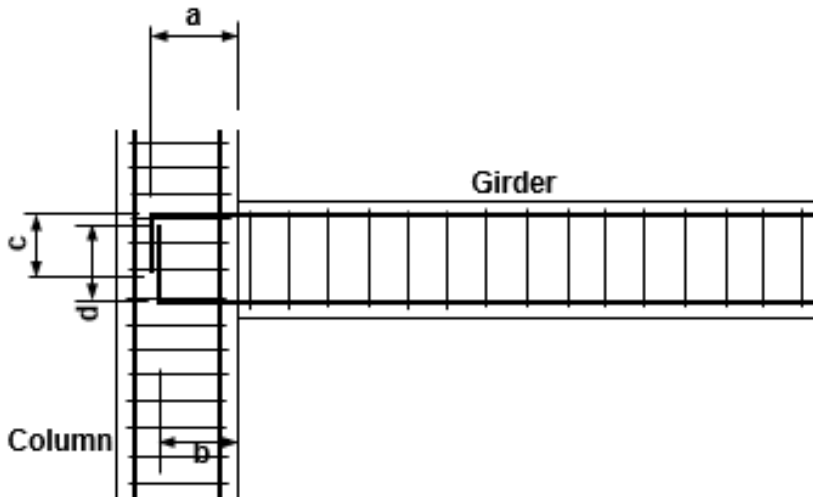


Figure 2-21 Anchoring length/ Girder Main bar

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

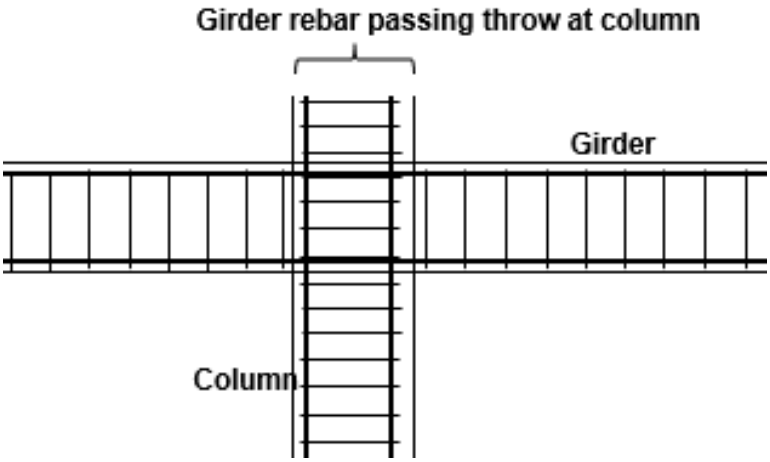


Figure 2-22 Girder Main Bar at panel zone of Column

✧ Sub-beam Rebar into Girder: Fixation length=a + c, and/or b + d

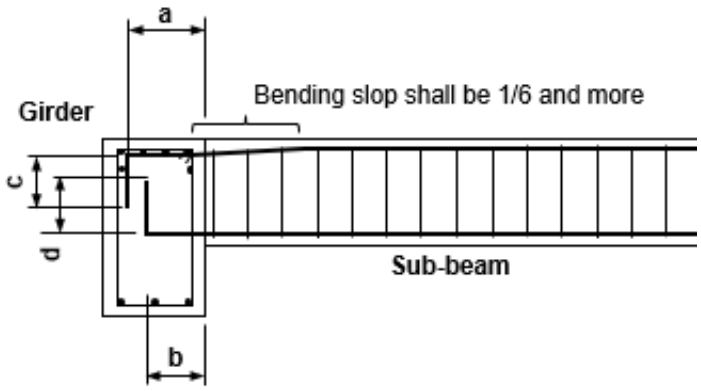


Figure 2-23 Anchoring of Sub-beam main bar into Girder

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

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

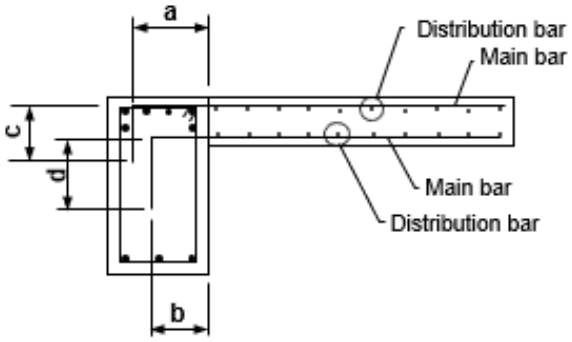


Figure 2-24 Anchoring of Main bar of Cantilever Slab

✧ In the case of both side fixed slab:

Fixation length at left side= a + c or b + d, at right side= e + g or f + h

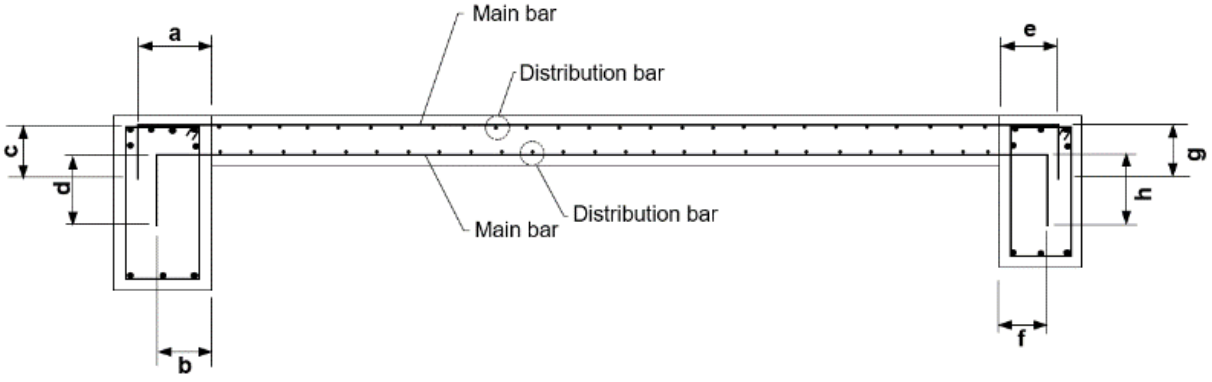


Figure 2-25 Anchoring of Slab Main bar (Both side fixed)

4) Careful point of arrangement for Hoop and/or Stirrup

(References of Placing rebar-2)

✧ First position of stirrup

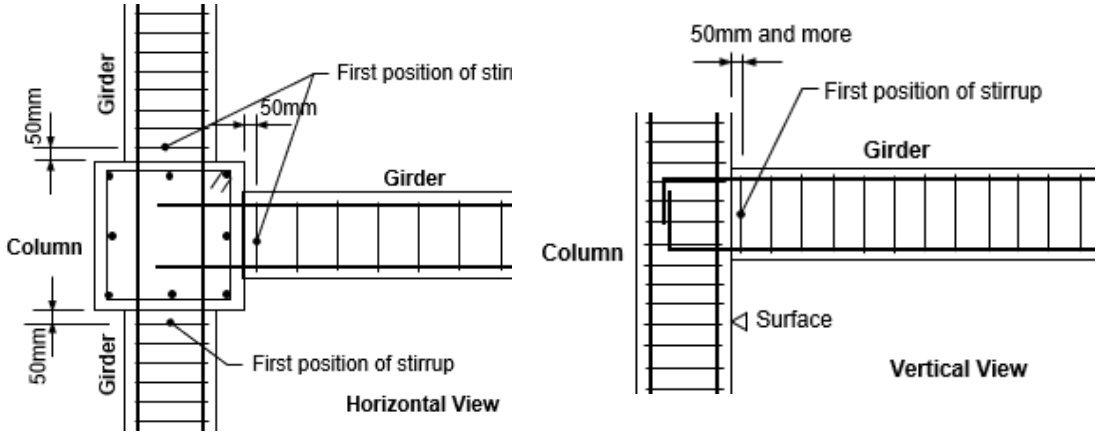


Figure 2-26 First position of Stirrup (From Column)

✧ First position of Hoop

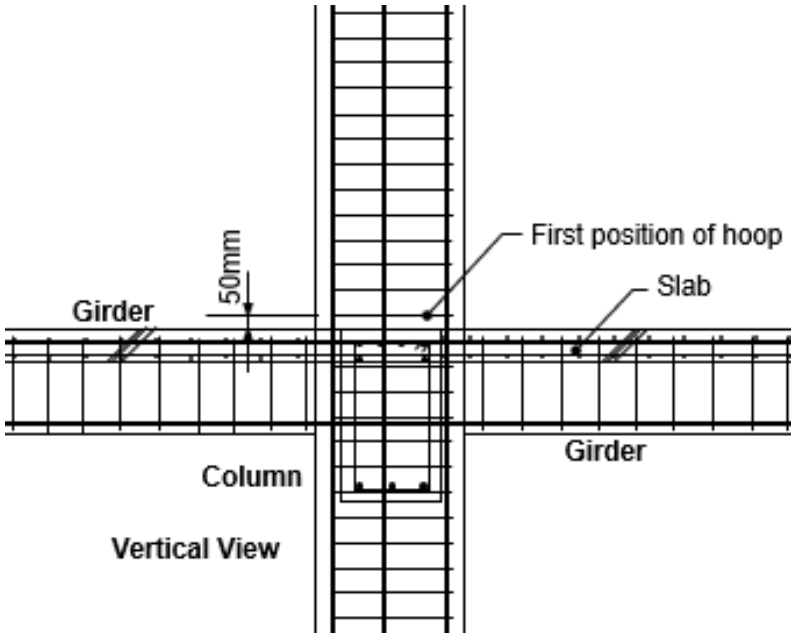


Figure 2-27 First position Stirrup (Above of Slab)

✧ Fixing condition of Hoop and Stirrup

Hoop and Stirrup has to be set in plumb and/or horizon, and stirrup has to be also set in right angle toward the direction.

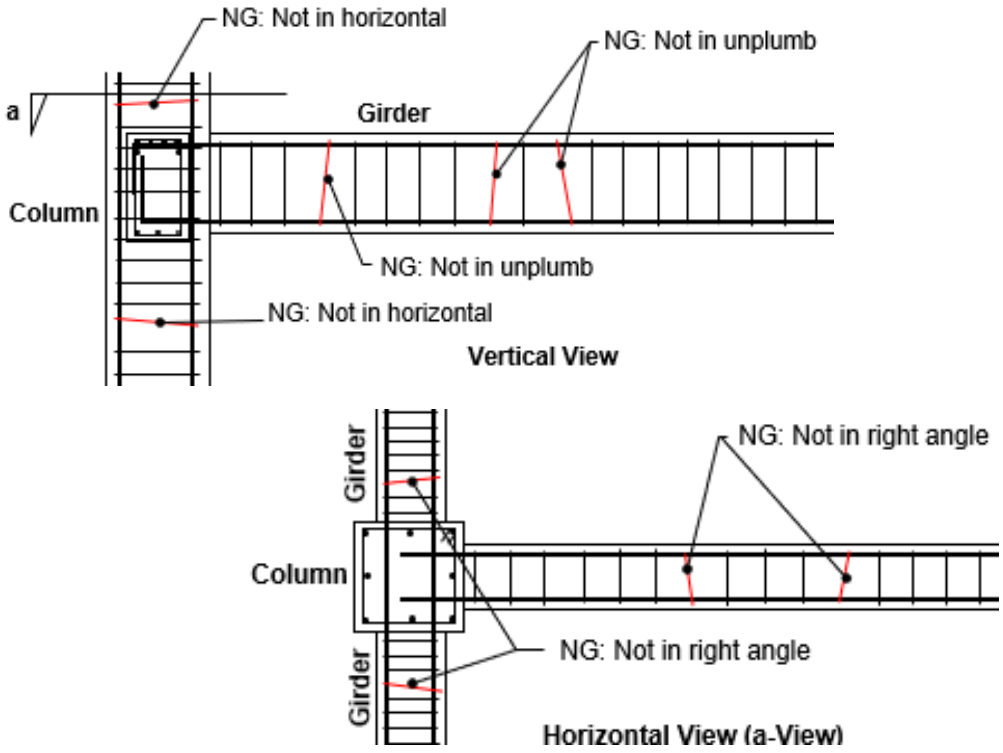


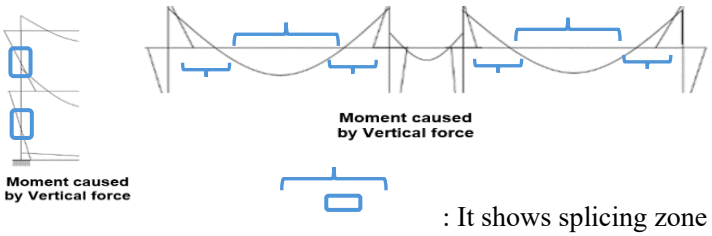
Figure 2-28 Condition of Stirrup/ Hoop arrangement

5) Splicing Rebar (Reference for Placing rebar-3)

✧ Splicing area

When Main rebar of Column, Girder and/or Beam will be spliced, the splicing position has to be in small stress area. Because Building frame has borne compressive and tensile stresses in part by part.

Refer to 2.2.1.1 “Stress on the Building structure”



: It shows splicing zone

Figure 2-29 Small stress area

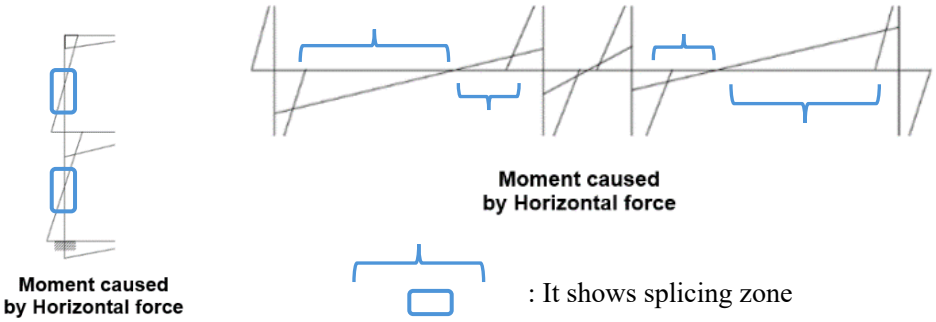


Figure 2-30 Small stress area

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 has to bear maximum stress, therefore, the splicing position has to be in middle part.

- Girder and Beam

In both cases, the condition of moment is as a sketch on above, so that the stress which appears on the Girder and Beam is compressive and tensile stresses at part by part.

Herein, for reference, the splicing area has to be positioned as the sketch below. It is depended on JASS 5 from Japan

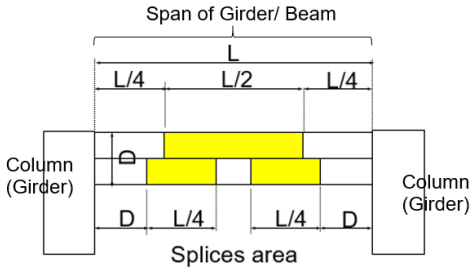


Figure 2-31 Splicing area of Girder Main bar (Quoting from JASS 5)

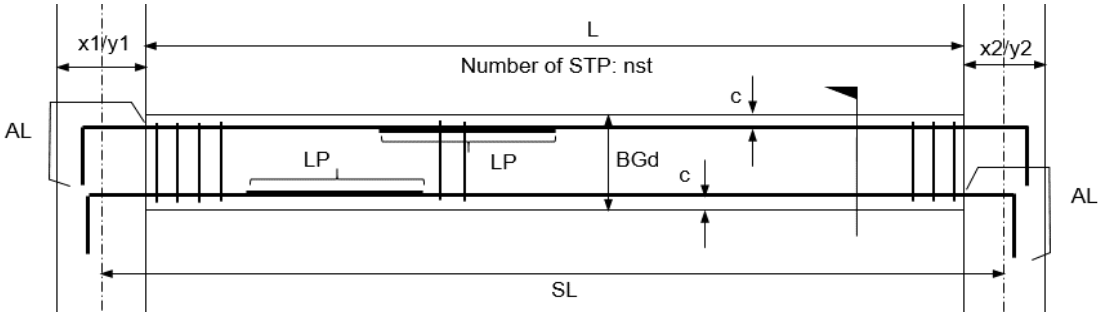


Figure 2-32 Arrangement of Girder Main bar (Sample of rebar arrangement)

*JASS 5 means Japan Architectural Standard Specification part 5

✧ Splicing length

A stress on one rebar is 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 below.

For Tension

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

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

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

$$K_{tr} = \frac{40A_{tr}}{sn} \qquad (6.8.2)$$

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:

(a) 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, $\psi_t = 1.0$.

(b) 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.

(c) For 19 mm diameter and smaller bars, and deformed wires, $\psi_s = 0.8$. For 20 mm diameter and larger bars, $\psi_s = 1.0$.

(d) Where lightweight concrete is used, λ 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 $\left[\frac{A_{s\,required}}{A_{s\,provided}}\right]$ 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 $\frac{0.24 f_y d_b}{\lambda \sqrt{f_c'}}$ and $0.043 f_y d_b$ with λ as given in Sec 8.2.3.4(d) and the constant 0.043 carries the unit of mm²/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:	$\left[\frac{A_{s\ required}}{A_{s\ provided}}\right]$
(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

The above is the BNBC regulations regarding lap joints, but there are other related items as well, some of which are listed below.

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 ψ_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 ψ_e taken as 1.2 for epoxy-coated reinforcement, and λ taken as 0.75 for lightweight concrete. For other cases, ψ_e and λ 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 — $\left[\frac{A_{s\,required}}{A_{s\,provided}}\right]$

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.

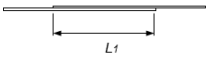
8.2.6.5 Hooks shall not be considered effective in developing bars in compression.

The required length of lap joints is within the scope of what the designer decides based on these BNBC regulations. Basically, it is necessary to follow the requirements of the design documents, and if the required joint length is not specified in the design drawings, the designer must confirm it directly.

Herein, the Japanese stipulation would be shown for the reference, which has been quoted from JASS 5 (JASS 5 means Japan Architectural Standard Specification part 5)

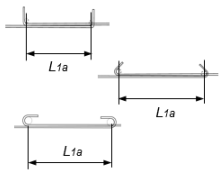
Table 2-8 Splicing Length (Quoted from JASS 5 Table 10.7: Splicing

Splicing length of streght bar L_1

Concrete Design Strength F_c (N/mm2)	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	

General usage

Splicing length of streght bar L_{1a}

Concrete Design Strength F_c (N/mm2)	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	

General usage

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 bendng 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 whict strength is Fc<=36N/mm2 and deformed bar excluding SD490.

In short, the splicing has to be at small tensile area, furthermore, before installing of rebar, it has to be cleaned up the rust, oil, muddy and any other dirty.

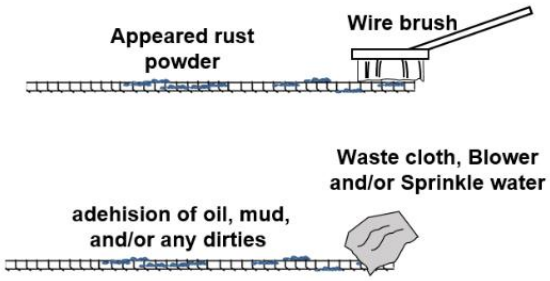


Figure 2-33 Removal of Rust on the rebar

BNBC has stipulated clearly for the above as well. Refer to the 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.

2.3.2.2 Form-work (including shoring system)

Formwork is extremely important in determining the shape of a building, and the strength and quality of formwork directly affect the quality of the building.

Furthermore, since formwork is formed using shoring, the formwork and shoring must be designed with a shape and strength appropriate for each part, such as columns, beams, and other components. While this is generally planned by the contractor, RAJUK inspectors also need to be aware of the basics.

Below is an explanation of formwork and shoring.

1) Shoring system

Shoring system is required to construct the Building frame such as column, Girder/Beam, and slab, which shall plan suitably, and there are several kinds of shoring system as below. And then the most important point is to have sufficient strength for dead load, live load such as workers and equipment and any impact during concrete casting, such as casting,

tamping/ vibrating and others.

[Using pipe support]

The figure below shows an example of support using pipe supports.

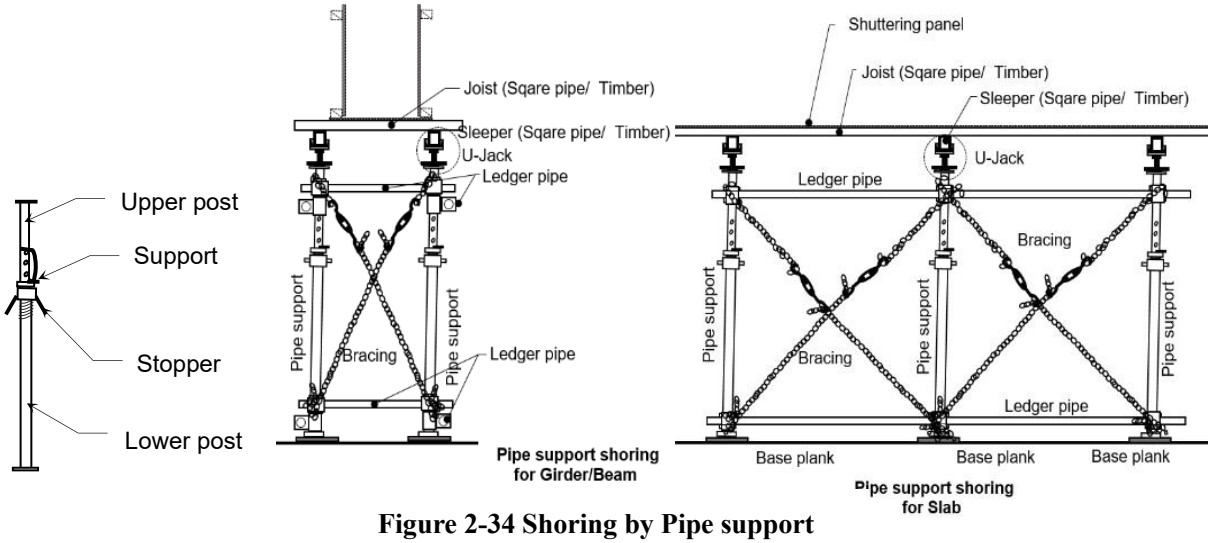


Figure 2-34 Shoring by Pipe support

- ✧ **Pipe support:** It shall be installed in each 900mm~1000mm (depending on the loads to be born), and it shall be set in plumb.
- ✧ **Base plank:** The thickness is approximately 25mm, which shall be set in each pipe support line.
- ✧ **U-Jack:** It shall be set in each pipe support 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):** Joist shall be installed in each 300mm~600mm, 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.
- ✧ **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.

[References] Allowable Bearing Power of Pipe support: Usually, it is approximately 2000 kg, which depends on the material, the left sketch shows normal type of the pipe support in Japan, and that the cross-sectional performance is showing on below table.

Table 2-9 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 [cm2]	12.40	12.18
Geometical moment of inertia [cm4]	71.30	187.10
Section modulas [cm3]	17.26	32.75
Radius of gyration of area [cm]	2.44	3.92

[Using 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

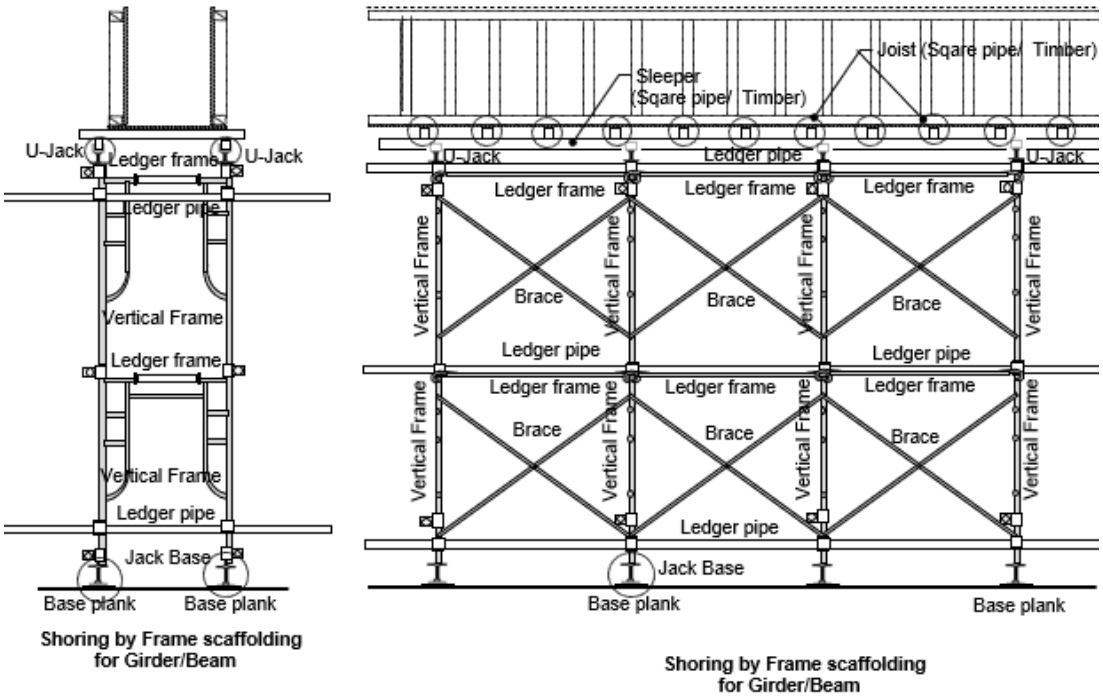


Figure 2-35 Shoring by Frame scaffolding (1)

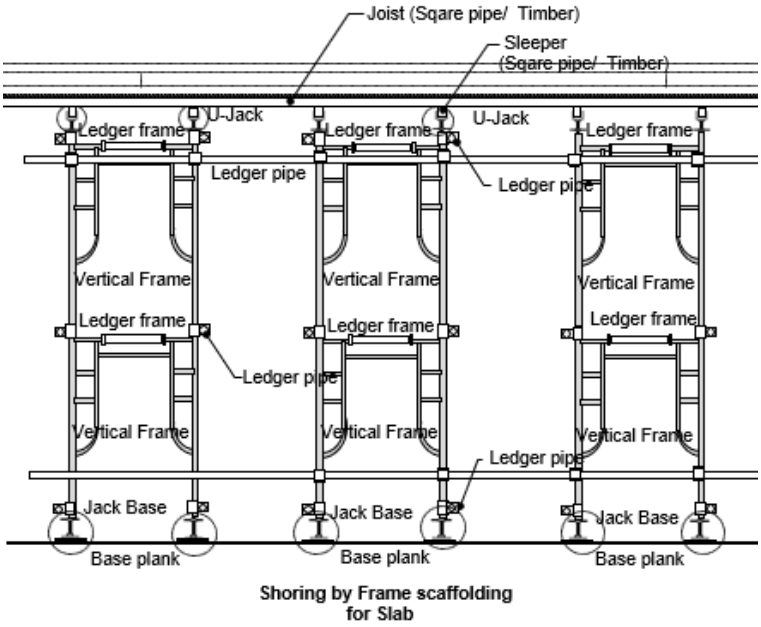


Figure 2-36 Shoring by Frame scaffolding (2)

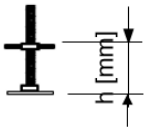
Furthermore, frame scaffolding consists of a vertical frame with jack base (for the q lower position), ledger frame, joint pins and braces (on both sides). This means that frame scaffolding can avoid collapse and other accidents with properly assembling of all parts. It is important that the scaffolding is properly assembled in this way to use effectively as a Support-system.

[References] 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 2-10 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

2) Shuttering Panel

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

Therefore, shuttering panel has composed the case for casting concrete together with the other reinforcing parts.

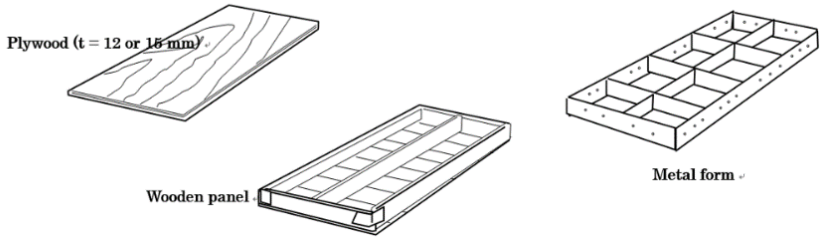


Figure 2-37 Kinds of shuttering panel

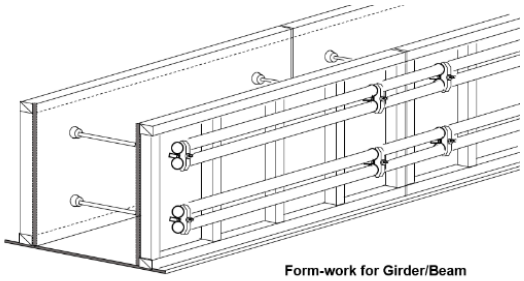


Figure 2-38 Formwork for Girder/Beam

✧ Composition of Formwork

The sketch on the below shows the composition of 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.

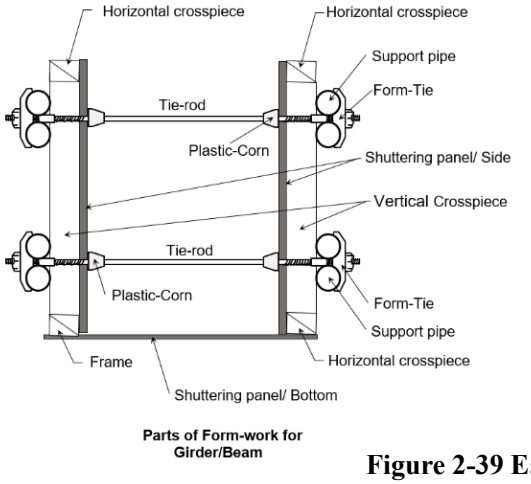
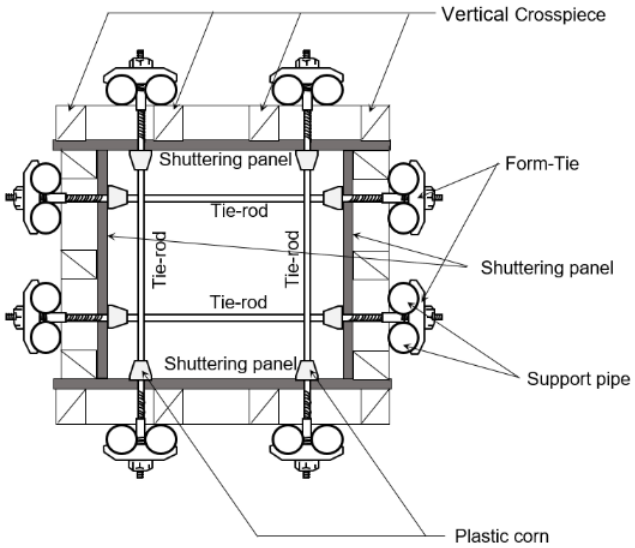
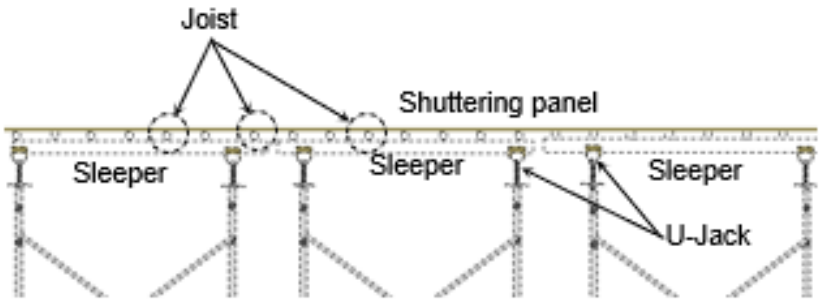


Figure 2-39 Each Parts for Girder formwork



Parts of Form-work for Column

Figure 2-40 Each Parts for Column formwork



Parts of Form-work for Slab

Figure 2-41 Slab form-work

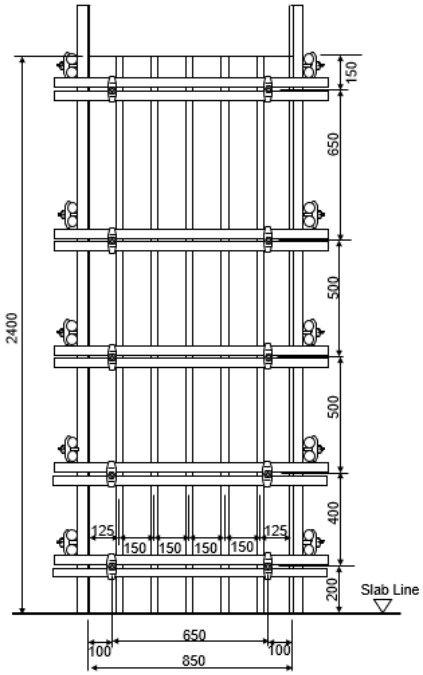
✧ Strength of formwork

Form-work is a mold for concrete, which has been formed by shuttering panels. 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, if necessary.

Basically, Form work has to 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.

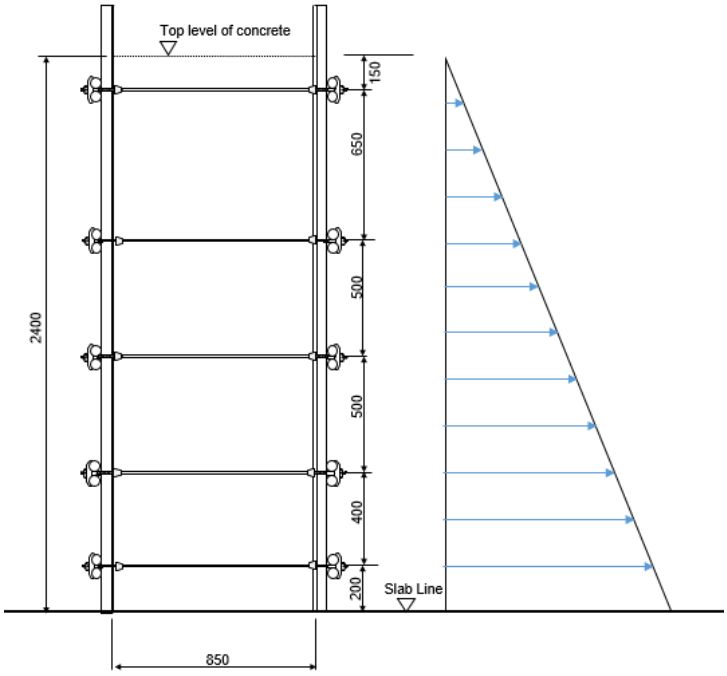
The surface of Column shuttering panel or side shuttering panel of Girder and Beam have been affected by the cast concrete, and that tie-rod are as well. Therefore, the shuttering panel and tie-rod has to be confirmed safely against the concrete pressure by calculation. In the case of no tie-rod, shuttering panel and arranged supporting material shall be checked by calculation as well.

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



Form-work for Column
Column size: 850 x 850

Figure 2-42 Column form-work



Concrete pressure on
Column form-work

Figure 2-43 Side pressure on shuttering panel

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

Table 2-11 Allowable stress on shuttering materials (Quoting from JIS)

Material Performance

Kinds /Shape		Section Modulus *Z* (x10^3mm3)	Geometrical Moment of Inertia *I* (x10^4m4)	Allowable Bending Unit Stress f_b (N/mm2)	Modulus of Direct Elasticity *E* (kN/mm2)	Remark
Shuttring 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
Spport pipe	Φ48.6 t=2.4mm	3.83	9.32	156.9	206	Horizontal direction
Tie-rod	Φ7, Carbon steel rod	Allowable Tension: 14kN/piece				

* 1): Unit wide is 1mm

[Calculation of Side Pressure]

For lowest tie-rod

Concrete pressure: P [kN/m], Bulk density of Concrete: W0 [kN/m3], Height of cast concrete: H [m]

P=W0 x H

In the case of "W0 =23.5 [kN/m3], P = 23.5 x 2.2 = 51.7 [kN/m2]

[Allowable deformation]

To assume that diameter of a tie-rod is 7mm and the allowable tension is 14kN/piece.

Cover area A is;

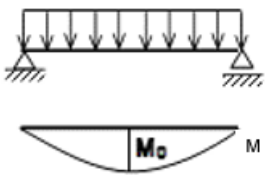
A = 14 [kN]/51.7 [kN/m2] = 0.271m2/Piece

As both sides set two tie-rods in each layer; The supporting area 2A = 0.271 x 2 = 0.542m2

The column wide is 0.85m in each side, so that setting pitch of the tie-rod is;

The pitch = 0.542/0.85 = 0.64 m → 0.6m

However, the pitch shall be less than 0.6m as safety considering the condition of the crosspieces.



$$M_0 = \frac{W*l^2}{8}$$

Figure 2-44 Bending moment (simple beam)

[Checking the shuttering panel]

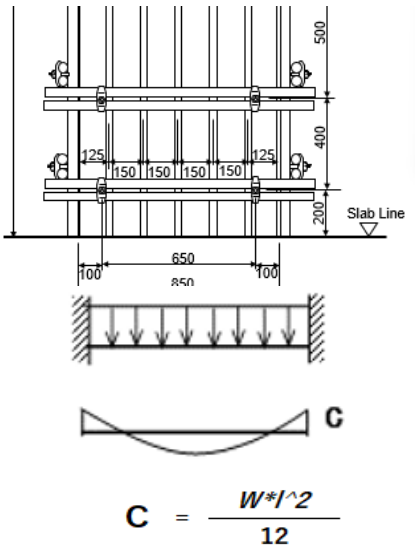
The shuttering panel is supported by crosspiece, therefore the support condition assumed intermediate of simple beam support and both sides rigid point.

Bending Stress σ [N/m] =M/Z =wl ^2/ (12 x Z)

= (51.7)x10^-3x(200)^2/ (12x24)=7.2N/m2 <7.8N/m2 →OK

Flexure δ[mm]=wl^4/ (128xEI)

= (51.7) x10^-3x (200) ^4/ (128x3.5x10^3*144) = 1.28mm



$$C = \frac{W*l^2}{12}$$

Figure 2-45 Bending moment (Fixed Beam)

[Checking Crosspiece]

Pressure per Unit length on Crosspiece w [N/mm]

w = (51.7) x10^-3 x 150 = 7.76N/mm,

Pitch of Support pipe = 400

Bending Stress σ [N/m] =M/Z =wl ^2/(12 x Z)

=7.76 x (400) ^2 / (12 x 10400) = 9.95 N/m2 < 10.3 N/m2→OK

Flexure δ[mm] =wl^4/ (128xEI)

= 7.76 x (400) ^4/ (128 x 6.9 x 10^3 x 26 x 10^4)

= 0.87mm

[Checking Support pipe]

The stress effect as uniformly distributed load,

w = 51.7 x10^-3 [N/mm2] x 400 mm = 20.7 N/m

The distance of both tie-rods is 650mm, and it is borne by 2 support pipes

Bending Stress σ [N/m] =M/Z =wl ^2/12x1/Z

= 20.7 x (650) ^2/ (12 x 3.83 x 10 ^3 x 2) = 95.1 N/m2 < 156.9 N/m2 →OK

***Flexure δ[mm]* =wl^4/128xEI**

= 20.7 x (650) ^4 / 128 x 206 x 10 ^3 x 9.32 x 10 ^4 x 2)= 0.75mm

[Checking Tightening Material]

Load P effected on a tie-rod,

P = 51.7 x 10^-3 N/mm2 x 400 mm x 850mm x 1/2 =8790N

=8.79 kN < 14 kN → OK

Effective sectional area (S) of tie-rod (Φ7mm) is 34mm2,

In the case of Column width (B) is 850mm, the Flexure is using a half of the width,

Flexure δ[mm] = 1/2 x B x P/ (S x E)

= 1/2 x 850 x 8.79/ (34 x 206) = 0.53 [mm]

Therefore,

Total Flexure ∑δ=1.28 + 0.87 + 0.75 + 0.53 = 3.43 mm < 5mm

However, in actual working on site, the casting height is higher at some time, therefore, the crosspiece shall be supported more using GI pipe and/or Pipe support.

- **Reference calculation 2 [Girder/Beam form-work]**

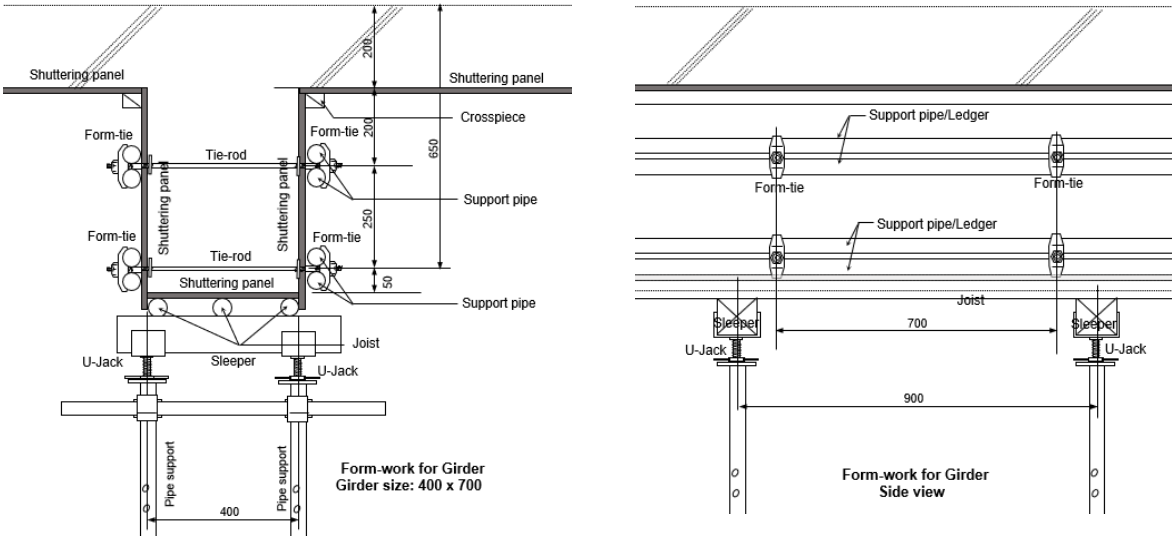


Figure 2-46 Sample for Beam-formwork

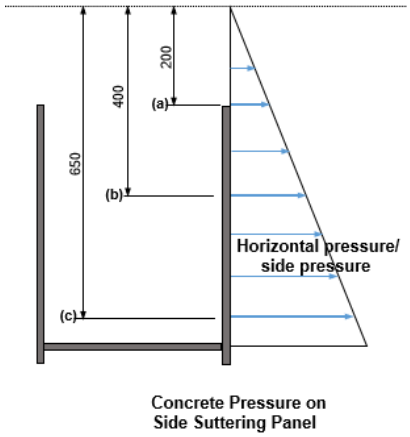
The material performance of Girder/ Beam form-work for reference calculation is shown below the table

Table 2-12 Cross Sectional Performance (Quoting from JIS)

Material Performance

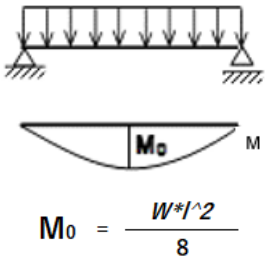
Kinds /Shape		Section Modulus	Geometrical	Allowable Bending	Modulus of Direct	Remark
Shuttring panel	Plywood, t=12mm	0.024 *1)	0.0144 *1)	7.8	3.5	Long side use on Vertical
Support pipe	Φ48.6 t=2.4mm	3.83	9.32	156.9	206	Horizontal direction
Joist	Φ48.6 t=2.4mm	3.83	9.32	156.9	206	2 pieces usage
Sleeper	Timber 100x100mm	167	833	10.3	6.86	
Shoring	Pipe Support	Allowable Bearing Capacity: 14.7 kN/piece (1500 kg/piece)				
Tie-rod	Φ7, Carbon steel rod	Allowable Tension: 14kN/piece (1400kg/piece)				

* 1): Unit wide is 1mm



Concrete Pressure on
Side Suttering Panel

Figure 2-47 Side pressure



$$M_0 = \frac{W*l^2}{8}$$

Figure 2-48 Bending moment (simple beam)

[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 x 0.20 = 4.70 kN/m2

Side pressure (Pb): 23.5 x 0.40 = 9.40 kN/m2

Side pressure (Pc): 23.5 x 0.65 = 15.3 kN/m2

[Checking the shuttering panel]

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

P = 15.3 kN/m2

And the load at the panel in each 1mm,

w = 15.3 x 10 ^-3 mm

Bending Stress σ [N/m] =M/Z =wl ^2/ (8 x Z)

=15.3 x 10 ^-3 x 250 ^2/ (8 x 24)

= 4.98 N/mm2 < 7.8 N/mm2 → OK

Flexure δ[mm] =5 x wl^4 / (384xEI)

=5 x 15.3 x 10 ^-3 x 250 ^4/ (384 x 3.5 x 10 ^3 x 144)

=1.54mm

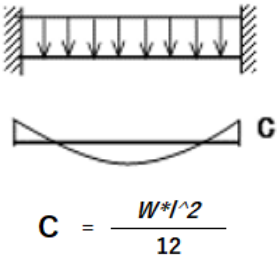


Figure 2-49
Bending moment
(Fixed Beam)

[Checking Support pipe]

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

w = 15.3 kN/m2 x 0.175m = 2.68 kN/m→2.68 N/mm

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

Bending Stress σ [N/m] =M/Z =wl ^2/ (12 x Z)

= 2.68 x 700 ^2 / (12 x 3.83 x 10 ^3 x 2)

= 14.3 N/mm2 < 156.9 N/mm2 → OK

Flexure δ[mm] =wl^4 / (128xEI)

= 2.68 x 700 ^4 / (128 x 206 x 10 ^3 x 9.32 x 10^4 x 2)

= 0.13mm

[Checking Tightening Material]

The load affected the tie-rod (P),

P = 2.68 N/mm x 700 mm = 1880 N

= 1.88 kN< 13.73 kN→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,

Flexure δ[mm] = 1/2 x B x P/ (S x E)

= 400 x 0.5 x 1880 / (34 x 206 x 10 ^3) = 0.05mm

Therefore,

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

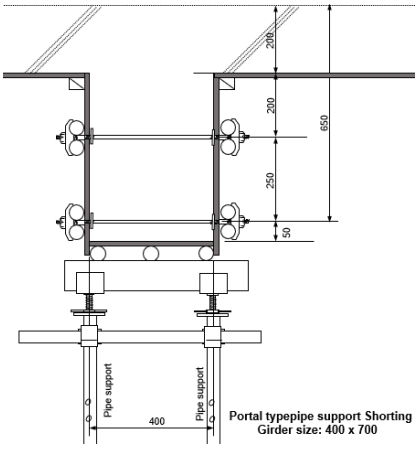


Figure 2-50 Beam formwork

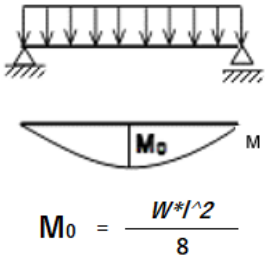


Figure 2-51 Bending moment (simple beam)

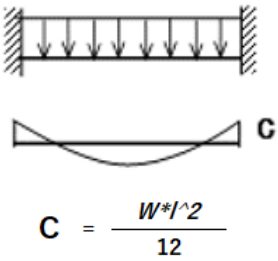


Figure 2-52 Bending moment (Fixed Beam)

[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/m3), however, herein it will be ignored

Vertical Loads = Dead Load (23.5 kN/m3 x 0.7m + 0.4 kN/m2) + Live Load (1.5 kN/m2) = 18.35 kN/m2

[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 kN/m2 → 1.84 x 10 ^-2 N/mm2

Therefore,

Bending Stress σ [N/m] =M/Z =wl ^2/ (8 x Z)

= 1.84 x 10 ^-2 x 200 ^2 / (8 x 24) = 3.83 N/mm2

< 7.8 N/mm2→ OK

Flexure δ[mm] =5 x wl^4 / (384xEI)

= 5 x 1.84 x 10 ^-2 x 200 ^4 / (384 x 3.5 x 10 ^3 x 144)

= 0.76mm

[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 kN/m2 x 0.2 m (Joist pitch) = 3.67 kN/m

→ 3.67 N/mm

Therefore,

Bending Stress σ [N/m] =M/Z =wl ^2/ (12 x Z)

=3.67 x 900 ^2 / (12 x 3.83 x 10 ^3) = 64.7 N/mm2 < 156.9 N/mm2 → OK

Flexure δ[mm] =wl^4 / (128xEI)

= 3.67 x 900 ^4 / (128 x 206 x 10 ^3 x 9.32 x 10 ^4)

= 0.98 mm

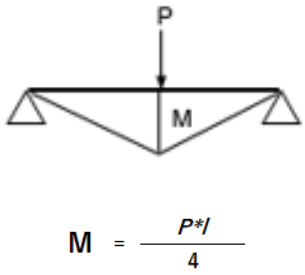


Figure 2-53
Moment of Concentrated load on the both side hinge Beam

[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 kN/m2 x 0.9m (Sleeper pitch) = 16.52 kN/m

→ 16.52 x N/mm

And the ***total loads p***=16.52 N/mm x 400mm =6.52 x 10 ^3 N

Half of the total loads are borne at both edge positions, 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 a half of total load at the center position.

P = p*1/2 = 6.52/2 =3.3 x 10^3

Bending Stress σ [N/m] =M/Z =pl / (4 x Z)

= 3.3 x 10 ^3 / (4 x 167 x 10 ^3) =0.005 N/mm

< 10.3 N/mm→ OK

F***lexure δ[mm] =pl^3 / (48xEI)***

= 3.3 x 10 ^3 x 400 ^3/ (48 x 6.86 x 10^3 x 833 x 10 ^4)

= 0.077mm

It can be ignored. Basically, Pipe support shall be fixed by connection pipe as portal type.

2.3.2.3 Concrete work (Transportation, Casting and Curing)

Concrete work on site has three steps such as “Transportation”, “Casting” and “Curing”.
Herein the important/ Careful point in each step will be explained as follows;

1) Transportation

✧ Transfer time from Concrete Plant to Construction Site

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.

In Japan, it has been stipulated as below.
T: Temperature, TL: Time limit from mixing to completion of pouring concrete.
T < 25 ℃ → TL=120 minutes, T=> 25℃ → TL=90 minutes
(Quoted from JASS 5 as reference)

It is an impact to that the concrete slump would be going down, the concrete temperature would be going to high and an air volume would be losing, according to passing of a time after mixing of concrete.
As result of the above, it will lead the concrete quality to worth such as a fault of pouring of concrete and/or losing of durability performance.
Especially, in the case of using ready mixed concrete, the below points has to be checked when the concrete plant is selected.

- The location of the concrete plant such as distance from construction site
- Concrete time such as morning time, daytime, and/or nighttime.
- Traffic condition on the route from Concrete plant to the site.
- Method of pouring concrete on site, some of which are using concrete pump, concrete bucket with Crane and/or wheelbarrow.

2) Casting Concrete

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

a) Conveying concrete to casting position

[Conveying concrete by Concrete pump]

✧ Concrete pumps have to be used considering the following points;

To avoid mixing any contaminants such as water including rainwater, mad and others. Especially in the rain, the concrete bucket on the pump shall be covered by vinyl sheet and others to avoid streaming rainwater into the concrete.

Furthermore, Cement-water ratio is very sensitive for the concrete quality, therefore it shall not allow to add a water into delivered concrete and mix.

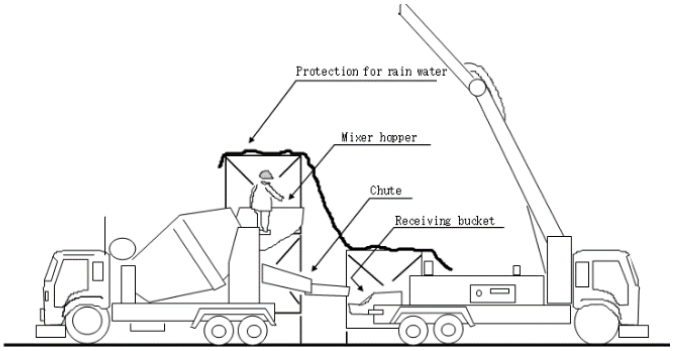


Figure 2-54 Protection concrete bucket

- ✧ To transfer continuously to avoid a gap in the conveying hose, therefore, the concrete shall be transferred slowly without a downtime.
- ✧ The tip of conveying hose has not to be lifted up during transfer of concrete to avoid separation of concrete and make a gap into the conveying hose. And the concrete shall not drop down from above, but shall transfer through conveying hose laying down on the casting position slowly

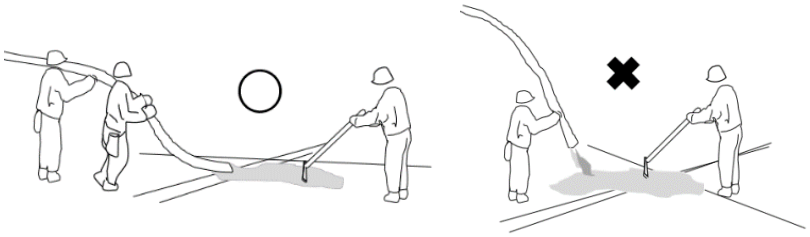


Figure 2-55 Handling of concrete hose

[Carrying concrete by Crane with Bucket]

Basically, the careful point for the execution is same as the above, in addition, the bucket shall be cleaned before concrete casting.

[Carrying concrete by Wheelbarrow]

When the volume of the casting concrete is small and casting 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.

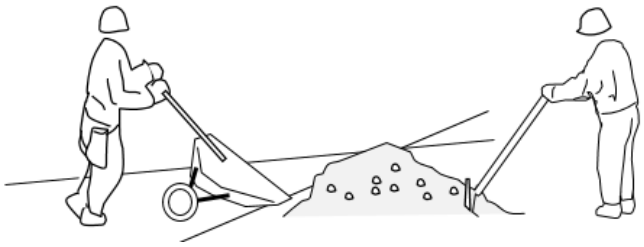


Figure 2-56 Carrying Concrete by wheel

b) Casting concrete

[To make a rigid condition of concrete]

When the concrete has been cast on site, some air would be mixed as a bubble, therefore the bubbles shall be taken away compaction the concrete to make a rigid condition. Refer to the sketch below.

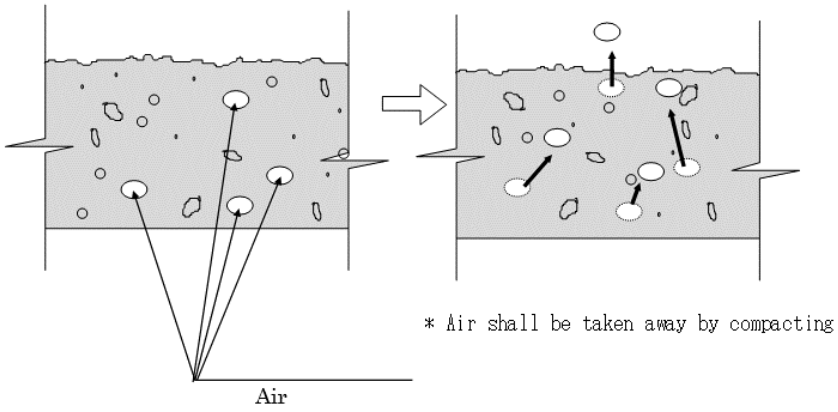


Figure 2-57 Imaging sketch for air bubbles

[To make a pure condition of concrete]

In addition, the above, concrete shall be cast as pure condition, so that mixed impurities shall be taken away as much as possible. 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”.

Therefore, it is reasonable to use vibrator during concrete for acceleration of removal of impurities. Refer to the sketch below.

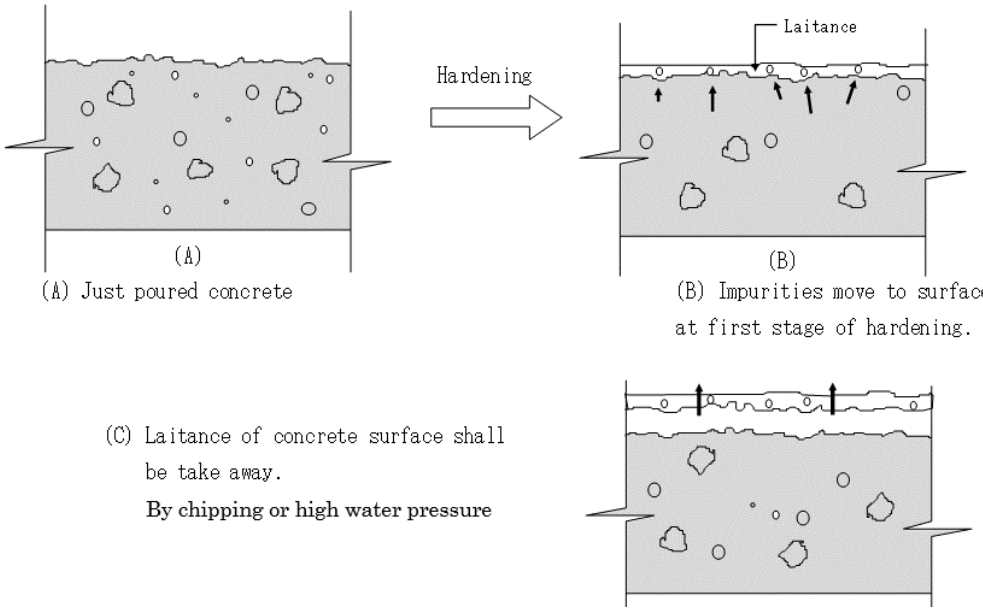


Figure 2-58 Imaging sketch for Laitance

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

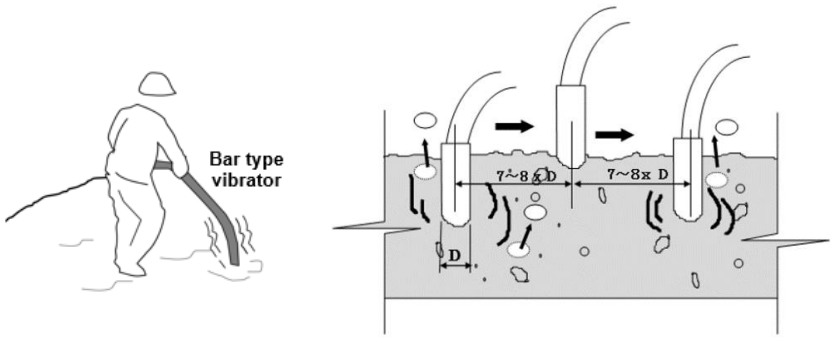


Figure 2-59 Imaging sketch for using bar vibrator

In case of bamboo stick, the sticking location into the concrete shall be uniformly as below sketch.

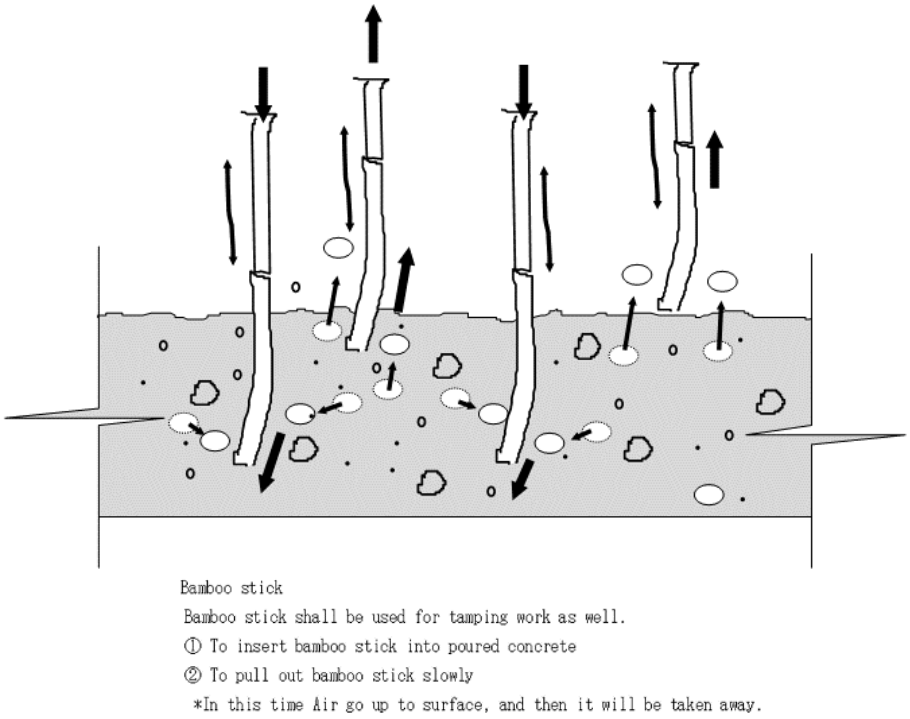


Figure 2-60 Imaging sketch for using Bamboo stick

c) Curing for the cast concrete

The cast concrete will harden slowly, and it has not enough strength as initial stage on the hardening, so that it has not to be given any impact at the initial curing to get an expected strength as planned.

[Removal of shuttering panels]

The curing term (Retention period) for removal of shuttering panel and the shoring has to be followed to BNBC and/or any other stipulation.

Table 2-13 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

[Curing method]

Cast concrete shall be suitably cured for quality. It is very important that the cast concrete shall be not inflicted before its hardening, in addition, the hardening of concrete shall be controlled curing avoiding the sudden drying off to protect making a crack, which is caused by strong wind and/or hard sunshine.

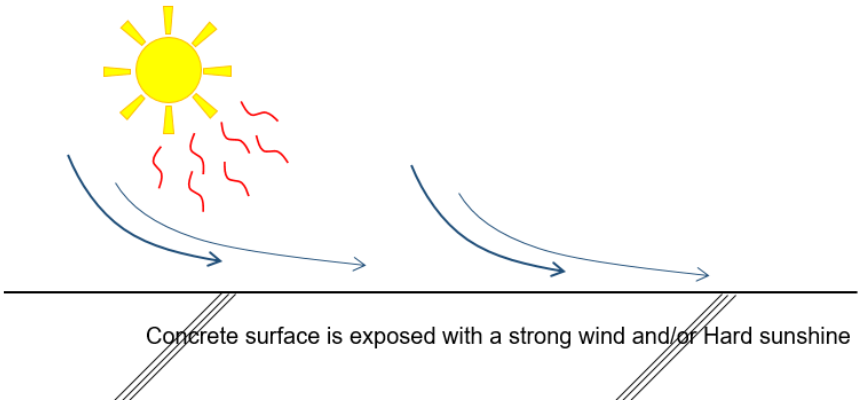


Figure 2-61 Imaging sketch for quick drying off Strong sunshine and/or wind

As result of Strong wind and/or hard sunshine, shrinkage crack will appear at the surface.

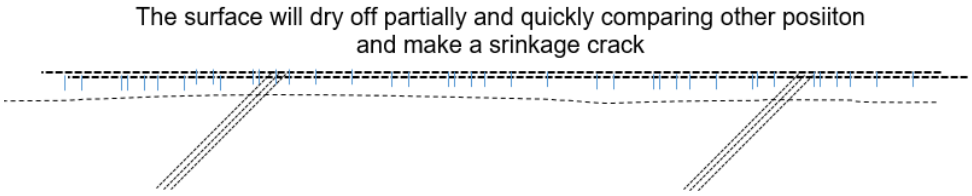


Figure 2-62 Imaging sketch for making cruck at the surface

- ✧ Countermeasure against strong wind: the concrete surface shall be covered by plastic sheet and/or another shed.
- ✧ Countermeasure against hard sunshine: the surface of concrete shall be kept in a wet condition using wet jute and sprinkling water.
- ✧ Chemical treatment: The concrete surface would be sprinkled with a chemical retarder and/or coated curing compound.

2.3.3 Creation of Work Records for Each Work Process in Structural Construction

Construction work, particularly structural construction, requires numerous checks at each work process. The construction status has to be checked, and the check results must be recorded and kept, especially for areas that affect the quality of the building. These records are generally prepared and kept by the contractor as evidence that the construction was carried out properly, but as part of construction inspections, it is extremely important to verify that the recorded content is accurate.

2.3.3.1 Checking points on Rebar work

The recording contents and style for rebar works are shown on the table below.

Table 2-14 Checking Item on Rebar work

Items		Checking points	Checking/ Record/ File			
			Driving Pile		Bore pile	
			Photograph	Recording Data	Photograph	Recording Data
Rebar Work	Material receiving	Specification of the materials (Mill sheet)	✓	-	-	-
		Sampling test	-	✓	-	✓
		Temporary stock condition for rebar (Raw material)	-	-	-	✓
		Rebar damages such as Rust, Bent, Twist, Warp	-	-	-	✓
	Fabrication	Tools for Rebar fabrication	-	-	-	✓
		Fabricated dimensions (Length, Hook, Anchor' Development length)	-	-	✓	✓
		Fabrication3/ Temporary stock condition for fabricated rebar	-	-	-	✓
	Placing condition	Placing number and size of main bar	-	-	✓	✓
		Anchored position and length of main bar	-	-	✓	✓
		Lapping position and length of main bar	-	-	✓	✓
		Distance in each main bar	-	-	✓	✓
		Placing pitch of Hoop and/or Stirrup	-	-	✓	✓
		Placing condition of Hoop at Panel zone (Size, Pitch, Number)	-	-	✓	✓
		Placing condition of spacer materials (Size, Pitch, Number)	-	-	✓	✓
		Placing condition of web bar (Size, Pitch, Number)	-	-	✓	✓
		Placing condition of tie bar (Size, Pitch, Number)	-	-	✓	✓
		Placing condition of main bar for slab (size, Pitch, Number)	-	-	✓	✓
		Placing condition of distribution bar for slab (size, Pitch, Number)	-	-	✓	✓
		Placing condition of main bar for stir (size, Pitch, Number)	-	-	✓	✓
		Placing condition of distribution bar for stairs (size, Pitch, Number)	-	-	✓	✓
		Placing condition of step bar for stair (size, Pitch, Number)	-	-	✓	✓
		Placing condition of tip bar for stir (size, Pitch, Number)	-	-	✓	✓
		Fixing condition of Rebar	-	-	✓	✓
		Setting of spacer materials for concrete	-	-	✓	✓

2.3.3.2 Checking points on Formwork

The formwork such as shoring and shuttering panel has to be an acceptable condition some of which are the material strength and materials damages, and that seriously influence the cast concrete quality, so that the checking result has to be recorded and filed to prove the correct construction work.

The recording contents and style for formwork are shown on the table below.

Table 2-15 Checking Items on Formwork

Items		Checking points	Checking/ Record/ File			
			Driving Pile		Bore pile	
			Photograph	Recording Data	Photograph	Recording Data
Formwork	Materials	Condition of shoring materials (Damage and Cleanness)	-	-	-	✓
		Condition of shuttering materials (Damage and Cleanness)	-	-	-	✓
		Condition of shuttering materials (Steel panel/Size and thickness)	-	-	✓	✓
		Condition of shuttering materials (Plywood/ Damage & Cleanness)	-	-	-	✓
		Condition of shuttering materials (Plywood/ Size and thickness)	-	-	✓	✓
		Condition of shuttering materials (Separator/ Damage)	-	-	-	✓
		Condition of shuttering materials (Formwork oil)	-	-	-	✓
	Fabrication	Panel Size	-	-	✓	✓
		Panel condition (Bent, Twist, Warp, Cleanness)	-	-	-	✓
	Construction	Setting level of shoring	-	-	-	✓
		Composition of shoring (Comparing with shoring design)	-	-	-	✓
		Shuttering panel size (width, height and/or depth)	-	-	✓	✓
		Shuttering panel straightness, plumbing, level	-	-	✓	✓
		Fixing of shuttering panel (tie-led, Weller and other supports)	-	-	✓	✓
		Size of concrete cover	-	-	✓	✓

2.3.3.3 Checking point on Concreting work

Casting work seriously influences to the Concrete Quality, therefore some important points have to be checked and recorded as evidence of Quality Control.

The recording contents for formwork are shown on the table below.

Table 2-16 Checking Items on Concreting work

Items		Checking points	Checking/ Record/ File			
			Driving Pile		Bore pile	
			Photograph	Recording Data	Photograph	Recording Data
Concreting work	Ready Mixed Concrete (Concrete Receiving)	Mixing record (mixing ration, Transportation time, Admixture)	✓	-	✓	-
		Slump test, Concrete flow, Concrete tempter)	-	-	✓	✓
		Sampling	-	-	-	✓
	Site Mixing	Mixing record (Mixing ratio, Measuring raw materials)	-	-	✓	-
		Slump test, Concrete flow, Concrete tempter)	-	-	✓	✓
		Sampling	-	-	-	✓
		Sampling	-	-	-	✓
	Preparation	Cleaning condition	-	-	-	✓
		Splining on shuttering panel	-	-	-	✓
	Casting	Carrying condition of concrete pump	-	-	-	✓
		Ready mixed concrete placing before starting Initial setting time)	✓	✓	-	-
	Casting	Carrying condition of Concrete hopper	-	-	-	✓
		Cleanness of wheelbarrow	-	-	-	✓
		Casting sequence	-	-	-	✓
		Using concrete vibration (using style, using position)	-	-	-	✓
		Condition of casting (Tamping and/or Finishing)	-	-	-	✓
		Treatment for Construction joint	-	-	-	✓
	After execution	Curing time for Casted concrete	-	-	-	✓
		Remaining terms for Shuttering panel	-	-	✓	-
		Curing method (Sprinkling water and/or other method)	-	-	-	✓
		Crushing test results (at least 1, 4 weeks)	-	✓	-	✓
		Condition of removal formwork	-	-	-	✓
		Treatment for construction joint	-	-	-	✓

2.4 Important point on other working in Building construction

Building construction has suitable steps in each work. Herein the standard procedure in structural body works.

2.4.1 Piling work

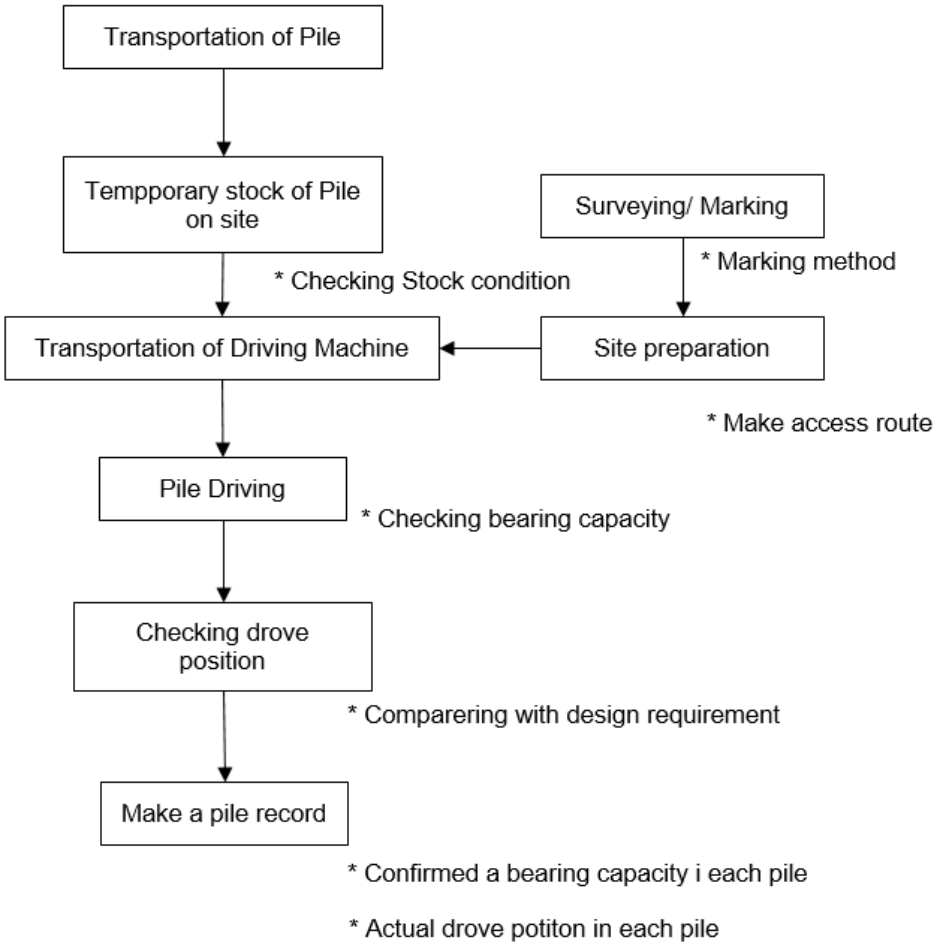
2.4.1.1 Pre-fabrication pile

Concrete piles can be mainly classified into Pre-fabricated piles and Pile cast in place. In addition, pre-fabricated piles have an RC pile, PC pile, PHC pile and others.

Each pile type and driving method shall be decided according to structural design, herein, RC pile in the group of Pre-fabricated pile and Bore pile will be explained.

1) Working-flow

Pre-fabrication pile would be executed as the following flow.



2) Checking points on the working steps

a) Damage of delivery, Handling and/or Stock

Prefabrication piles such as RC piles, PC piles, PHC piles and others 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.

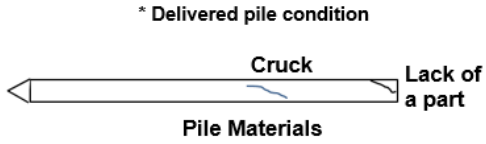


Figure 2-63 Damages on the Pre-fabricated pile

b) 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.

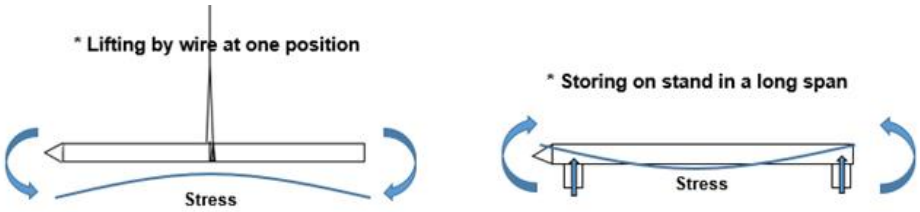


Figure 2-64 Incorrect Handling

c) Marking condition of piling position

The piling position shall be marked the wooden stakes with nails or rebar with marking wire, etc. normally, and that the backup point shall be set at least two positions as following illustrations.

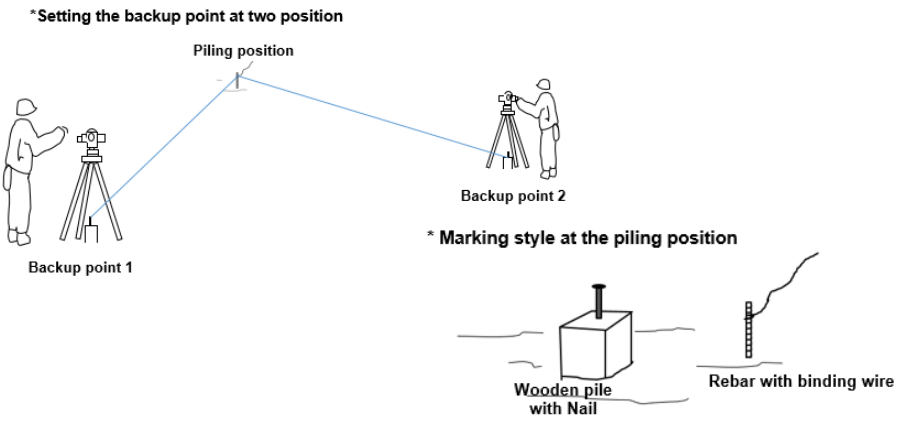


Figure 2-65 Marking style and Two-way backup point

d) 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.

e) Verticality of Piling leader and the driven piles

The pile shall be driven in plumb to avoid any bending stress. For this reason, during pile driving operations, it is important to constantly check that the pile driver's tower is maintained vertically from two directions.

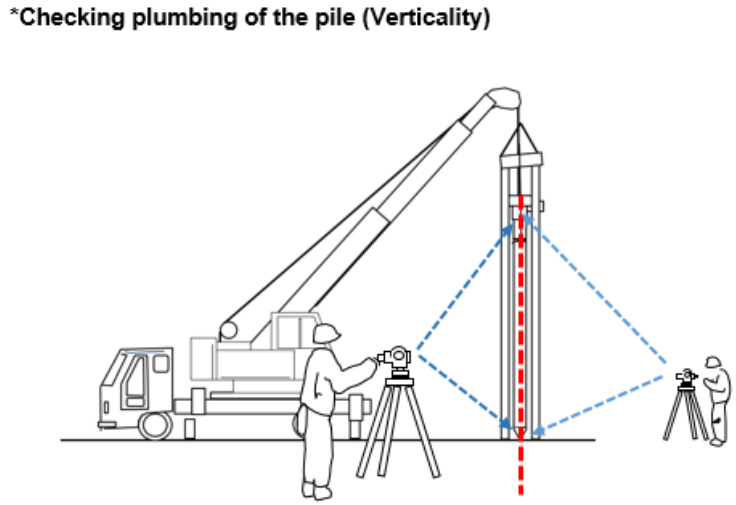


Figure 2-66 Checking plumbing of pile

f) Checking Bearing capacity of driven piles

It has to be confirmed by checking the current load of press fitting machine, settlement of pile at final driving and other methods. Therefore, inspector has to be checked with the piling record which is made by contractor.

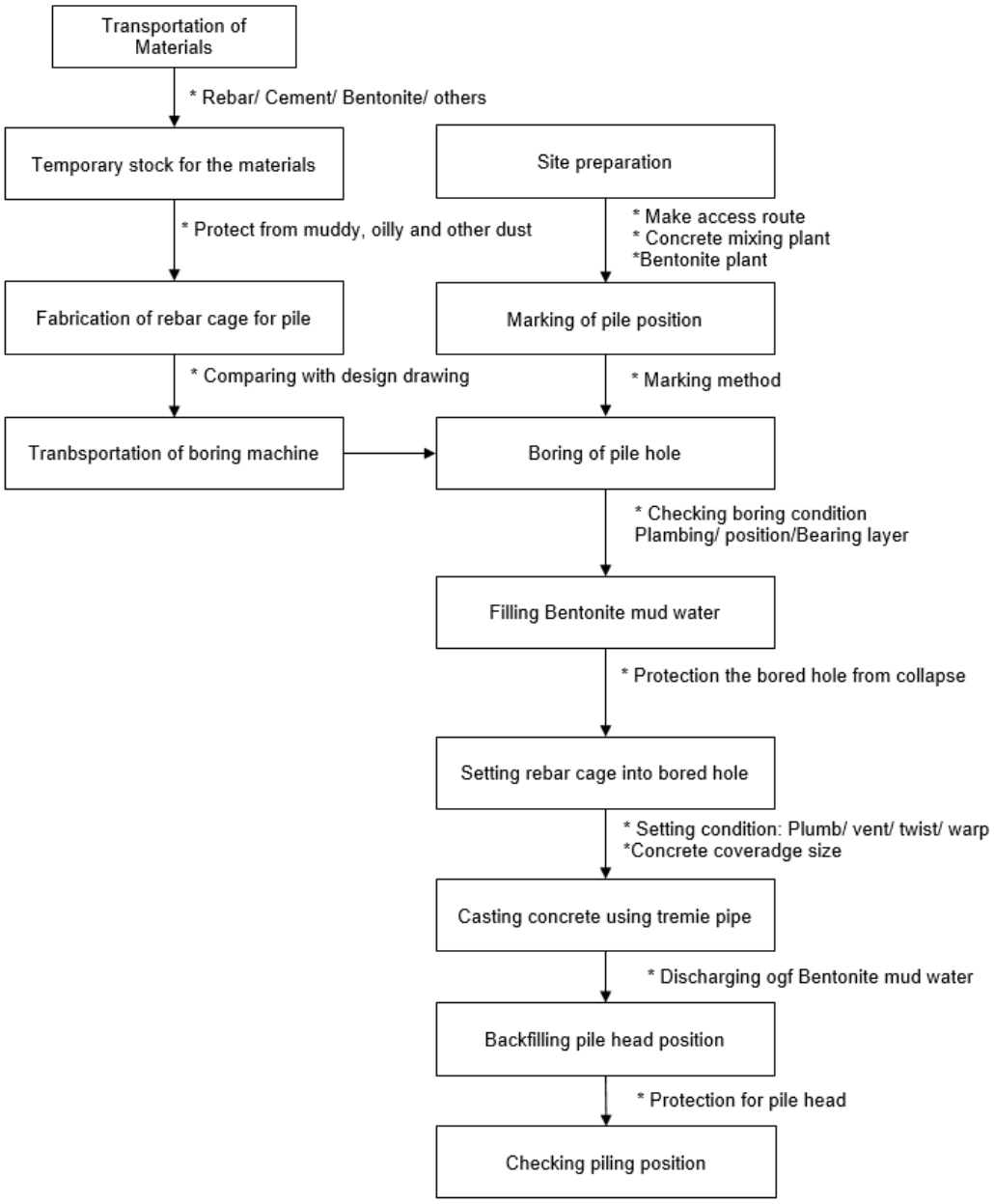
2.4.1.2 Pile cast in place (Bore-pile)

Cast-in-place piles are constructed by drilling a hole of a specified diameter at a planned location down to the supporting ground layer, inserting rebar, and then pouring concrete into the hole. Methods are classified into Earth Drill method, reverse circulation method, etc. depending on the pile hole excavation method (method for preventing the excavation wall from collapsing, etc.).

Herein it will be explained as sample of Earth drill method.

1) Working-flow

Bore-pile would be executed as the following working flow.



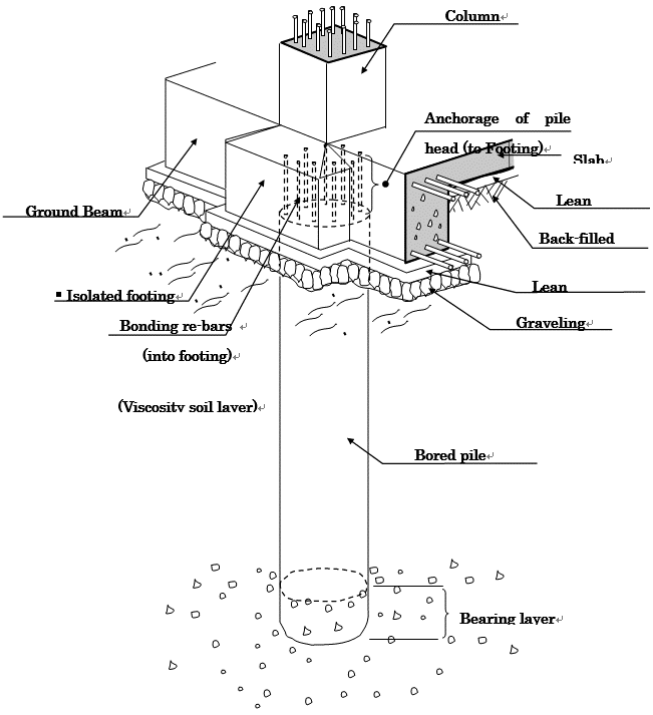


Figure 2-67 Imaging sketch of Pile Foundation

2) Checking points on the working steps

The sketch on the left is showing imaging “Earth drill-pile Foundation"

In the earth drilling method, bentonite is used as a stabilizer to prevent the collapse of the pile hole excavation wall.

Therefore, construction sites require storage areas for rebar and other materials, a place to manufacture rebar cages, and facilities for mixing, supplying, and recovering bentonite stabilizers. Therefore, whether these spaces are properly planned and located is also a factor that affects construction quality.

Therefore, there are many points for the quality of the pile as below, which has to be checked the conditions.

a) Temporary stock condition

The materials such as rebar, cement, sand, aggregate and other required materials shall be stocked correctly.

b) Preparation of Batching plant/ Bentonite plant/ Access route

Storage areas for materials such as rebar and cement, processing areas for pile rebar, concrete mixing plants, and bentonite stabilizer supply plants must be located so as not to obstruct pile driving operations, and the plans must allow efficient access to each installation location. Inspectors must consult with construction supervisors as necessary to confirm that there is no adverse effect on construction quality.

The below is showing imaging of Bentonite plant

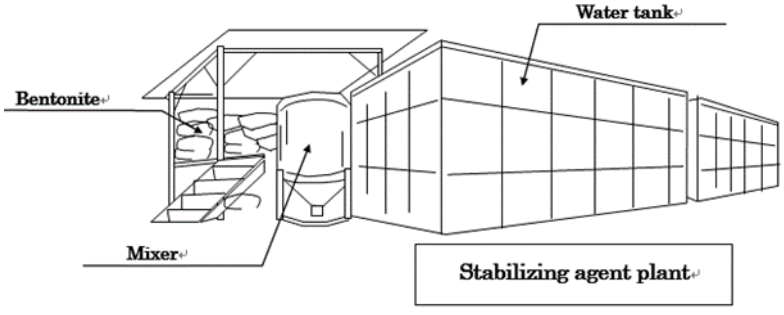


Figure 2-68 Imaging sketch of Stabilizing Agent Plant

c) Fabricated condition of rebar cage

Pile rebars, including main and spiral rebars, has to be manufactured according to the requirements of the design documents. Furthermore, it is important that the rebars are firmly bonded together so that they remain in the correct position without coming apart, from the time of manufacturing to the time of installation in the pile hole and the completion of concrete pouring.

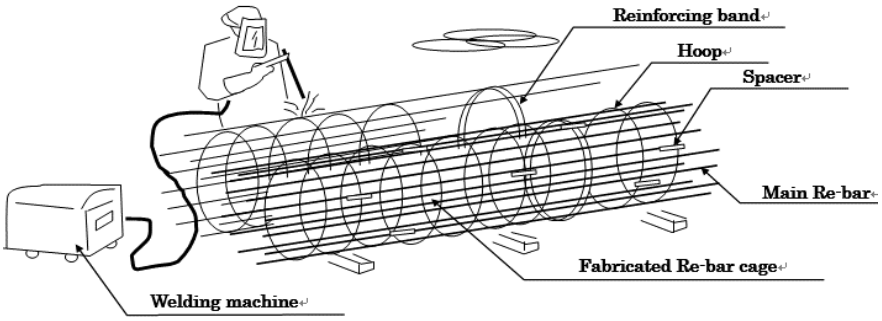
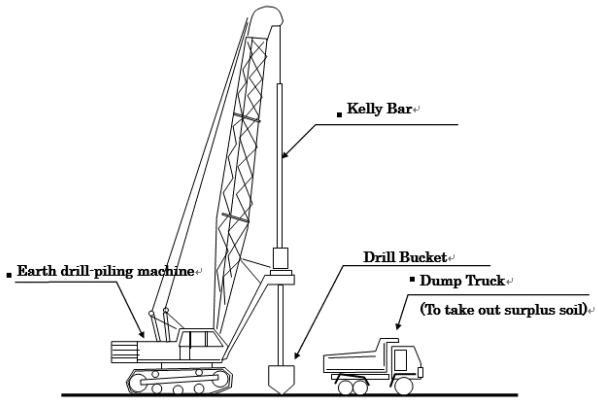


Figure 2-69 Imaging sketch of Rebar cage for bore-pile

d) Marking condition of piling position

It has to be marked and checked as well as Pre-fabricated pile work

e) Boring condition for pile holes



✧ Kelly bar shall be kept in plumb

✧ The bored hole has to reach into the bearing layer at least one meter and/more.

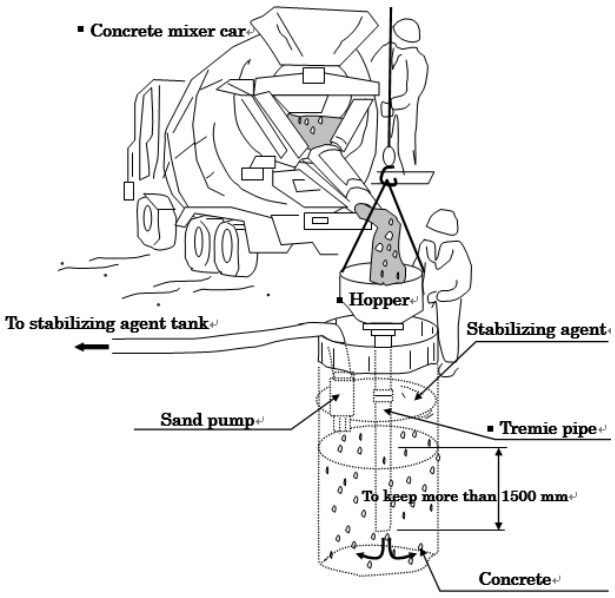
✧ Bearing layer shall be checked by depth and the soil condition.

Figure 2-70 Imaging sketch of Boring Machine

f) Setting condition for the rebar cage

Setting position (At same center position of pile/ Concrete covering size)

g) Concrete casting condition

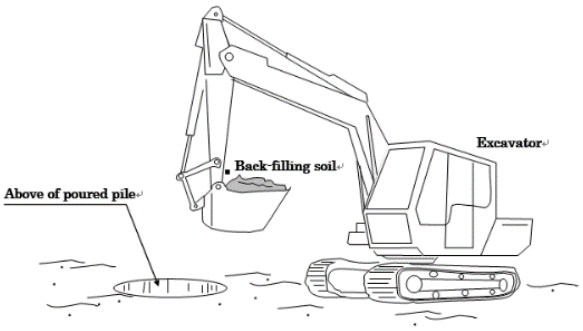


✧ Using tremie pile: Tremie pipe shall be kept into poured concrete.

✧ Poured concrete level: The pile concrete shall be poured additionally, so that the additional length shall be 600mm~1200mm more, which is depended on the pipe Diameter.

Figure 2-71 Imaging sketch of Pouring concrete into Bored hole

h) Curing the pile head



✧ The position shall be backfilled to avoid any damage.

Figure 2-72 Imaging sketch of Pile head protection

i) Piling position and Condition (After excavation)

✧ Executed pile position: It shall be surveyed, and the deviation of pile center has to be confirmed.

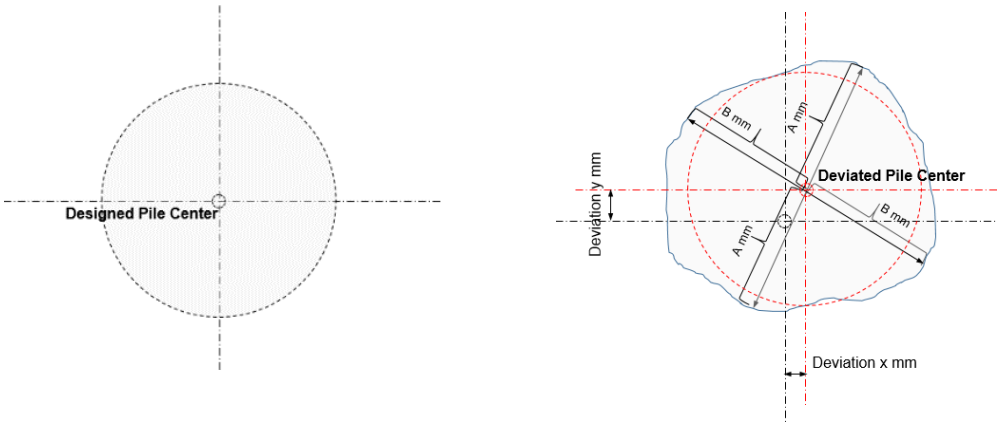


Figure 2-73 Checking of pile deviation

- ✧ Pile Head condition

  The Pile Head shall enter into the pile cap approximately 100mm, which depends on design requirement.

- ✧ Damage of Pile head

  The pile head shall not be damaged such as a lack, break, shortage of dia-meter and any other damage.

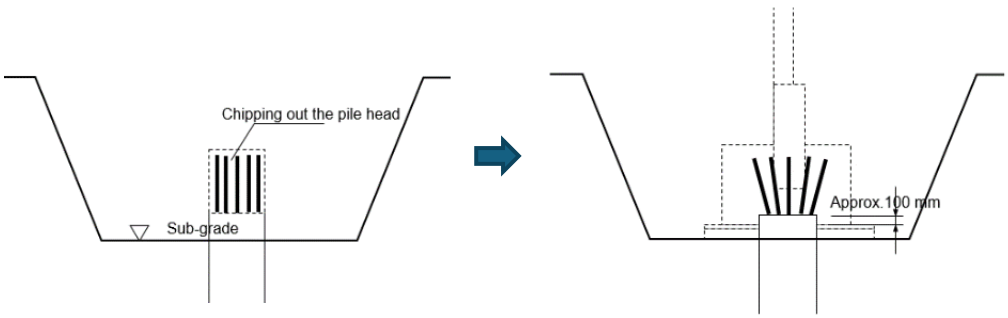


Figure 2-74 Illustration of Checking pile head treatment

2.4.1.3 On-site Inspection of Pile Work

During construction inspections, it is important for inspectors to review the contractor's construction records and ensure that the piling work is being carried out in accordance with the design documents.

The table below is an example of a list of construction inspections.

1) Pre-fabricated pile
2) Bore Pile

Table 2-17 Checking Items on Pre-fabricated pile work

Items		Checking points	Checking/ Record/ File			
			Driving Pile		Bore pile	
			Photograph	Recording Data	Photograph	Recording Data
Pre-fabricated piles	Delivery	The condition of delivered pile (Grade, type)	✓	-	-	-
		The condition of delivered pile (Diameter, length, Damages)	-	-	✓	✓
	Stock & Handling	The storing condition (using timber stand, etc.)	-	-	-	✓
		Wiring condition (Minimum stress)	-	-	-	✓
	Marking	Suitable marking condition and position	-	-	✓	-
		Setting pickup point (two positions)	-	-	-	✓
	Pile Driving	Setting pile at the driving machine in plumb	-	-	-	✓
		Driving data (Pilling Depth)	-	-	✓	-
		Driving condition (Number of hammerings, Load current value, etc.)	-	-	✓	-
	Confirmation	Checking executed pile position	-	-	✓	-
		Condition of driven pile head (Damages)	-	-	-	✓

Table 2-18 Checking Items on Bore pile work

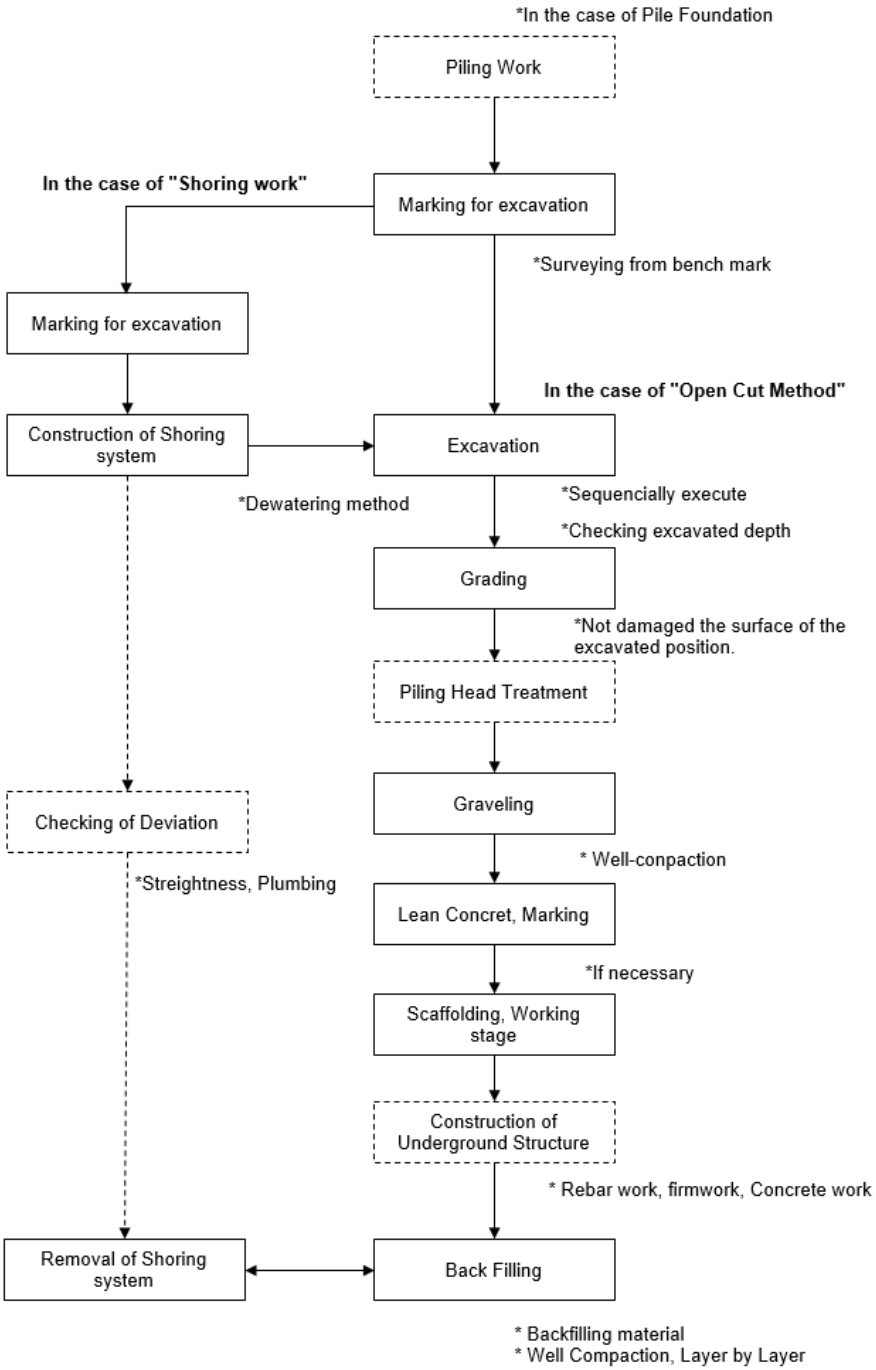
Items		Checking points	Checking/ Record/ File			
			Driving Pile		Bore pile	
			Photograph	Recording Data	Photograph	Recording Data
Bore-Pile	Preparation	Site mixing concrete (Concrete plant, Material storage)	-	-	✓	✓
		Ready mixed concrete (Water-cement ratio, other mixing ratio, others)	✓	✓	-	-
		Ready mixed concrete placing before starting Initial setting time)	✓	✓	-	-
		Bentonite plant	-	-	-	✓
		Surveying and marking	-	-	✓	-
		Marking condition (Pile center & backup point)	-	-	-	✓
		Storing condition of rebar	-	-	-	✓
		Fabrication of rebar cage (Diameter, number, pitch, Spacer, etc.)	-	-	✓	✓
		Fabrication of rebar cage stiffener)	-	-	✓	✓
	Boring hole	Setting casing	-	-	-	✓
		Boring condition (Plumbing)	-	-	-	✓
		Checking of Boring depth (Length & level)	-	-	✓	✓
		Confirmation of Bearing layer (Kind and condition of the soil)	-	-	✓	✓
		Cleaning condition of Bored Hole	-	-	-	✓
		Protection method for collapse of Bored hole (Top Casing, Full casing, Bentonites muddy water, etc.)	-	-	-	✓
	Pouring concrete	Using condition of tremies pipe	-	-	-	✓
		Before concreting tremies pipe seal	-	-	-	✓
		Volume of poured concrete	-	-	✓	-
		Poured concrete level	-	-	✓	-
		Additional concrete length at pile head (=+500 mm~+1000mm)	-	-	✓	-
		Curing （Backfilling on the pipe position)	-	-	-	✓
		Test (PIT, Load test)	-	-	-	✓

2.4.2 Earth work/ Foundation work

There is high risk that Earth work influences the building quality, such as uneven settlement and/or some damages for the building structure. It is very important to be suitable for the construction quality. Therefore, the outline of “Earth work” and important point will be explained

2.4.2.1 Working-flow

Earth work would be executed as the below working flow



2.4.2.2 Checking points for Excavation work

1) Surveying and Marking

It is normal procedure for surveying and marking that firstly, Standard line and Benchmark shall be set on site. And then at first, each excavating line and excavated depth shall be marked using the standard line and benchmark. And the mark has to be protected from any

damage. Therefore, Inspector shall check the marked position which surveyed and marked correctly.

The sketches below show two kinds of surveying steps

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

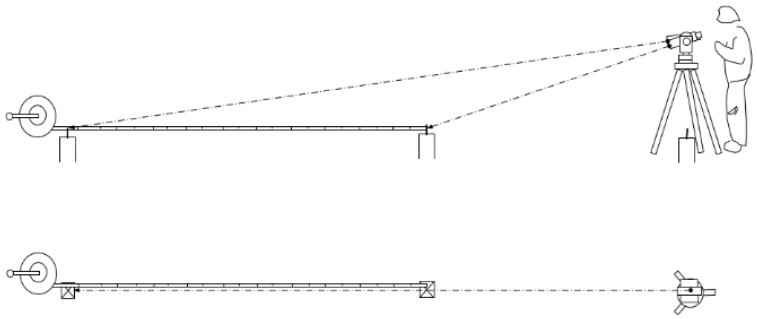
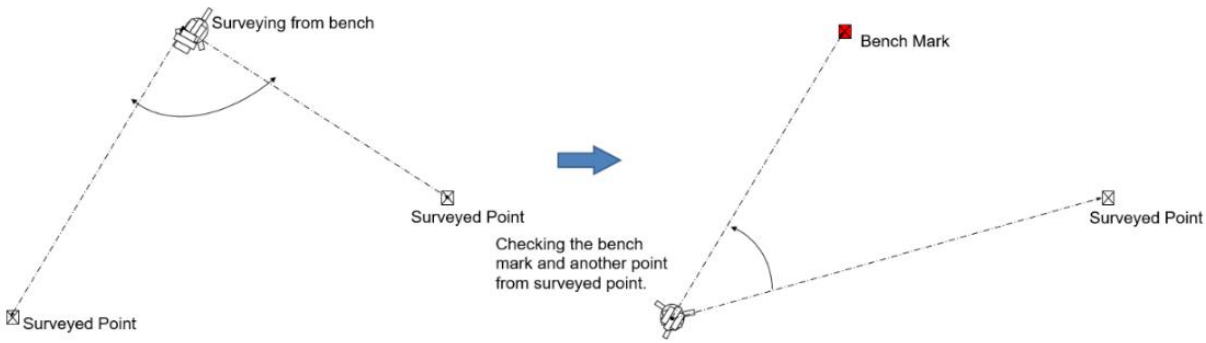


Figure 2-75 Surveying of using standard line

In case of surveying with total station, the result shall be re-checked from surveyed position.



As if the the cheking result is not matched with original benchmark point, the surveyed point shall not used, so that it is necessary to survey again.

Figure 2-76 Surveying of using Total station

2) Working Space

The excavated size has to include the working space for rebar work, formwork and concrete work.

Basically, the working Space shall be 600mm~800mm at least. If an adequate workspace is not secured, care must be taken as there is a possibility that situations may arise that are unfavorable for ensuring quality, such as making it difficult to work.

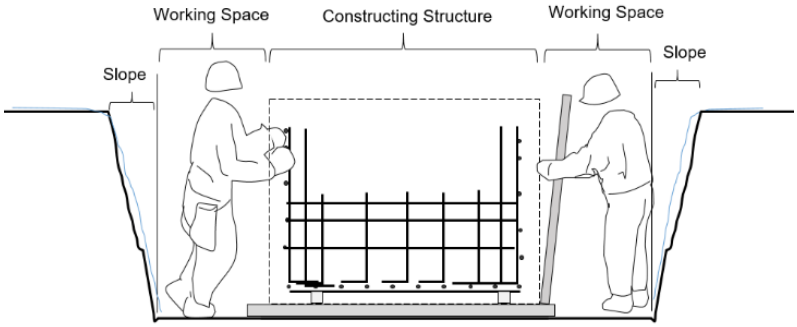


Figure 2-77 Working Space

3) Protection of Excavated area (Shoulder and Sub-grade)

The excavated area has to be protected from any damage, which is disturbing the surface of subgrade and/or collapse of the slope.

✧ For rainwater

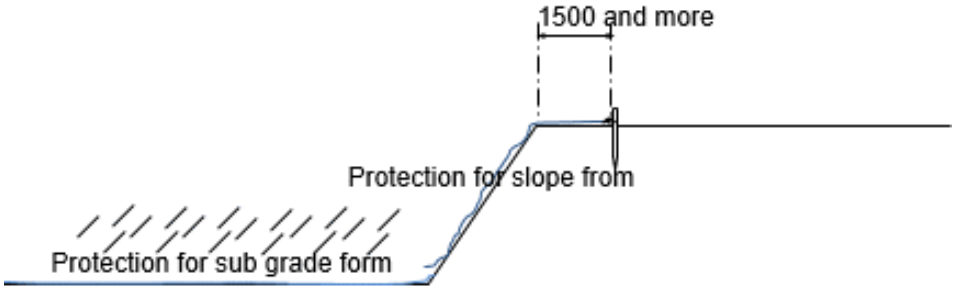


Figure 2-78 Damages by Rainwater

* Plastic sheet cover: the excavated slope has to be covered by plastic sheet to protect collapsing, and the finished sub grade has to be covered also to protect from rainwater as well. The covering length at slope shoulder must be 1500mm and more.

✧ For Heavy Load on the shoulder

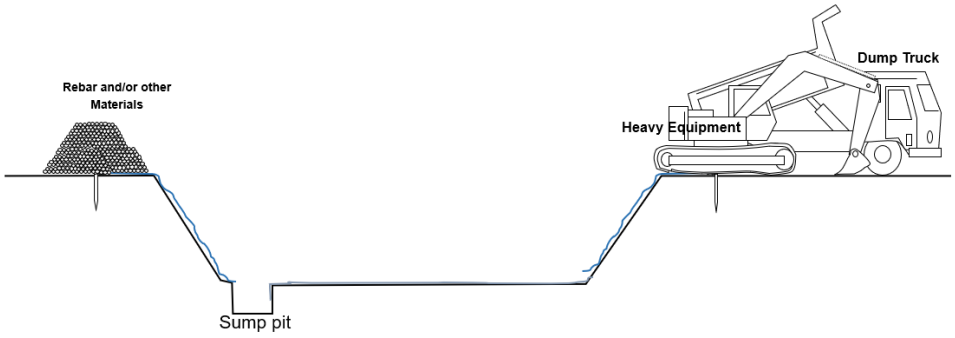


Figure 2-79 Incorrect load at the shoulder

* Heavy equipment and/or other heavy weight materials have not to park or stock at the shoulder position of excavated area

✧ Safety Treatment

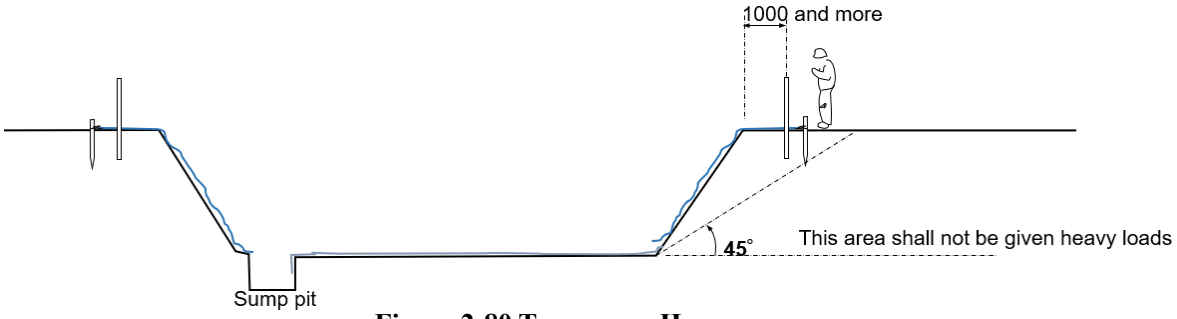


Figure 2-80 Temporary Hence

* Temporary fence: Temporary fences shall be constructed around excavated areas using steel pile, safety rope and sign board, and the location shall be 1000mm and more from shoulder position. Furthermore, the shoulder area shall not be given any heavy loads such as material stock, parking dump truck and so on. refer to the sketch below

4) Excavation Work

It is important that excavation work has to be carried out carefully without disturbing of the sub-grade following the below points

a) The excavation area and depth

- 1st execution: 100mm and/or 200 above the required depth.
- Finishing execution: Until the required depth.
- Completion mark: Marking on the sub-grade

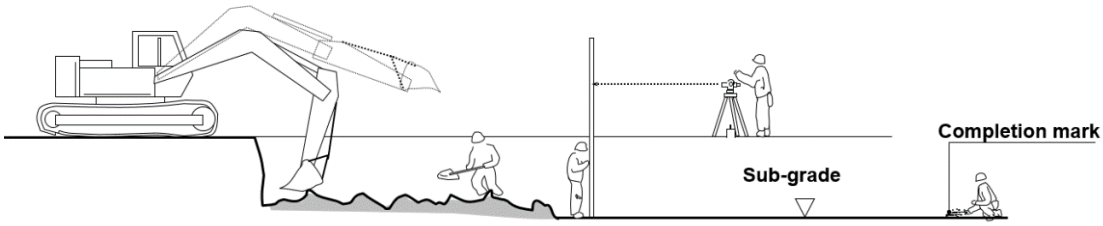


Figure 2-81 Working step of excavation work

*Excavation will be carried out by excavator and/or manpower according to marked line, and the excavation depth shall be checked by auto level and marked with cement powder and/or lime

b) Recovering of damaged the sub-grade

As if the sub-grade has been damaged and/or too much position excavated, the area has to be repaired with the following action.

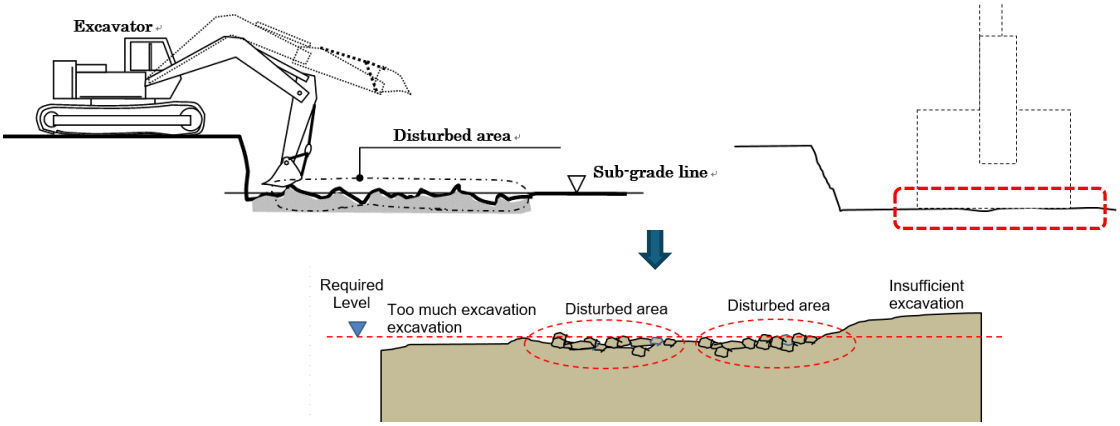


Figure 2-82 Incorrect excavated condition

- Removal of the disturbed soil and/or surface soil on too much excavated position
- Filling by good soil at the position
- Well compaction

5) Graveling

Gravelling area has to include additional space for Marking space, Formwork space and/or any other necessary space for construction.

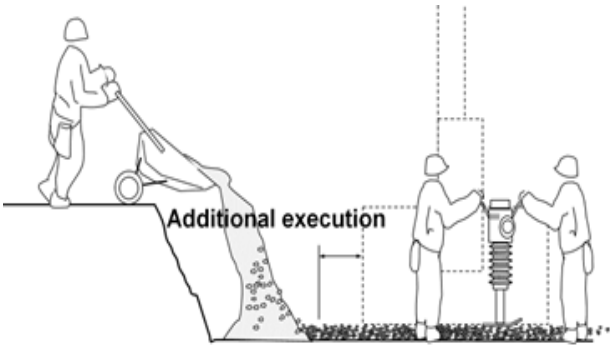


Figure 2-83 Additional gravelling area

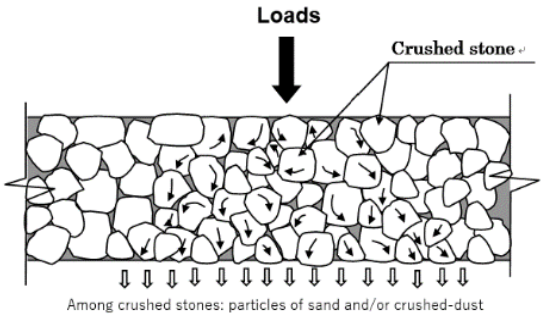


Figure 2-84 Mechanism of Loads distribution

[Reference]

The laying crush stone/gravel shall be well compacted as locking each other, and the gap between particles would fill by sand and/or others to make a rigid condition, therefore Loads would be distributed wide area. The mechanism is shown on the left illustration.

6) Backfilling

Backfilling work has to be executed with suitable materials and reasonable method to avoid any shrinkages of the backfilled position. Therefore, it is very important to understand the basic technical knowledge for soil condition and working method.

a) Backfilling Materials

Backfilling materials have to be checked to get a suitable working result.

The Backfilling material shall not be muddy clay, clay clod and any other unsuitable condition, so that in the case of using clay for the backfilling soil, the backfilling work shall take care of treatment for muddy and/or clod condition.

- Muddy condition: It is so difficult to compact the back filled soil that reasonable countermeasure.
- Clay clod: In the case of using clay clod, it would be roots of settlement at the backfilled area as shown on the illustration.

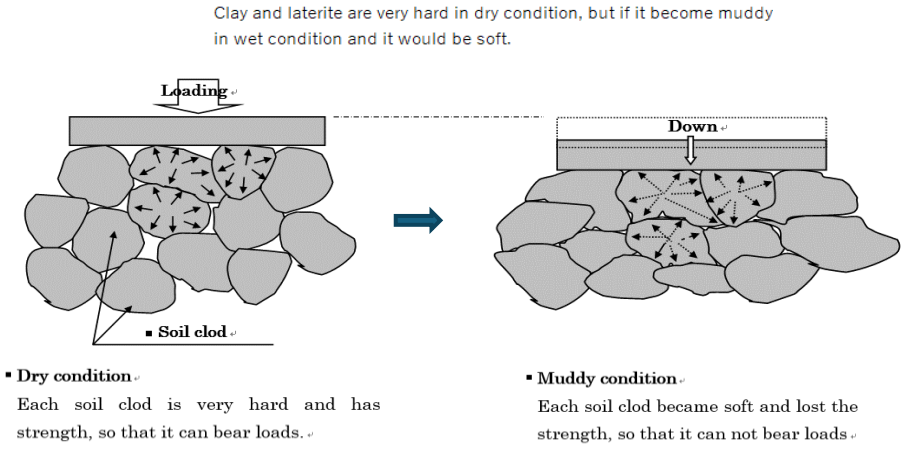
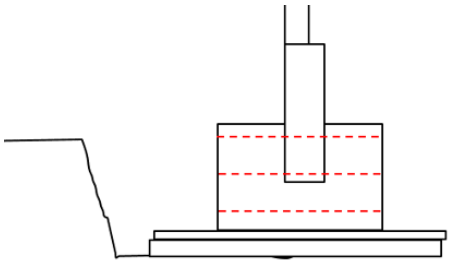


Figure 2-85 Mechanism of settlement of soil clod

◆ In the case of using sand of backfilling

In the hand, in the case of using sand for backfilling, the backfilling work shall be executed with sprinkling water to get a rigid condition.

b) Backfilling thickness



The backfilling work has to be executed with layer by layer to keep well compaction, which thickness of layer shall be 30 centimeters (cm) and less.

Because compacting impact will achieve certainly until 30 centi-meter and less.

In addition, each layer must be well compacted by suitable equipment such as vibration-roller, tamping hammer, and others.

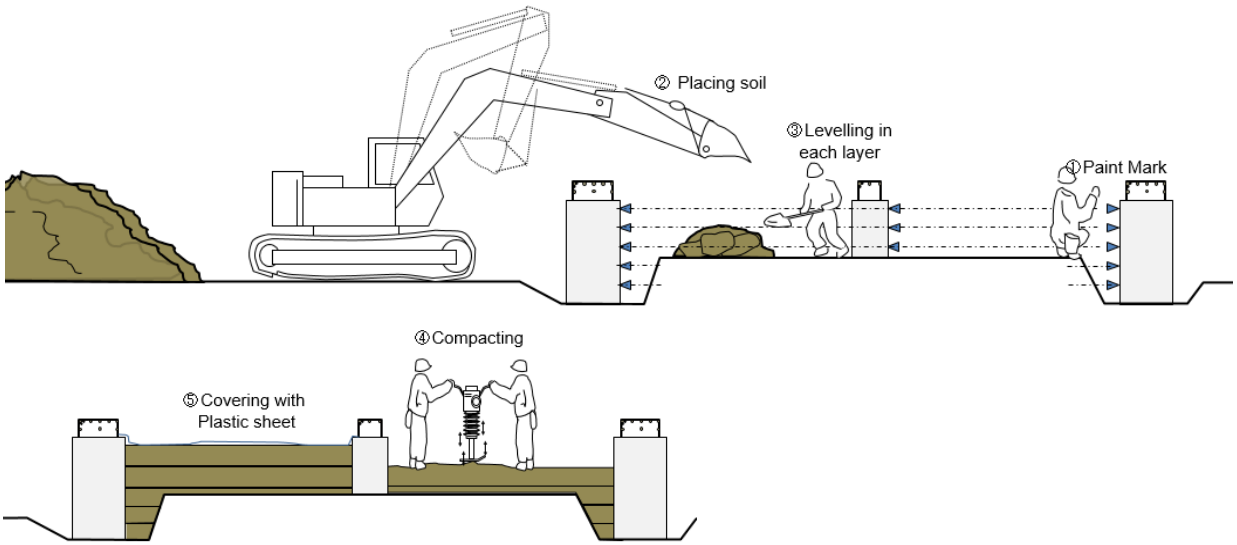
Figure 2-86 Marking on the structure

c) Working Steps

The working procedure will be shown below as reference.

Step1/Marking has to be executed as shown on “Figure 2-81 Marking on the structure”

①: Back filling area shall be marked in each backfilling layer by paint on the concrete surface, and that each layer shall be 200mm and less for compactor.
②: The filling soil will be placed by excavator, and that the placing work shall carried out together with levelling work in each layer.
③: Placed soil shall be graded by manpower in each layer.
④: Placed soil shall be compacted by compacting equipment such as a engine compactor, wooden tamper and so on, until required density.



Compacting by Roller

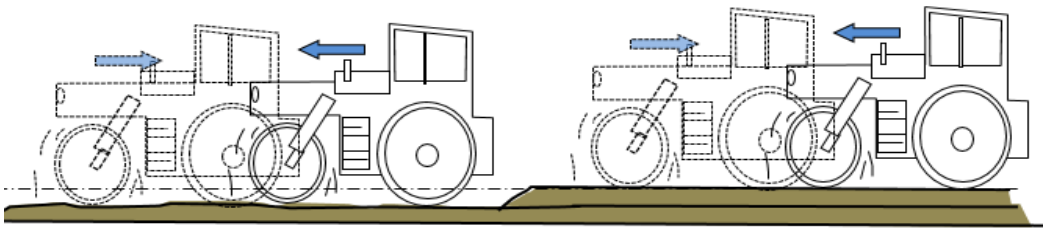


Figure 2-87 Working steps for Backfilling

d) Confirmation of Backfilling result

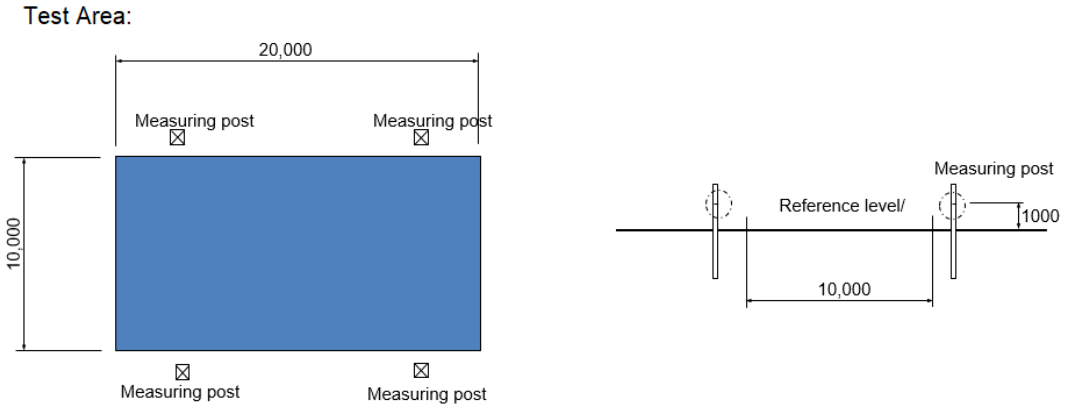
The backfilling has to be required to be executed with well compaction, and that the compacted result shall be confirmed.

[Reference: Test Compaction]

Compacted condition shall be checked the required condition on the design specification at layer by layer. However, it makes many working downtimes. Therefore, 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.

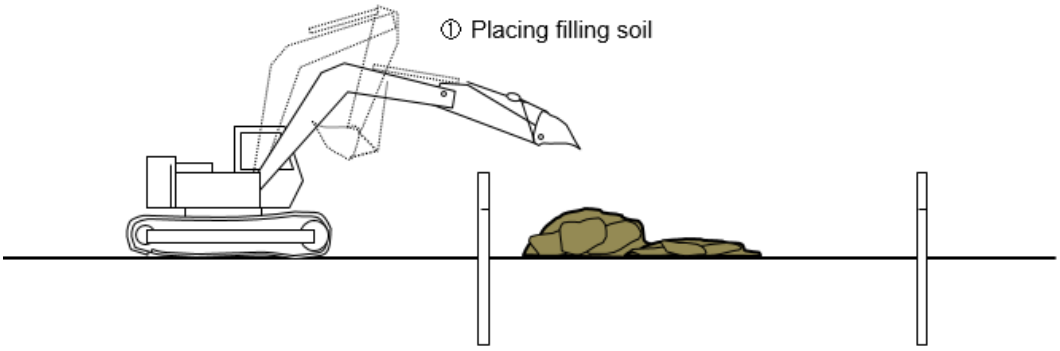
In actual backfilling time, the compact condition would be confirmed using the control value, which is reasonable way to carry out backfilling work correctly.

The sketch below shows the procedure of test compaction.

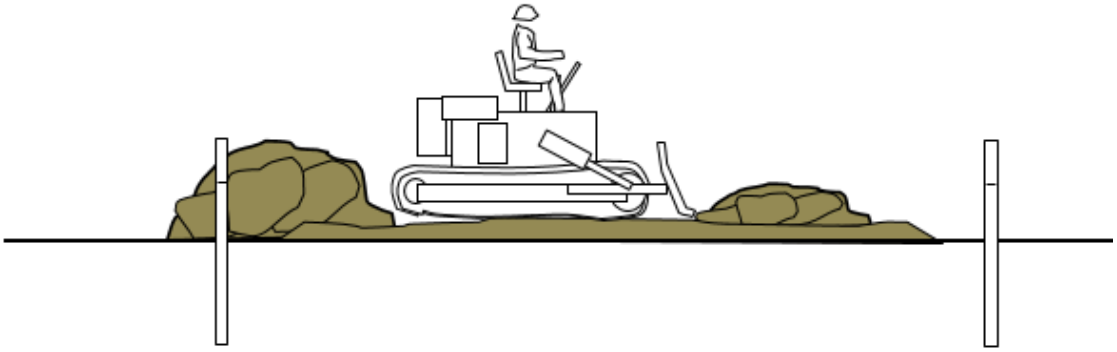


Test compaction

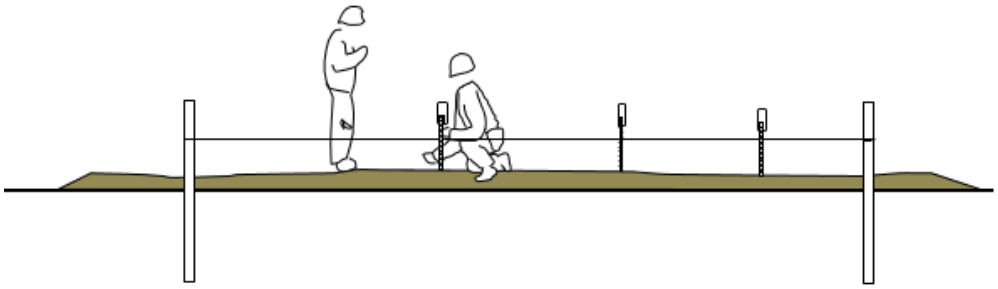
① Placing filling soil



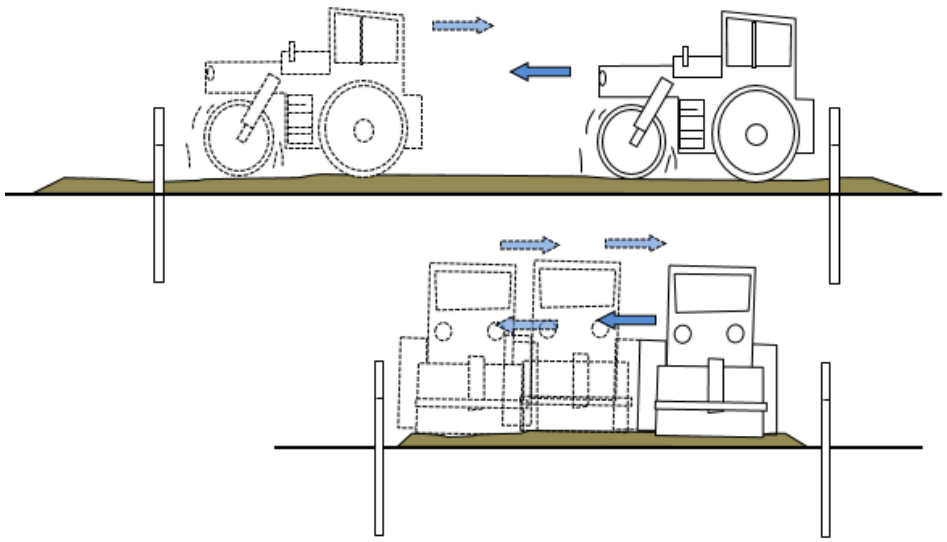
② Grading with dozer brade roughly



③ Checking measuring fillling layer



④ Compacting by Roller, 5 time, 7thims, 10 times and 15



1 round compaction shall be counted as 1 time.

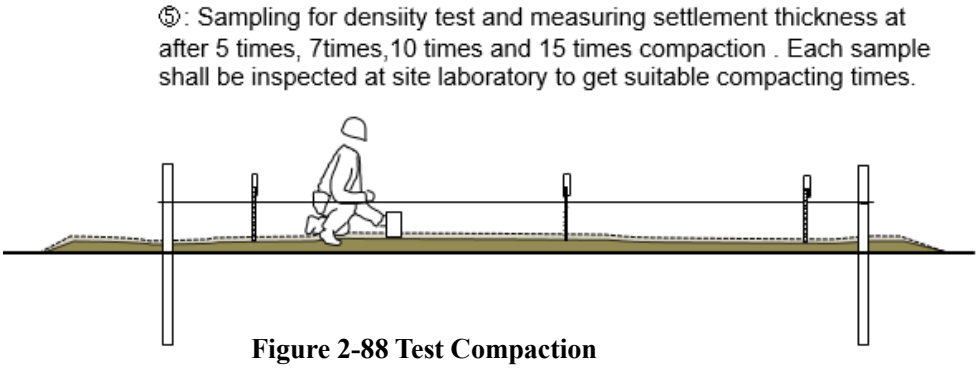


Figure 2-88 Test Compaction

The testing data such as thickness of filling layer, density test result in each sample, settlement thickness in each sampling time, compacting speed of roller, name of utilized equipment and the compacting capacity has to be recorded.

Tested heavy equipment such as compaction roller and filling material has not to be changed at actual execution. As if the changing equipment and/or materials, the test compaction has to be executed to get correct data for the compaction.

[Reference: CBR Test]

- Testing Method: It has to be done as follows;

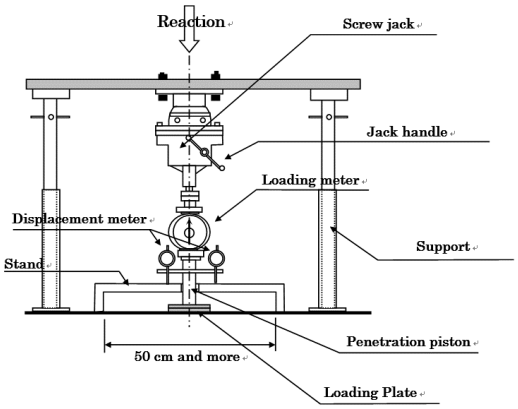
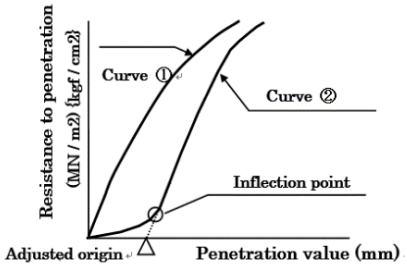


Figure 2-89 CBR Test Devise



Revising: The straight-line after inflection point shall be extended, and revised initial point shall be fixed.

Curve ①: It does not need to revise.

Curve ②: It needs to revise.

Figure 2-90 Resistance penetration-Penetration value curve

i) The surface of penetration has to be leveled, where it is 30cm square, and lay dry sand.

ii) CBR testing devices have to be seated at testing position. After seating the device four pieces of surcharge weights have to be placed the penetration position.

iii) It applies loads of 0.05kN [5kgf] and less to fit penetration position on testing surface. In the time, the value of load indicator and penetration dial indicator has to be initial value.

iv) It applies the loads to the penetration, so that the rate of penetration is uniform at 1mm/minute, and it shall be recorded the loads when the penetration is 0.5mm, 1.0mm, 1.5mm, 2.0mm, 2.5mm, 3.0mm, 4.0mm, 5.0mm,7.5mm,10mm and 12.5mm. If the load indicator shows maximum value before the penetration value achieves 12.5mm, the value of indicator and penetration dial indicator has to be recorded.

v) After testing, test piece for moisture ratio shall be sampled at the tested position. And the moisture ratio has to be checked.

[Record of testing data and CBR value]

- Making resistance to penetration-penetration value curve

The loading value in each time shall be divided by section area of penetration to get loading strength. And resistance to penetration-penetration value shall be plotted.

If the curve will be as ② shown at the left side graph, which has inflection point at initial term, it shall be revised

Loads value can be used instead of the loading strength, in this case, the graph is called Loads- penetration value curve.

- Conversion to CBR value

Loading strength at 2.5mm penetrated time and t.0mm penetrated time shall be got on loading strength-penetration value curve, and then CBR value shall be estimated by the following formula with using standard loading strength corresponding to each penetration value which is 2.5mm and 5.0mm.

$$CBR = \frac{q}{q_0} X\ 100$$

q : Loading strength at the penetrated value (MN/m2) [kgf/cm2]
q_0 : Standard loads value at the penetrated value (kN) [kgf]
Refer to Table2-12

Table 2-19 Standard Loading strength and Standard loads

Penetration value (mm)	Standard loadig stregth (MN/m2 [kgf/cm2]	Stadard loads value (kN) [kg]
2.5	6.9 [70]	13.4 [1370]
5	10.3 [105]	19.9 [2030]

Remark: If the data of penetration test result is loading value, CBR value shall be estimated by the following formula with using standard loads value corresponding to each penetration value is 2.5mm and 5.0mm

$$CBR = \frac{Q}{Q_0} X\ 100$$

Q : Loads value at the penetrated value (kN) [kgf]
Q_0 : Standard loads value at the penetrated value (kN) [kgf]
Refer to Table2-12

- Utilizing CBR value

Usually, CBR value shall be used the calculated value corresponding to penetration value which is 2.5mm. However, the calculated CBR value corresponded to penetration value which is 5.0mm can be used, if it is larger than the calculated value corresponded to penetration value which is 2.5mm, and that re-testing rest is also same as first testing.

2.4.2.3 On-site inspection for Earth work/ Foundation work

Each checking point on the below table shall be checked at site inspection time, and that the record has to be filed and preserved.

Table 2-20 Checking Items on Earth (Foundation) Work-1

Items		Checking points	Checking/ Record/ File			
			Driving Pile		Bore pile	
			Photograph	Recording Data	Photograph	Recording Data
Earth Work/ Foundation work	Surveying	Excavation area shall be surveyed using standard line and/or Benchmark.	-	-	✓	✓
		Each surveyed result shall be re-surveyed as double checking	-	-	✓	✓
	Marking	Marking shall mark clearly using comet powder and/or Lime powder	-	-	✓	✓
		Butter board for marking shall be kept until working completion	-	-	✓	✓
	Working Space	Excavation area shall be considered enough working space	-	-	✓	✓
	Protection	Excavated slope have been covered by plastic sheet and/or others	-	-	-	✓
		Excavated areas have been covered by plastic sheets and/or others	-	-	-	✓
		Shoulder of Excavated slope has not loaded	-	-	-	✓
		Any heavy equipment and materials shall not be put on the shoulder of the slope	-	-	-	✓
		Safety fence has been constructed	-	-	-	✓
	Excavation	The excavated grade shall not disturb	-	-	-	✓
		Excavated area	-	-	✓	✓
		Excavated depth	-	-	✓	✓
		Repaired condition at damaged sub-grade, if any	-	-	-	✓
	Gravelling	Using material (Gravel, Crush stone and others)	✓	-	-	-
		Laying thickness	-	-	✓	✓
		Compacting condition	-	-	-	✓
		Compacted result (Density)	-	-	✓	✓
	Backfillig	Preparation/ Cleaning of backfilling area)	-	-	-	✓
		Preparation/ Treatment for the structure (waterproofing and/or others)	-	-	-	✓
		Preparation/ Marking of backfilling layer (300 mm and less)	-	-	✓	✓
		Backfilling materials (Kind of soil)	✓	-	-	✓
		Ensure Max dry density95%	✓	-	-	✓
	Backfilling	Backfilling materials (Crushing of soil clod)	-	-	-	✓
		Backfilling condition (Execution with well compaction in each layer)	-	-	-	✓
		Backfilling condition (Execution with sprinkling water, in the case of sand)	-	-	-	✓
		Checking compacted condition (Density test and/or CBR test)	-	-	✓	✓
		Checking compacted condition (Using trial compaction result)	-	-	✓	✓

2.4.3 M & E Works

Construction for M&E works has to ensure the working step and the construction behavior also to achieve Building Quality. Herein the important point on the construction works would be explained to be clear the checking points at on-site inspection

2.4.3.1 Mechanical Work (Including plumbing work)

Mechanical work has several categories, some of which are plumbing work (sanitary work), air-conditioning system and air-ventilation facility. In each work, there are some important points on its construction work, herein some major points of all would be explained with illustrations.

1) Water supply facility

The careful point for water supply facility is to avoid a convexity piping, which causes the interruption for the stream in the pipe, and then it will cause a wrong condition for water supply.

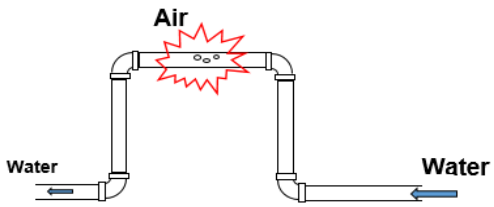
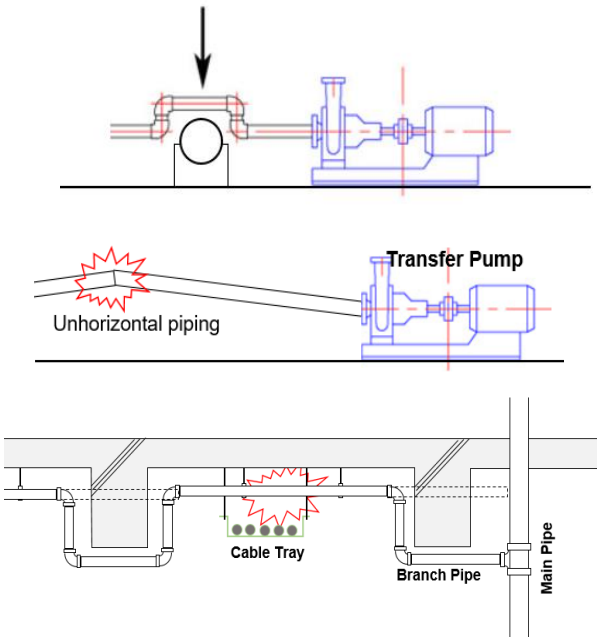


Figure 2-91 Convexity Piping

Sometime, the convexity piping appears under construction without design, therefore the piping condition has to be checked and improve the condition, if any.

In this condition, It is necessary to pay attention that Air will gather at the above position in the pipe and the air mass will interrupt the stream water.

The below cases are also one type of convexity piping.



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

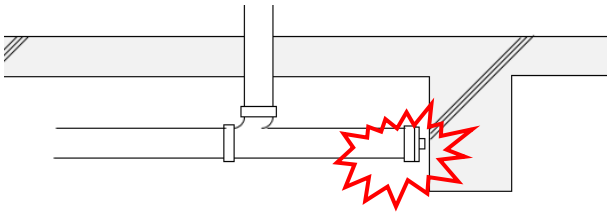
b) In the case of unlevel piping

c) In the case of interference of cabling and piping or incorrect prevention of beam penetration.

Figure 2-92 Variations of convexity piping

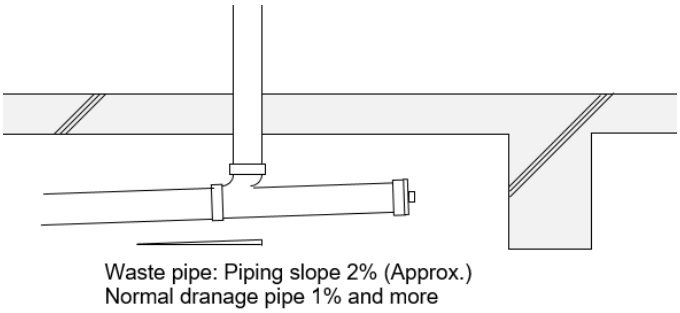
2) Drainage facility

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



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

Figure 2-93 Incorrect position of clean out



b) Piping slope

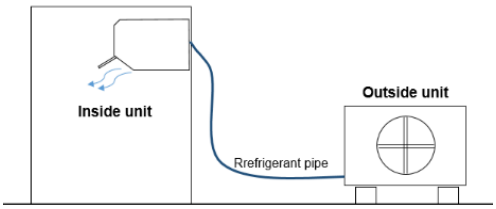
Waste pipe: 2% and more

Normal drainage pipe: 1% and more

Figure 2-94 Incorrect position of clean out

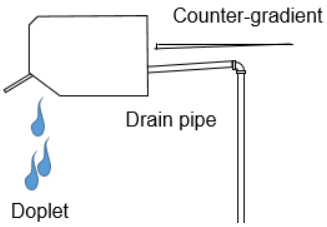
3) Air conditioning system

Air conditioning system has several types of system, such as central air conditioning system, separate unit type and so on. Each type has a merit and/or demerit, which has been considered and selected by designer. Therefore, Inspector has to check the condition of construction at on-site inspection. Site engineers will inform and discuss some problems with designers, if any.



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

Figure 2-95 Limit of refrigerant pipe length

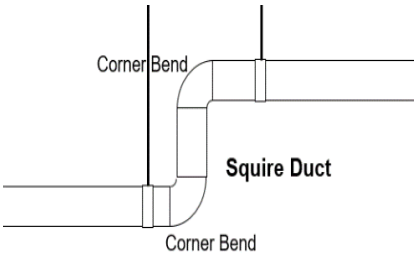


b) Drain pipe for inside unit shall not be counter-gradient to avoid a droplet.

Figure 2-96 Working laying of AC unit drainpipe

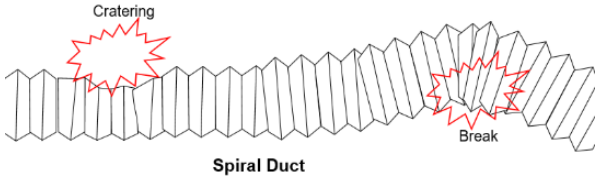
4) Air-ventilation facility

Air ventilation systems, especially ducting mechanical ventilation systems, have to be executed carefully without any damage such as dents, crushing and others for the duct.



a) In the case of squire duct, a corner bend shall be minimized to avoid losing the ventilation efficiency.

Figure 2-97 Working arrangement of squire



b) In the case of Spiral duct, the material shall not be damaged during installation work, some of which are Cratering, Break and so on.

Figure 2-98 Damages of spiral duct

2.4.3.2 Electrical work

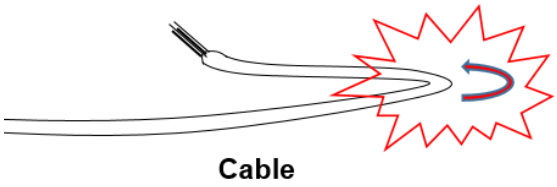
Cable route, cable size and other design points have been designed by designer, therefore, the construction work has to be executed following design documents.

In addition, Electrical work also has some careful points during the construction work. There are many kinds of work on Electrical work such as power receiving, Feeder apparatus, Light outlet equipment, and others. Furthermore, the used material/ equipment has many kinds such as Trans, Condensers, Panels, Breaker, Cables, and so on. Herein a part of the major careful points in cabling work would be introduced.

1) Cable materials

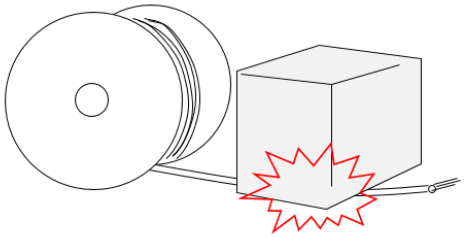
Cable materials shall not be damaged during construction work and the stock on site are as below.

Scratch on the covering material on wire has to prevent, and the handling of cable materials must be carried out carefully.



a) Do not bend cable drastically to prevent damage of inside wire

Figure 2-99 Drastic cable bent



b) Do not put something on the cable and do not walk on the cable

Figure 2-100 Incorrect handling

2) Cabling work (Laying cable/wire)

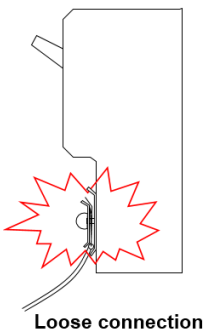
It is necessary that Laying cable and/or wire has to be executed with the below to prevent heating up of cables.

a) Laying cable/ wire has to be executed with suitable additional length

b) Do not lay a cable with much surplus length.

c) Laid cable has not to lay in a muddle (Correct cable arrangement is necessary)

3) Connecting cable



It is necessary that the cable has to be fixed rigidly to prevent heating up of cables when cables connect to terminal on the Breaker and/or others.

In addition, cable connecting to outlet, lighting fixture and others are also as well as a connection to terminal.

Figure 2-101 Loose cable connection

4) Cable arrangement

Laid cable on a cable tray and/or set cable at a cable ladder shall not be in a muddle condition, so that the cable shall be arrange the condition after laying a cable.

(Refer to the illustration below)

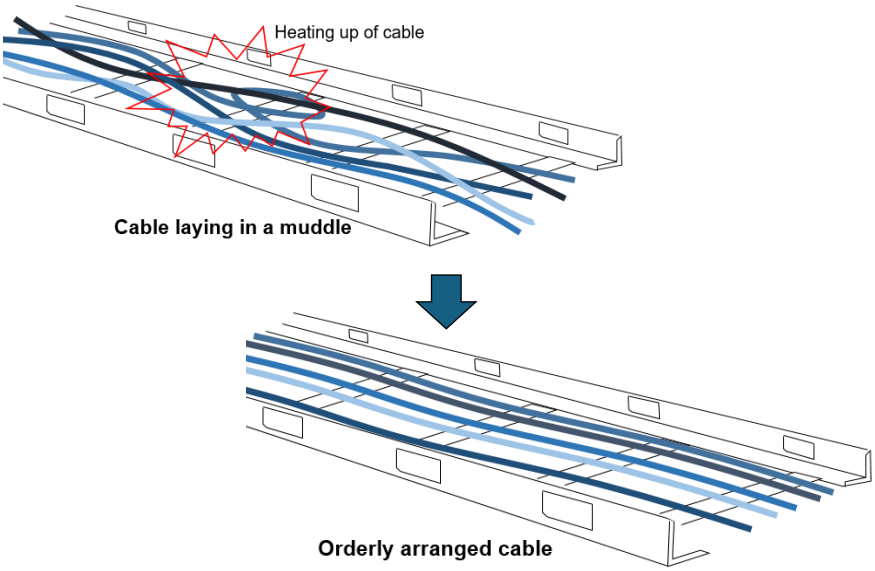


Figure 2-102 Cable arrangement

2.4.4 Fire prevention

Fire prevention facilities and Firefighting equipment have been included in M&E works.

For example;

Fire prevention facilities and Firefighting equipment have been included in M&E works.

For example;

Fire alarm system in fire prevention facility classify in one of electrical work, so that the careful point for cabling work is same as cabling work in Electrical work.

And integrated hydrant system and/or sprinkler system in firefighting system are included in Mechanical work, and that the piping work shall avoid convexity piping without any countermeasure such as air valve as well as plumbing work.

Those facilities and/or equipment have to be designed following BNBC, BCR and/or Fire prevention law, therefore, construction work must be executed as the requirement of design document. Herein we will explain some basic points for detector installation location and preventing the spread of smoke and fire, which inspectors can easily check during construction inspections.

2.4.4.1 Setting location of Smoke detector and Heat sensor.

Smoke detector and Heat sensor shall be located at the position where could detect a fire easily.

1) Setting distance from beam and/or Wall

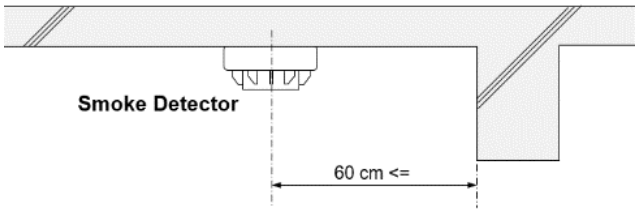


Figure 2-103 Setting location for smoke detector

a) In the case of Smoke detector, it has to be set at 60 centimeter and more from Wall and/or Beam position.

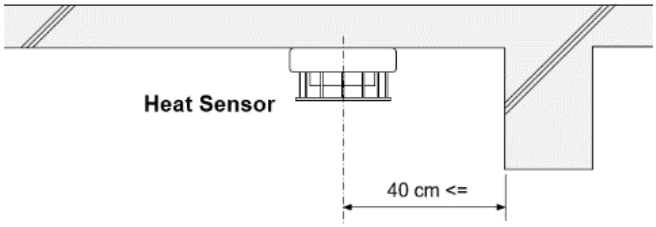


Figure 2-104 Setting location for heat sensor

b) in the case of Heat sensor, it shall be set at 40 centimeter and more from Wall and/or Beam position

2) Setting distance from A/C unit

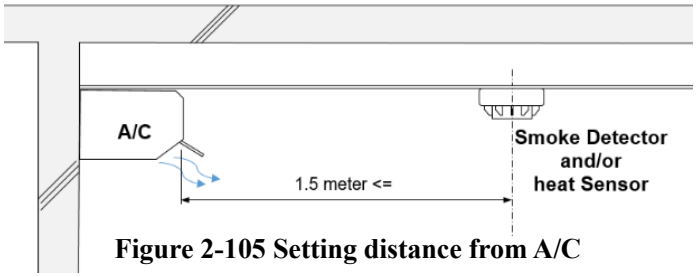


Figure 2-105 Setting distance from A/C

c) Smoke detector and/or Heat Sensor shall be placed at 1.5 meter and more from air blow port of A/C

3) Avoidance of setting at location interrupted the fire detection
Smoke detector and/or Heat Sensor shall not be placed at location prevented fire detection such as neat ceiling fan, lighting fixture and so on.

4) Setting location for fire alarm

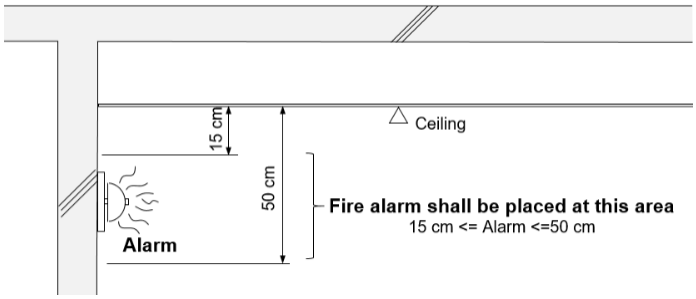
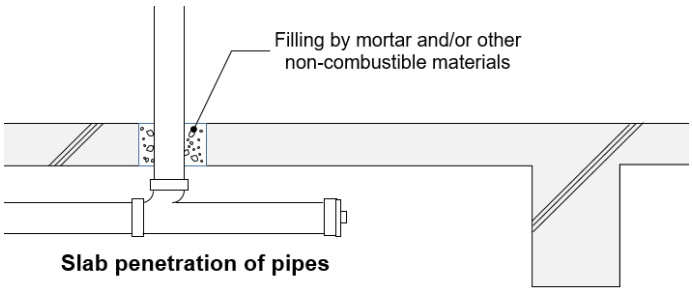


Figure 2-106 Setting position of Fire alarm

Fire alarm shall be located as showing on left figure.

2.4.4.2 Treatment for Slab and Wall penetration

Fire limit is very important point to check the spread of the fire. The following point is necessary treatment for the Fire limit.



In the case of wall penetration, the treatment for wall penetration of pipes, ducts and/or others are also same.

Figure 2-107 Treatment for slab penetration of pipe

2.4.4.3 Treatment for around a frame of fire prevention door

Mortal and/or non-combustible materials shall be filled rigidly at around the frame of the fire prevention door.

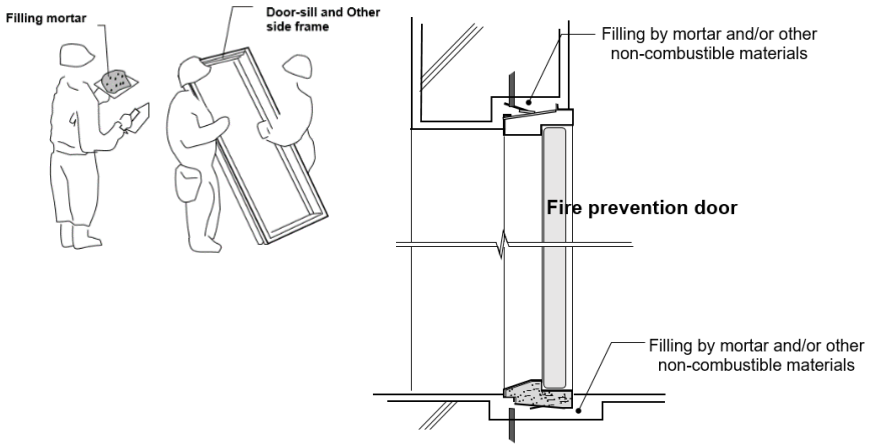
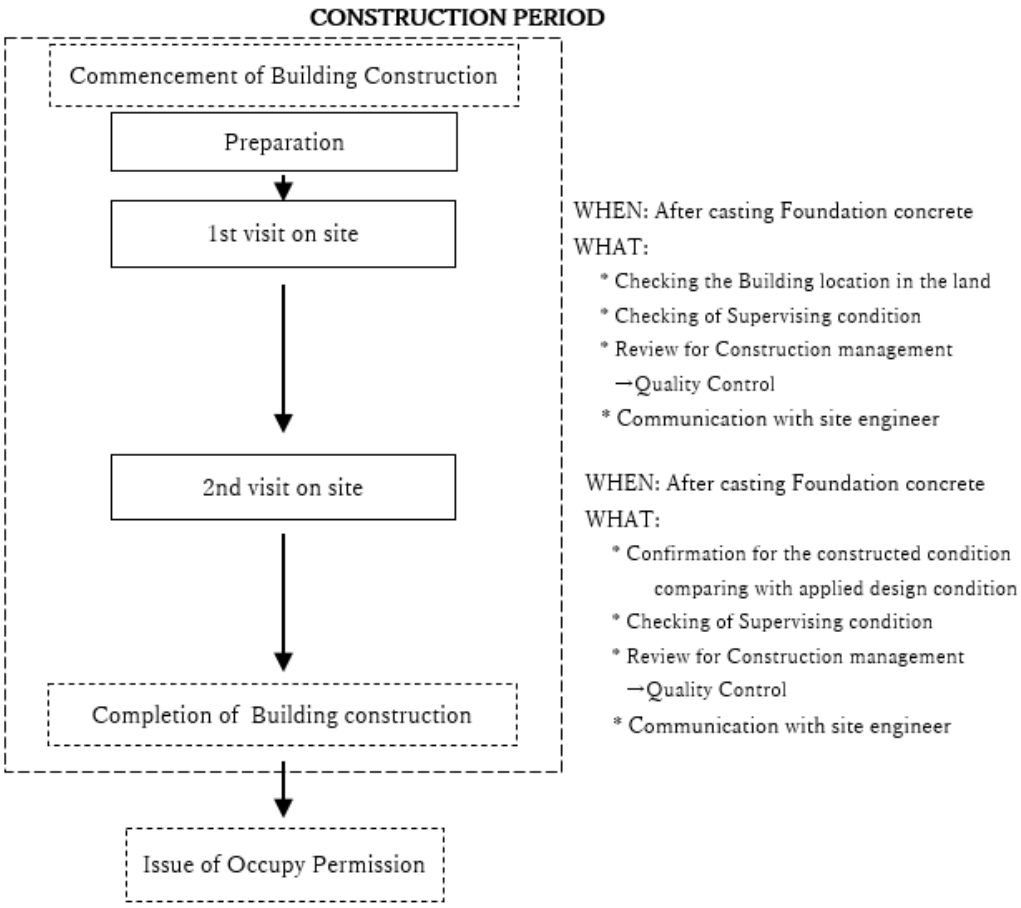


Figure 2-108 Treatment for Fire door frame

Chapter 3 On-site inspection

Construction inspections are carried out based on the workflow shown below (1.3.1.3 Construction inspection/excerpt from workflow diagram), but here we will explain construction inspections at construction sites in more detail.



3.1 Preparation

When RAJUK carry out a site inspection, some preparation work shall be executed to make a smooth inspection. Furthermore, it is very important to make a correct image, some of which are what is aimed at by designers such as design concepts and what is risk for Building Quality. Herein the preparation work will be explained.

3.1.1 Pre-study

Basically, each Building has applied the design which is permitted by RAJUK. Therefore, Inspector has to check the inspection points in prior of site visit to execute site inspection smoothly and correctly.

3.1.1.1 Applied design

All of Building construction has to follow all permitted conditions, therefore, the permitted

drawing shall be confirmed again. Refer to Table3-1 “Confirmation contents on permitted design”.

Table 3-1 Confirmation of permitted design

Category	Works	Contents	Confirmation Points		
			Number	Value	Specification
General	Layout	The set-back distance from Front road	-	✓	-
		The set-back distance from Front neighbour boundary	-	✓	-
	Outline	Structural style (RC, S, SRC)	-	-	✓
		Top height of Building	✓	-	-
		Number of building story	✓	-	-
		Total area of Building	-	✓	-
		Number of Staircase	✓	-	-
		Width of stairs	-	-	✓
		Maximum distance from stair case.	-	✓	-
		Width of corridor	-	✓	-
	Fire Prevention/ Fire Fighting	Smoke detector	-	-	✓
		Heat sensor	-	-	✓
		Fire alarm	-	-	✓
		Fireplugt/ Fire hydrant (Box, Hose)	-	-	✓
		Connecting water supplying pipe	-	-	✓
		Sprinkler system	-	-	✓
		Fire extinguisher (Potable)	-	-	✓
		Heat resistant cable	-	-	✓
		Heat resistant wireway	-	-	✓
		Emargency Lamp	-	-	✓
		Exit sign	-	-	✓

3.1.1.2 Re-conformation of permitted condition

As if there are some requirements to be permitted, all point shall be re-confirmed. Refer to Table3-2 “Requirement of Design permission”.

Table 3-2 Confirmation of requirements to be permitted

Category	Contents	Requirements/ Comments on Permission
Layout	Set-Back distance	
Outline	Building Height	
	Building story	
	Total area og Building	
	Number of staircase	
	Width of stairs	
	Width of corridor	
Fire prevention/ Fire fighting	Fire prevention system	
	Fire fighting system	
Additional Requirement/ Comennts		

SAMPLE

Building structure shall follow strictly with designed specifications, drawing and any notes to achieve a required quality. Therefore, designed structural condition shall be confirmed in prior of the site inspection, which confirming points are shown on the Table3-3 “Designed specification”.

Table 3-3 Designed specification

Category	Works	Contents	Confirmation Points		
			Notes	Drawing	Specification
Piling Work	Pile type	Pile type (Pre-fabricate pile, Bored pile, otthers	-	✓	✓
	Piling	Confirmation method of bearing capacity	-	✓	✓
		[Pre-fabricated pile] Confirmation of tearment for pile joint	-	✓	✓
		[Bored pile] Rebar cage (Main bar, Spiral bar, concrete spacer,etc.)	-	✓	✓
		[Bored pile] Rebar cage (Main bar, Spiral bar/ Hoop, Spacer)	✓	✓	✓
		[Bored pile] Concrete specification	✓	✓	✓
Earth work	Excavation	Excavating depth	-	✓	-
		Confirmation method of sub-grade	✓	-	-
	Graveling	Graveling material (Kinds, Size)	-	✓	✓
		Graveling thickness	-	✓	-
	Backfilling	Backfilling Materials	✓	-	✓
		Condition of compaction (Method, Value)	✓	-	✓
Concrete work	Re-bar	Material grade	-	-	✓
		Required dia-meter in each kind Rebar	-	✓	-
		Splicing length and Anchoring length	-	✓	✓
		Concrete covering size	✓	-	✓
	Formwork	Shuttering size in each position (Column, Girder/Beam, Slab)	-	✓	-
		Construction Level (Bottom of Girder/Beam, Slab and Top of Column)	-	✓	-
	Concrete	Mixing strength	-	-	✓
		Size of aggregate	-	-	✓
		Strongness of aggrigate	-	-	✓
		Particle size of fine aggregate	-	-	✓
		Required Admixture	-	-	✓
		Water-cement ratio	-	-	✓
		Required slamp	-	-	✓

3.1.2 Preparation for Inspection Sheet

RAJUK Inspector shall prepare Inspection sheet considering the current site progress referring the pre-studied points such as “Confirmation of permitted design”, “Confirmation of requirements to be permitted” and “Designed specification”.

The inspection point shall be listed up on Inspection Point Sheet, which shall include the following points;

3.1.2.1 Inspection date and time

Inspection date and time shall be recorded.

3.1.2.2 Inspector Name

Inspector’s name shall be recorded.

3.1.2.3 Building Name

Inspecting Building name shall be recorded.

3.1.2.4 Construction progress on site

Construction progress on site at inspection day shall be confirmed previously to be ensured which point should be confirmed.

3.1.2.5 Checking point

Checking point shall be focused according to the site progress, which points can be referred to contents of "(1) Pre-study". The format will be attached on "Chapter 5 Annex".

3.2 Inspection

3.2.1 Communication on site

RAJUK inspector shall communicate with site supervisor and site engineer to catch an exact site management, which communication point is below.

3.2.1.1 Supervising condition

Site management seriously influence to the "Building Quality", therefore, the management condition shall be checked and RAJUK inspector shall comment and advise suitably to Supervisor and Constructor.

1) Preservation of construction documents

Building design shall be implemented as designed condition shown on the construction document such as drawing, specification and any other notes by Designer. In addition, Construction rules, regulations and any stipulations which are implemented by Bangladesh, Dhaka and/or the construction area shall be followed completely.

Therefore, those documents shall be under the condition always to be confirmed timely during construction term. Furthermore, the construction conditions are important for Building Quality also, therefore some other documents for construction record and/or evidence had better to be confirmed. That document has to be controlled suitably.

Table 3-4 Control Document for Construction

Category	Name	Contents	Prepared/ Issued		Keeping in		
			N/A	Applied	Site Office	Head Office	Nothing
Construction Documants	Design drawing	Required Building Contents		✓	-	-	✓
	Specification	Required grade, allowable error, other requirements		✓	-	-	✓
	General notes	Requirement for the constrcution					
Control Documents	Shop-drawing	Detail demention, Arrangement, etc.					
	Working procedure	Construction Methodlogy Document					
Construction evidence	Material warranty	Evidence of materials Quality such as rebar millsheet					
	Test report	Test report for crushing test, tensil test,others					
	Working photograph						
Construction law, Regulation, Stipulation	BNBC	Construction rule, requirement					
	BCR (RAJUK Gazzete)	Construction rule, requirement					
	Other stipulations	If any					

2) Arrangement of site management engineer and/or technical supervisor

RAJUK shall check the arrangement of site engineers such as site management engineer and technical supervisor for the Building Quality, and that RAJUK has to notify and instruct necessary comments to Building owner, if any.

Therefore, Building owner, Constructor and RAJUK have to cooperate and share the responsibilities on their duty to achieve the Building Quality, The duty in each party has been explained

Refer to Chapter 1-3-2) “Definition of each party” and Figure 1-2 “Duty on each party”

3.2.1.2 Supervising record

Site engineers have to confirm the important reports such as test reports, quality certificates, and photographs, and have to file to prove their construction performance.

Thus, RAJUK inspector has to make good communication with site supervisor or contractor and check the performance of Quality Control. Again, Building quality is seriously influenced by site behavior even though the design has been followed construction laws, regulations and other stipulations. Thus, suitable constructing style has to be required for Building Quality. Furthermore, it is not cost but careful sense.

3.2.2 Contents for Site Inspection

In actual construction inspections, it is necessary not only to check the results of the construction (position, dimensions, etc.), but also to check the status of QA/QC activities at the construction site, construction record, and material inspection reports, furthermore, it is also important to confirm that the contents of the construction records match the actual construction results.

3.2.2.1 Checking of QA (Quality Assurance) and QC (Quality Control) Activity

QA/QC actions is very important for Building Quality, therefore, RAJUK inspector shall check on site QA/QC action and give suitable advice and/or instructions, if any.

1) Quality Assurance (QA) and Quality Control (QC) by Contractor

Site engineers have to make a construction plan to achieve the required quality as designed condition, which is shop-drawing, working procedure, and so on. It is called Quality Assurance.

Again, the established construction plan (working plan) shall be followed and executed actually, and the result of construction work according to the working plan. As if the result has not matched with required Quality (Condition), the construction plan shall be checked and revised, if any.

2) QA activity

Site engineers have to establish some activities such as QA for Building Quality, some of which are working procedure, shop-drawing and any other construction documents such

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, priorty and/or relationship among all working activities shall be clearly explained
- A-6 Execution schedule
- A-7 Careful point and/or Important point
  - * Anyother pioints to be clear-understanding of the work
- A-8 Safety measures

B. Paticular (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

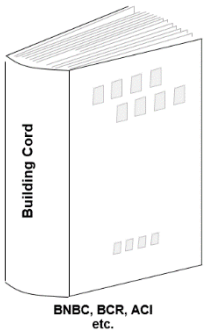
C. Formats
- *Sample for report, record and others

as Instruction Document. Prepared document has to be checked to catch the engineering condition.

Working procedure: Site work shall be executed considering with site circumstance, working difficulty, all of careful points and any working risk. Therefore, working procedures have to be prepared previously to avoid any confusion and/or miss-understanding. The contents on the work procedure as showing on the right.

a) Shop Drawing: Shop drawings shall be provided to avoid any miss-construction, because necessary information for site construction is described on Design drawing, specification document and/or general notes. It is needed to review several documents for each construction step.

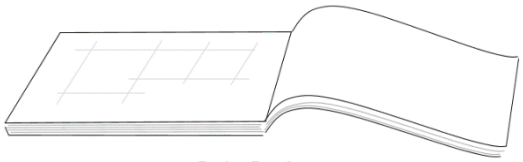
In addition, some working points shall follow to BNBC, BCR and other regulations such as ACI etc. It is very complicated condition, so that those following points shall gather on one drawing part by part and item by item, which is shop-drawing. Again shop-drawing shall show what kind of materials shall be used, which point shall be cared for, how to assemble, etc.



Allowable error, Construction rule and/or stipulation

Requirement for;

* Construction behavior such as application, technical stipulations, checking points and/or reporting points
* Following point for designing



Design Drawing

Building dimensions, material size, required treatment, etc.

Requirement for;

* Each dimension of Building such as each span distance, beam and column size, finishing detail in each location and any other requirements for Building construction, etc.

Specification

Material grade, strength, type, etc.

Requirement for;

* Material grade/ type such as its quality
* Material strength such as tensile strength of Rebar, compressive strength of concrete.
* Technical Notes such as construction method, etc.

All required information is consolidated on one sheet (Shop-drawing)

Some kinds of shop-drawing are shown the below table 3-5 “Kinds of shop-draw

Table 3-5 Reference list of Shop-drawing

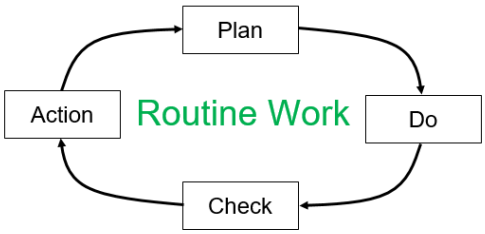
Category	Name	Descriptions	Reference Design document		
			Drawing	Specification	General notes
Piling Work	Pile arrengement	Piling position, piling depth or top level/ bearing soil layer, Type of pile, etc.	✓	✓	✓
	Pile fabrication drawing	[Pre-fabricated pile] size, lendth ,number. Reinforcing method, etc.	✓	✓	✓
	Pile rebar	[Bore Pile] Maing 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 thicness, 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 arrangement.	✓	-	✓
		[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 requlation and/or stipulation such as BNBC, BVR, and others.

3.2.2.2 QC action on site

Quality control is the process of ensuring that construction work meets the required quality standards. Therefore, inspectors must understand the content of QC activities, verify the work being carried out by the contractor, and provide appropriate advice and recommendations.

Actually, QC action would be performed with the following steps;



1st Step: Make an execution plan

2nd Step: Do the plan

3rd Step: Assess efficacy

4th Step: Make a countermeasure to improve.

Figure 3-1 PDCA Working Cycle

First of all, exact working plan/procedure shall be devised to process construction work.

Subsequently, the established working plan/ Procedure shall be executed, and assess the efficacy, and then the working plan will be revised to improve the efficacy, which is called PDCA working cycle, and it is well-known QC action in the world. Thus, the construction action and the result shall be checked day by day and/or step by step, and the countermeasure shall be planned and executed without any downtime, if any.

3.2.3 On-site Inspection by RAJUK

Constructed condition shall be checked, confirmed and recorded, and that RAJUK inspector shall review the supervising/Construction record and compare with actual site condition directly using check-list. According to the duty of each party concerned the building construction, the daily checking shall be executed by site engineer and site supervisor, so that RAJUK duty is to check and confirm the site engineering (supervising) condition. Thus, Site-Inspection by RAJUK shall check the construction behavior such as material certification, record of construction behavior and the supervising and required test report.

Basically, RAJUK Inspection will execute at three terms such an initial term (Beginning of Construction), Construction term and Completion of construction term, and that it might be several times during the constriction term.

It is most important point that required Building Quality would be achieved or not, so that an object on RAJUK Inspection has three main points as below.

Again, RAJUK inspection shall be executed following the point mainly.

3.2.3.1 Urban Design

a) Building Layout stipulated on BCR 2008

b) Purpose of the Building stipulated on DAP (Detailed Area Plan)

3.2.3.2 Designed Condition (Required Building Quality) under construction

a) Structural detail point (Rebar, Shuttering and Concrete during construction)

b) Structural detail point (Rebar, Shuttering and Concrete during construction)

3.2.3.4 Constructed Building condition

a) Set back distance and Maximum height of the Building stipulated BCR

b) Fire-prevention and Emergency evacuation

Especially, Construction for Design condition has to check and confirm, some of which are site activities of QA/QC and the constructing action.

Main checking point and the method are showing the following tables.

Table 3-6 Checking items and points (1)/Layout, Pilling work, Earth work

Term	Category	Subject	Checking point	Inspection Style		
				Measurement	Report/Photo	Visual check
Initial Term	General	Layout	Actual constructing position for the Building	✓	-	-
			Actual Set-back distance from front road and/or adjaent boader	✓	-	-
			Actual circumstance around the construction land	-	-	✓
Construction Term	General	Layout	Actual constructing position for the Building	✓	-	-
			Actual Set-back distance from front road and/or adjaent boader	✓	-	-
	Structure	Piling work	Executed piling length and depth	✓	-	-
			Confirmed the condition of bearing layer at pile tip position	-	✓	✓
			Level of the pile head position	✓	✓	
			Teatment of pile head	-	-	✓
			Executed pile position	✓	✓	
			[Driving pile] Hanmering times	-	✓	-
			[Driving pile] Pnnecting condition of pile joint	-	✓	✓
			[Bore pile] Cleaning condition of bored hole (Removal of slim)	-	✓	✓
			[Bore pile] Casting condition of pile concrete	-	✓	✓
		Earth work	[Excavation] Excavated area	✓	✓	-
			[Excavation] Excavated depth	✓	✓	-
			[Graveling] Grading condition (excated sub-grade condition)	-	✓	✓
			[Graveling] Gravel and/or Crush stone material (Size/ Thickness)	✓	✓	-
			[Graveling] Compaction of Gravel/ Crush stone	-	✓	✓
			[Backfilling] Thickness of each filling layer	✓	✓	-
			[Backfilling] Result of compaction	-	✓	-

Table 3-7 Checking items and points (2)/ Rebar work

Term	Category	Subject	Checking point	Inspection Style		
				Measurement	Report/Photo	Visual check
Construction Term	Structure	Rebar work	[Materials] Required grade	✓	-	-
			[Materials] Required size	✓	-	-
			[Materials] Delivered/ stock condition		-	✓
			[Fabrication] Column Mainbar: Diameter and length	✓	✓	-
			[Fabrication] Column Mainbar: Length of end hook (Top only)	✓	✓	-
			[Fabrication] Column Mainbar: Bending angle of end hook (Top only)	✓	✓	-
			[Fabrication] Girder/Beam Mainbar: Diameter and length	✓	✓	-
			[Fabrication] Girder/Beam Mainbar: Length of end hook	✓	✓	-
			[Fabrication] Hoop/Stirrup: Bending angle angle	✓	✓	-
			[Fabrication] Hoop/Stirrup: Bending size and diameter	✓	✓	-
			[Fabrication] Hoop/Stirrup: Hook length	✓	✓	-
			[Arrangement] Column Mainbar: Size and number	✓	✓	-
			[Arrangement] Girder/Beam Mainbar: Size and number	✓	✓	-
			[Arrangement] Hoop/ Stirrup: Size and number	✓	✓	-
			[Arrangement] Hoop/ Stirrup: Starting position	✓	✓	-
			[Arrangement] Hoop: Arrangement at panel zone	✓	✓	-
			[Arrangement] Web bar: Size and number	✓	✓	-
			[Arrangement] Slab Mainbar: Size and number	✓	✓	-
			[Arrangement] Slab Mainbar: Start position of the arrangement	✓	✓	-
			[Arrangement] Slab Mainbar: Anchor position	✓	✓	-
			[Arrangement] Slab Mainbar: Anchored length	✓	✓	-
			[Arrangement] Slab Distribution bar: Size and number	✓	✓	-
			[Arrangement] Slab Distribution bar: Start position of the arrangement	✓	✓	-
			[Arrangement] Slab Distribution bar: Anchor position	✓	✓	-
			[Arrangement] Slab Distribution bar: Anchored length	✓	✓	-

* Stir rebar shall be same as slab rebar

Table 3-8 Checking items and points (2)/ Rebar work

* Report includs certificate

Term	Category	Subject	Checking point	Inspection Style		
				Measurement	Report/Photo	Visual check
Construction Term	Structure	Rebar work	[Placing condition] Mainbar: streightness of arranged bar	-	✓	✓
			[Placing condition] Mainbar: Splicing zone	-	✓	✓
			[Placing condition] Mainbar: Splicing length	✓	✓	-
			[Placing condition] Mainbar: Anchored length	✓	✓	-
			[Placing condition] Mainbar: Anchored position	-	✓	✓
			[Placing condition] Mainbar: Concrete spacer position and size	✓	-	✓
			[Placing condition] Hoop/Stirrup: Holizontality	-	✓	✓
			[Placing condition] Hoop/Stirrup: Verticality	-	✓	✓
			[Placing condition] Hoop/Stirrup: Concrete spacer position and size	-	✓	✓
			[Placing condition] Web bar: Streightness	-	-	✓
			[Placing condition] Web bar: Arranged pitch	✓	-	-
			[Placing condition] Slab Mainbar: Horizontality	-	-	✓
			[Placing condition] Slab Mainbar: concrete cover size	✓	-	✓
			[Placing condition] Slab Distribution bar: Horizontality	-	-	✓
			[Placing condition] Slab Distribution bar: concrete spacer size	-	✓	✓
			[Placing condition] Slab bar: Space between Mainbar and Distribution bar	✓	-	-

* Stir rebar shall be same as slab rebar

Table 3-9 Checking items and points (3)/ Formwork

* Report includs certificate

Term	Category	Subject	Checking point	Inspection Style		
				Measurement	Report/Photo	Visual check
Construction Term	Structure	Formwork	[Shoring] Materials: Condition (rust, damages such as cruck and/or bent)	-	✓	✓
			[Shoring] Constructed condition: Rigid and/or Loose	-	✓	✓
			[Material] Plywood condition: Peeling the surface	-	✓	✓
			[Material] Plywood condition: Recycle times	-	✓	✓
			[Material] Steel Panel: Flatness, Bent, twist	-	✓	✓
			[Material] Tmber/ Pipe: Streightness, Bent, Twist, Damages	-	✓	✓
			[Fabrication] Shettring panel: Size	-	✓	✓
			[Assembling] Column: Size (X/Y)	-	✓	✓
			[Assembling] Column: Top level	-	✓	✓
			[Assembling] Column: Verticality	-	✓	✓
			[Assembling] Girder/Beam: Size (BxD)	-	✓	✓
			[Assembling] Girder/Beam: Horizontality	-	✓	✓
			[Assembling] Girder/Beam: Bottom and Top level	-	✓	✓
			[Assembling] Girder/Beam: Deflection (Curvature)	-	✓	✓
			[Assembling] Girder/Beam:Setting condition/ Rigid or Loose	-	✓	✓
			[Assembling] Slab: Horizontality	-	✓	✓
			[Assembling] Slab: Setting level	-	✓	✓
			[Assembling] Slab: Setting condition/ Rigid or Loose	-	✓	✓
			[Removal] Side shuttering panel: Terms of curing concrete	-	✓	✓
			[Removal] Bottom shuttering panel: Terms of curing concrete	-	✓	-
			[Removal] Dismantle condition: Without any impact to consrete	-	✓	-
			[Removal] Dismantle Shoring: Curing terms of concrete	-	-	✓

* Stir formwork shall be same as slab formwork

Table 3-10 Checking items and points (4)/ Concrete work

ıds certificate

Term	Category	Subject	Checking point	Inspection Style		
				Measurement	Report/Photo	Visual check
Construction Term	Structure	Concrete work	[Material] Mixing: Mixing ratio/Measurement	-	✓	✓
			[Material] Mixed condition: Slump test, Flow checking	-	✓	✓
			[Material] Delivery (Ready Mixed Concrete): Transpotation time	-	✓	✓
			[Pouring] Sprinkle water on suttering panel	-	✓	✓
			[Pouring] Cleaning in the formwork	-	✓	✓
			[Pouring] Temporary working access/stage	-	✓	✓
			[Pouring] Casting condition: Handling of a tip of concrete hose	-	✓	✓
			[Pouring] Casting condition: Tamping and vibrating	-	✓	✓
			[Curing] Cooling down: Splinkele water/ Curing compound	-	✓	✓

Table 3-11 Checking items and points (5)/ M & E work

Report includs certificate

Term	Category	Subject	Checking point	Inspection Style		
				Measurement	Report/Photo	Visual check
Construction Term	M & E	Plumbing work	[Water supply] Piping materials	-	✓	✓
			[Water supply] Piping route	-	✓	✓
			[Water supply] pipe size	-	✓	✓
			[Water supply] Piping condition such as joint and support	-	✓	✓
			[Water supply] arrangement of air-vent	-	✓	✓
			[Water supply] arrangement of gate valve, non-return valve, other valves	-	✓	✓
			[Water supply] Piping treatment of penertarion for fire prevention section			
			[Drain pipe] Piping material	-	✓	✓
			[Drain pipe] Piping slope	-	✓	✓
			[Drain pipe] Piping route	-	✓	✓
			[Drain pipe] Pipe size			
			[Drain pipe] Piping condition such as Joint, support, others	-	✓	✓
			[Drain pipe] Arrangement of Cleaning port			
			[Drain pipe] Piping treatment of penertarion for fire prevention section	-	✓	✓
		Air-intake & Air-vantilation	Arrangement of the setting position	-	✓	✓
			Size/Area of Air intake	-	✓	✓
			Size/Area of Air ventilation	-	✓	✓
			Route of Air-intake line	-	✓	✓
			Size of Air-intake duct (spiral and/or squire)	-	✓	✓
			Size of Air-ventilation duct (spiral and/or squire)	-	✓	✓
			Ducting treatment of penertarion for fire prevention section	-	✓	✓
		Erectrical Work	Cable size and type as required design document	-	✓	✓
			Cabling route as design document	-	✓	✓
			Cable connection to be rigid	-	-	✓
			Cabling condition under a little more than exact distance	-	-	✓
			Ordinal vable arrangement	-	-	✓

Table 3-12 Checking items and points (6)/ Fire Prevention

* Report includs certificate

Term	Category	Subject	Checking point	Inspection Style		
				Measurement	Report/Photo	Visual check
Construction Term	Fire Prevebtion	Fire alrm system	[Smoke detector] Material: Product certificate		✓	-
			[Smoke detector] Arranged setting location	-	-	✓
			[Heat sensor] Material: Product certificate	-	✓	-
			[Heat sensor] Arranged setting location	-	-	✓
			[Fire alarm] Setting location	✓	-	✓
			[Cabling] Cable material	-	-	✓
			[Cabling] Matrial of condit pipe	-	-	✓
			[Cabling] Cabling treatment of penertarion for fire prevention section	-	-	✓
			[Fire limit] Wall penetration of pipe, cable, duct and others	-	-	✓
			[Fire limit] Slab penetration of pipe, cable, duct and others	-	-	✓
			[Fire limit] Treatment for gap around fire prevet door	-	-	✓

3.2.4 Safety on site work [Reference]

Safety-working is very important point to achieve the required Building Quality. There are three structures in site construction work, some of which are Cost, Schedule and Quality, and that the three structures have closely influenced in each other.

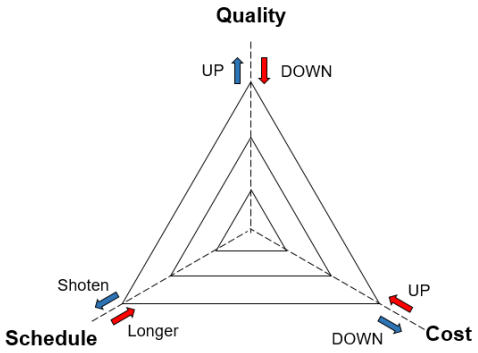


Figure 3-2 Relation-ship of 3 structures

[Quality]

It is upgraded, "Cost" will rise up, and "Schedule" (construction terms) will be longer.

[Cost]

It becomes lower (deduction), "Quality" will be go down, and "Schedule" will be longer.

[Schedule]

It will be shortened, "Cost" will be higher, and "Quality" will go down

In addition, Safety will impact to those three structures seriously, which mechanism would be checked.

In the case of breaking safety, "Schedule" will delay, and "Cost" will be required additional and then "Quality" will be going down. Therefore, Risk of safety would be same as Risk of "Quality", which reasons why safety is very important point for Building Quality.

3.2.4.1 On-site Safety

There are two pints for safety on site, which is site circumstance/condition and worker's condition. Site circumstance means working circumstance such as condition of working place, and Worker's condition means a state of fatigue.

Furthermore, "Safety condition means would be explained as first of all.

1) Stable Condition

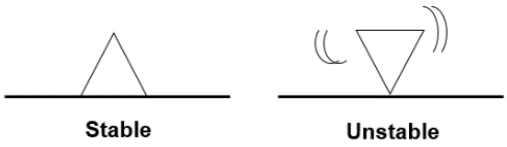


Figure 3-3 Stable & Unstable (1)

The figure on the left is very clear which condition is stable.

Therefore, the working conditions also shall be stable to perform the work with required quality and safety conditions.

For example, “Scaffolding” shall be constructed on site stably, so that it is one of risk hedge how to construct stably.

On the left figure, the following points shall be improved for safety working, which impacts to “Construction Quality” directly.

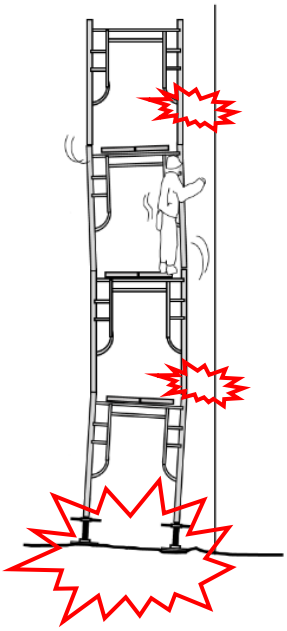


Figure 3-4 Unacceptable scaffolding

For example, “Scaffolding” shall be constructed on site stably, so that it is one of risk hedge how to construct stably.

On the left figure, the following points shall be improved for safety working, which impacts to “Construction Quality” directly.

[Risk]

* Collapse of the scaffolding
* Falling of workers and/or others
* Law workability

[Countermeasure]

* The setting position on the ground shall be level.
*The scaffolding frame shall be fixed to the structure using wall tie.

On the other hand, the motorbike which is driving by high speed is much riskier than a parked one.

Moving slowly is necessary for Safety action, and then it led the “Construction Quality” to be better.

The figure below, the following points shall be improved for safety working, which impacts to “Construction Quality” indirectly.

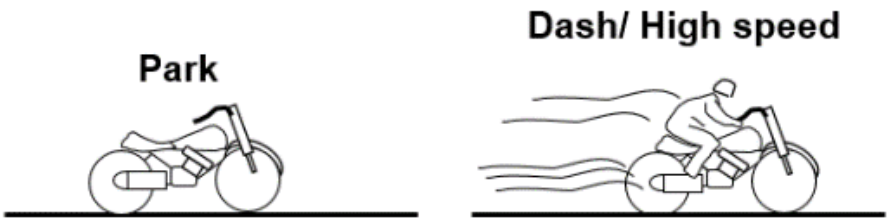


Figure 3-5 Stable & Unstable

The figure below, the following points shall be improved for safety working, which impacts to “Construction Quality” indirectly.

Figure 3-6 Unacceptable behavior

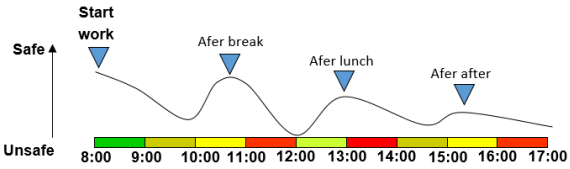


Figure 3-7 Attentiveness Biorhythm

[Risk]

*Falling down on the working place

*Spilling materials

Those incidents impact to “Construction Quality”

[Countermeasure]

*Not to fast moving on site

*Keep the safety access

2) Attentiveness Biorhythm on “Working Time”

During working time on a day, Worker is behaving according to a biorhythm on the left.

It shows recovering of an attentiveness.

Therefore, worker shall take a breaking timely to avoid an accident, and then it would impact to "Safety work" then “Construction Quality”.

3) Frequency of serious accidents

Figure 3-8 Risk Pyramid

The figure on the left shows a frequency for serious accidents, so that;

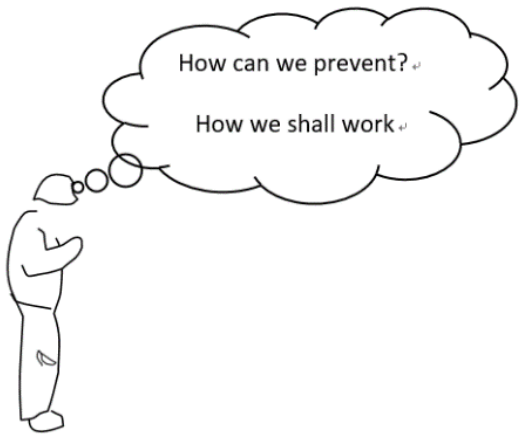
One minor accident occurs based on three hundreds a feeling as dangerous, and that one serious accident occurs based on thirty minor accidents.

Thus, If someone has felt as dangerous, all persons concerned the construction work have to pay more attention to construction safety and strive to work safely.

3.2.4.2 Prevention of Working Accident.

There are many indications for a working accident on site, therefore, site manager has to check the working condition, and assume the risk of working accident, and then make a countermeasure.

It is also very important that prevention of accidents means to keep a construction quality.



Safety working is caused by the construction circumstance and human mind of site workers.

Inspectors must pay attention to such safety work and provide advice and recommendations regarding construction safety as necessary.

3.3 Inspection Report

The confirmed construction on site by RAJUK inspection has to be recorded as a data for an empirical value.

3.3.1 Purpose

The purpose of RAJUK's on-site inspection is to confirm that the building confirmed in the design review and approved for construction is being constructed as applied for. Furthermore, the inspection records demonstrate that the inspection work was carried out reliably, and by keeping records that the construction work was carried out, they can be used as materials to check the construction status after completion.

3.3.2 Contents of Inspection Record

Inspection report has to be provided using a uniformed format, which contents shall be as follows;

3.3.2.1 Outline of Project

The outline of project shall be inspection record shall be mentioned on the inspection record, some of which are Building Name, Building Category, Application number and Owner name.

- Building name
  Building Name which is described on the application to RAJUK shall be mentioned.
- Building address and Area cord
  The address where the building will be constructed and Area cord shall be mentioned.
- Building structure
  The constructing area, Total floor area, Number of story (ground/ underground) and Structural type shall be mentioned.
- Building Category
  The category of the Building shall be mentioned, some of which are, factory/workshop, office, apartment, house and commercial building.
- Application Number
- Application number issued by RAJUK shall be mentioned
- Owner name
  Owner name shall be mentioned.

3.3.2.2 Details of Site Inspection

In addition, the details of site inspection shall be mentioned on the inspection record, some of which are Inspection Date/Time, Inspector Name, Subject of the Inspection, Inspected detail and the Result, and Comment/Message.

- Inspection Date/Time
  The inspected date and time shall be recorded.

- Inspector Name

  Inspector Name shall be mentioned, and in the case of multiple inspectors having joined, the main inspector's name shall be mentioned.
- Subject of the Inspection

  Subject of the Inspection such as initial, second time or final and/or inspection for foundation, inspection for 1st floor, 2nd Floor and/or Roof floor inspection.
- Inspected detail

  Checking results using the check list shall be attached as the record.
- Inspection result

  Total judgement of the inspection shall be mentioned.
- Comments/Message

  Comments and/or Massage for the future inspection time shall be mentioned.

3.3.3 Inspection report format

To ensure smooth and consistent on-site inspections, reports must be prepared in a prescribed format. However, if there are any deficiencies in the content, it is recommended that the content be revised before use. A sample format is attached for reference. (See the attached form.)

Draft

ON-SITE INSPECTION REPORT

Report No. _____

Building Name _____ Inspection Date : :

Address _____ Inspection Time : ~ :

Owner Name _____ Inspector Name _____

The captioned named Building has been inspected, and the inspection results are below, and the detail in each item is as attached.

1. Category/ Outline

Item	Correct	Acceptable	Rejected
Buikding Category			
Set Back			
Building Height			

Comment .....

.....

.....

2. Documentation

Item	Correct	Partial shortage	Non
Cord/ Regulatuion			
Design document			

Comment .....

.....

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3. QA/QC

Item	Correct	Partial shortage	Non
Work Procedure			
Shop Drawing			
Certificate/ Test Report			
Supervising Report			

Comment .....

.....

.....

4. Site Activities

Item	Correct	Acceptable	Rejected
Buiklding Category			
Buiklding Category			
Set Back			
Building Height			

Comment .....

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5. Issued notice/Letter .....

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6. Attachment: a) Checklist b) Photograph c. Notice/Letter d. Instruction sheet e. Others:

Chapter 4 Checklist

4.1 Purpose/ Definition

The purpose and definition are as explanation on the below.

4.1.1 Purpose for Checklist

The purpose of "MANUAL for Site Inspection" is to clarify the working outline on RAJUK Inspection, and RAJUK Inspection on site has to be carried out with uniformed criterion and checking scope. Therefore, it is important that all RAJUK Inspector will carried out the site inspection using a same (unified) checklist under basic technical knowledge as shown on the Manual. Thus, the basic technical knowledge would be root of the check list.

As an equal to the above the purpose of Manual, Checklist intend to unify the inspection points and rejecting private opinion, which is the purpose of Checklist.

In short, Checklist would simplify the site inspection and upgrade the effectiveness of the inspection on site.

4.1.2 Definition of Checklist

Checklist will be defined as follows;

1) Tool to unify the Inspection grade
2) Tool to prevent missing the inspection point
3) To show the minimum requirement for Building Quality

Therefore, RAJUK Inspector shall execute a site inspection considering the above mentioned points. The checklist would select the minimum checking points according to the definitions for site inspection.

4.2 Constitution of Checklist

Constitution of the Checklist shall be three main points, which are shown below. In addition, the item on the checklist is a part of all, and RAJUK inspection is suitably checking. Therefore, it is limited only to confirm a partial construction condition only, so that it is required that RAJUK inspector check a supervising report/record which provided by site engineer on site.

4.2.1 Building Category in constructing location

All constructing Buildings shall follow to the allowable categories required by land use clearance and/or large and special project clearance, some of which are Building height, set back distance from the road and/or boundary line of adjacent land, so that these points shall be checked on site as RAJUK site inspection.

4.2.2 Constructed condition as required by design document

Any Buildings shall be constructed following resign requirement, construction rules and stipulation such as BNBC, BCR, and any other stipulations, some of which are each dimension of the structure, required reinforcing bar (number, diameter and grade), number and size of staircase (especially for evacuation) and so on.

4.2.3 Construction Behavior

Building Quality will be impacted by construction behavior on site such as Material Handling, Construction Style/Activities, and others. It is also very important to check some test results such as tensile test results for reinforcing bar, compressive crushing test for concrete, and others.
Therefore, construction record by constructor and/or supervisor shall be checked, RAJUK inspector shall advise/instruct to make a construction record and/or report.
Building Quality will be impacted by construction behavior on site such as Material Handling, Construction Style/Activities, and others. It is also very important to check some test results such as tensile test results for reinforcing bar, compressive crushing test for concrete, and others.
Therefore, construction record by constructor and/or supervisor shall be checked, RAJUK inspector shall advise/instruct to make a construction record and/or report

The checklist has been consisted by above three compositions, and that it is minimum checking points for site inspection. Refer to attached CHECKLIST.

4.3 Important point for using Checklist

The checklist shall be used onsite, and it shall be filed as data-base for the future, which is required by BNBC stipulations. The following point has to be considered when it would be used on site.

1) The checking item shall be selected according to the site progress when it was executed. (Random Checking)

2) The important point on the Building quality based on checklist shall be confirmed by Construction photograph, Construction report and/or any other evidence such as test report, certificate, etc. (Confirmation by evidence)

3) In the case of dispatching site supervisor and/or construction engineer, it is important to communicate with them and explain what is necessary for Building Quality showing checklist (Publishing of RAJUK intention)

Chapter 5 ANNEX

ANNEX A: ON-SITE CHECKING ITEM

ANNEX B: ON-SITE INSPECTION REPORT

ANNEX C: CHECK LIST

ANNEX D: Samples of Constructed Condition on Site

ANNEX A

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ON-SITE CHECKING ITENM

August, 2025

DCQR

Items		Checking points	Checking/ Record/ File			
			Driving Pile		Bore pile	
			Photograph	Recording Data	Photograph	Recording Data
Pre-fabricated piles	Delivery	The condition of delivered pile (Grade, type)	✓	-	-	-
		The condition of delivered pile (Diameter, length, Damages)	-	-	✓	✓
	Stock & Handling	The storing condition (using timber stand, etc.)	-	-	-	✓
		Wiring condition (Minimum stress)	-	-	-	✓
	Marking	Suitable marking condition and position	-	-	✓	-
		Setting pickup point (two positions)	-	-	-	✓
	Pile Driving	Setting pile at the driving machine in plumb	-	-	-	✓
		Driving data (Pilling Depth)	-	-	✓	-
		Driving condition (Number of hammerings, Load current value, etc.)	-	-	✓	-
	Confirmation	Checking executed pile position	-	-	✓	-
		Condition of driven pile head (Damages)	-	-	-	✓
Bore-Pile	Preparation	Site mixing concrete (Concrete plant, Material storage)	-	-	✓	✓
		Ready mixed concrete (Water-cement ratio, other mixing ratio, others)	✓	✓	-	-
		Ready mixed concrete placing before starting Initial setting time)	✓	✓	-	-
		Bentonite plant	-	-	-	✓
		Surveying and marking	-	-	✓	-
		Marking condition (Pile center & backup point)	-	-	-	✓
		Storing condition of rebar	-	-	-	✓
		Fabrication of rebar cage (Diameter, number, pitch, Spacer, etc.)	-	-	✓	✓
		Fabrication of rebar cage stiffener)	-	-	✓	✓
	Boring hole	Setting casing	-	-	-	✓
		Boring condition (Plumbing)	-	-	-	✓
		Checking of Boring depth (Length & level)	-	-	✓	✓
		Confirmation of Bearing layer (Kind and condition of the soil)	-	-	✓	✓
		Cleaning condition of Bored Hole	-	-	-	✓
		Protection method for collapse of Bored hole (Top Casing, Full casing, Bentonites muddy water, etc.)	-	-	-	✓
	Pouring concrete	Using condition of tremies pipe	-	-	-	✓
		Before concreting tremies pipe seal	-	-	-	✓
		Volume of poured concrete	-	-	✓	-
		Poured concrete level	-	-	✓	-
		Additional concrete length at pile head (=+500 mm~+1000mm)	-	-	✓	-
		Curing （Backfilling on the pipe position)	-	-	-	✓
		Test (PIT, Load test)	-	-	-	✓
Earth Work/ Foundation work	Surveying	Excavation area shall be surveyed using standard line and/or Benchmark.	-	-	✓	✓
		Each surveyed result shall be re-surveyed as double checking	-	-	✓	✓
	Marking	Marking shall mark clearly using comet powder and/or Lime powder	-	-	✓	✓
		Butter board for marking shall be kept until working completion	-	-	✓	✓
Earth Work/ Foundation work	Working Space	Excavation area shall be considered enough working space	-	-	✓	✓
	Protection	Excavated slope have been covered by plastic sheet and/or others	-	-	-	✓
		Excavated areas have been covered by plastic sheets and/or others	-	-	-	✓
		Shoulder of Excavated slope has not loaded	-	-	-	✓
		Any heavy equipment and materials shall not be put on the shoulder of the slope	-	-	-	✓
		Safety fence has been constructed	-	-	-	✓
	Excavation	The excavated grade shall not disturb	-	-	-	✓
		Excavated area	-	-	✓	✓
		Excavated depth	-	-	✓	✓
		Repaired condition at damaged sub-grade, if any	-	-	-	✓
	Gravelling	Using material (Gravel, Crush stone and others)	✓	-	-	-
		Laying thickness	-	-	✓	✓
		Compacting condition	-	-	-	✓
		Compacted result (Density)	-	-	✓	✓
	Backfillig	Preparation/ Cleaning of backfilling area)	-	-	-	✓
		Preparation/ Treatment for the structure (waterproofing and/or others)	-	-	-	✓
		Preparation/ Marking of backfilling layer (300 mm and less)	-	-	✓	✓
		Backfilling materials (Kind of soil)	✓	-	-	✓
		Ensure Max dry density95%	✓	-	-	✓
Earth Work/ Foundation work	Backfilling	Backfilling materials (Crushing of soil clod)	-	-	-	✓
		Backfilling condition (Execution with well compaction in each layer)	-	-	-	✓
		Backfilling condition (Execution with sprinkling water, in the case of sand)	-	-	-	✓
		Checking compacted condition (Density test and/or CBR test)	-	-	✓	✓
		Checking compacted condition (Using trial compaction result)	-	-	✓	✓

Items		Checking points	Checking/ Record/ File			
			Driving Pile		Bore pile	
			Photograph	Recording Data	Photograph	Recording Data
Rebar Work	Material receiving	Specification of the materials (Mill sheet)	✓	-	-	-
		Sampling test	-	✓	-	✓
		Temporary stock condition for rebar (Raw material)	-	-	-	✓
		Rebar damages such as Rust, Bent, Twist, Warp	-	-	-	✓
	Fabrication	Tools for Rebar fabrication	-	-	-	✓
		Fabricated dimensions (Length, Hook, Anchor' Development length)	-	-	✓	✓
		Fabrication3/ Temporary stock condition for fabricated rebar	-	-	-	✓
	Placing condition	Placing number and size of main bar	-	-	✓	✓
		Anchored position and length of main bar	-	-	✓	✓
		Lapping position and length of main bar	-	-	✓	✓
		Distance in each main bar	-	-	✓	✓
		Placing pitch of Hoop and/or Stirrup	-	-	✓	✓
		Placing condition of Hoop at Panel zone (Size, Pitch, Number)	-	-	✓	✓
		Placing condition of spacer materials (Size, Pitch, Number)	-	-	✓	✓
		Placing condition of web bar (Size, Pitch, Number)	-	-	✓	✓
		Placing condition of tie bar (Size, Pitch, Number)	-	-	✓	✓
		Placing condition of main bar for slab (size, Pitch, Number)	-	-	✓	✓
		Placing condition of distribution bar for slab (size, Pitch, Number)	-	-	✓	✓
		Placing condition of main bar for stir (size, Pitch, Number)	-	-	✓	✓
		Placing condition of distribution bar for stairs (size, Pitch, Number)	-	-	✓	✓
		Placing condition of step bar for stair (size, Pitch, Number)	-	-	✓	✓
		Placing condition of tip bar for stir (size, Pitch, Number)	-	-	✓	✓
		Fixing condition of Rebar	-	-	✓	✓
		Setting of spacer materials for concrete	-	-	✓	✓
Formwork	Materials	Condition of shoring materials (Damage and Cleanness)	-	-	-	✓
		Condition of shuttering materials (Damage and Cleanness)	-	-	-	✓
		Condition of shuttering materials (Steel panel/Size and thickness)	-	-	✓	✓
		Condition of shuttering materials (Plywood/ Damage & Cleanness)	-	-	-	✓
		Condition of shuttering materials (Plywood/ Size and thickness)	-	-	✓	✓
		Condition of shuttering materials (Separator/ Damage)	-	-	-	✓
		Condition of shuttering materials (Formwork oil)	-	-	-	✓
	Fabrication	Panel Size	-	-	✓	✓
		Panel condition (Bent, Twist, Warp, Cleanness)	-	-	-	✓
	Construction	Setting level of shoring	-	-	-	✓
		Composition of shoring (Comparing with shoring design)	-	-	-	✓
		Shuttering panel size (width, height and/or depth)	-	-	✓	✓
		Shuttering panel straightness, plumbing, level	-	-	✓	✓
		Fixing of shuttering panel (tie-led, Weller and other supports)	-	-	✓	✓
		Size of concrete cover	-	-	✓	✓
Concreting work	Ready Mixed Concrete (Concrete Receiving)	Mixing record (mixing ration, Transportation time, Admixture)	✓	-	✓	-
		Slump test, Concrete flow, Concrete tempter)	-	-	✓	✓
		Sampling	-	-	-	✓
	Site Mixing	Mixing record (Mixing ratio, Measuring raw materials)	-	-	✓	-
		Slump test, Concrete flow, Concrete tempter)	-	-	✓	✓
		Sampling	-	-	-	✓
		Sampling	-	-	-	✓
	Preparation	Cleaning condition	-	-	-	✓
		Splining on shuttering panel	-	-	-	✓
	Casting	Carrying condition of concrete pump	-	-	-	✓
		Ready mixed concrete placing before starting Initial setting time)	✓	✓	-	-
Concreting work	Casting	Carrying condition of Concrete hopper	-	-	-	✓
		Cleanness of wheelbarrow	-	-	-	✓
		Casting sequence	-	-	-	✓
		Using concrete vibration (using style, using position)	-	-	-	✓
		Condition of casting (Tamping and/or Finishing)	-	-	-	✓
		Treatment for Construction joint	-	-	-	✓
	After execution	Curing time for Casted concrete	-	-	-	✓
		Remaining terms for Shuttering panel	-	-	✓	-
		Curing method (Sprinkling water and/or other method)	-	-	-	✓
		Crushing test results (at least 1, 4 weeks)	-	✓	-	✓
		Condition of removal formwork	-	-	-	✓
		Treatment for construction joint	-	-	-	✓

ANNEX B

Draft

ON-SITE INSPECTION REPORT

August, 2025

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Draft

ON-SITE INSPECTION REPORT

Report No. _____

Building Name _____ Inspection Date : :

Address _____ Inspection Time : ~ :

Owner Name _____ Inspector Name _____

The captioned named Building has been inspected, and the inspection results are below, and the detail in each item is as attached.

1. Category/ Outline

Item	Correct	Acceptable	Rejected
Buikding Category			
Set Back			
Building Height			

Comment .....

.....

.....

2. Documentation

Item	Correct	Partial shortage	Non
Cord/ Regulatuion			
Design document			

Comment .....

.....

.....

3. QA/QC

Item	Correct	Partial shortage	Non
Work Procedure			
Shop Drawing			
Certificate/ Test Report			
Supervising Report			

Comment .....

.....

.....

4. Site Activities

Item	Correct	Acceptable	Rejected
Buiklding Category			
Buiklding Category			
Set Back			
Building Height			

Comment .....

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5. Issued notice/Letter .....

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6. Attachment: a) Checklist b) Photograph c. Notice/Letter d. Instruction sheet e. Others:

ANNEX C

Draft

CHECKLIST

[Site Inspection]

August, 2025

DCQR

Category	Kind of Works	No	Priority	Items	Reference Cord and/or Stipulation	Checking Result		
						Acceptable	Revise/Repair	N/A
Building Category and Outline	Building Category	1	A	Occupancy of the Building is same as permitted categry	BNBC			
	Setback of Building	2	A	Distance from front road and/or pathway is same as applied condition	BNBC			
		3	A	Distance from neighboring boundary line is same as applied condition	BNBC			
	Building Height	4	A	Height of Building Top	BNBC			
Documentation	Cord/ Regulation	5	B	Standing of Construction Documents on site/ BNBC	-			
		6	B	Standing of Construction Documents on site/ BCR	-			
		7	B	Other Cords and/or Regulation Books	-			
	Design Document	8	A	Design Drawing (Architectual)	-			
		9	A	Design Drawing (Strauctural)	-			
		10	A	Design Drawing (Mechanical)	-			
		11	A	Design Drawing (Electrical)	-			
		12	A	Design Specification Book	-			
QA/QC	Work Procedure	13	C	Piling work	BNBC, ML			
		14	C	Earth work	BNBC, ML			
		15	C	Foundation work	BNBC, ML			
		16	C	Rebar work	BNBC, ML			
		17	C	Formwork/ Shuttering	BNBC, ML			
		18	C	Concrete work	BNBC, ML			
	Shop Drawing	19	B	Piling layout	ML			
		20	B	Excavation plan	ML			
		21	A	Rebar bending schedule	ML			
		22	A	Rebar arrangent/Placing	ML			
		23	B	Shoring construction drawing	ML			
		24	A	Shuttering fabrication drawing	ML			
		25	A	Shuttring Construction drawing	ML			
	Certificate/ Test Report	26	A	Soil investment report	D/R (D/D, S/D, C/N)			
		27	B	Sampled soil	D/R (D/D, S/D, C/N)			
		28	A	Grade of Reinforcing bar (Mil Sheet)	D/R (D/D, S/D, C/N)			
		29	A	Grade of Reinforcing bar (Tensil test reort)	D/R (D/D, S/D, C/N)			
		30	A	Concrete mixing design	D/R (D/D, S/D, C/N)			
		31	B	Trial Crushing test report	D/R (D/D, S/D, C/N)			
		32	A	Crushing test report	D/R (D/D, S/D, C/N)			
	Supervising	33	A	Controlled by Resident Supervisor	BNBC			
		34	A	Controlled by Supervisor suitably	BNBC			
Construction	Pile work	35	B	Material certification for the piles (Driving pile)	D/R (D/D, S/D, C/N)			
		36	B	Stock condition of derivered piles	ML			
		37	B	Rebar cage condition is followed the design requirement (Bore-pile)	D/R (D/D, S/D, C/N)			
		38	B	Concrete grade for pile is followed the design requirement. (Bore-pile)				
		39	B	Piling result (the piled position shall be under allowable deviation)	D/R (D/D, S/D, C/N)			
		40	B	Concition of pile head treatment	ML			
	Earth work	41	B	Excavatated result (Area and Depth)	ML,D/R			
		42	C	Protection for excavated area (slope protection)	ML			
		43	C	Checking the excavated condition at the sub-grade	D/R (D/D, S/D, C/N)			
		44	C	Suitable graveling materials	ML			
		45	B	Thickness of gravelling materials	D/R (D/D, S/D, C/N)			
		46	C	Condition of compaction for gravels	ML, D/R			
		47	C	Backfilling materials	ML			
		48	C	Suitable backfilling layer (Thickness of each backfilking layer)	ML			
		49	C	Compactiing condition	D/R (D/D, S/D, C/N)			
	Rebar (material)	50	B	Checking grade for rebar material (Mill sheet or Test report)	D/R (D/D, S/D, C/N)			
		51	B	Stock condition of Rebar on site	D/R (D/D, S/D, C/N)			
	Rebar (Column)	52	B	Main column rebar arrangement (Size/Number/Spacing/Hook)	D/R (D/D, S/D, C/N)			
		53	B	Main column rebar arrangement (Plumbing/Twist/Bent)				
		54	B	Splicing condition of mainbar (Position/Length/Hook)	D/R (D/D, S/D, C/N)			
		55	B	Hoop arrangement at panel zoon of Column (Size/Pitch/Hook)	D/R (D/D, S/D, C/N)			
		56	B	Hoop arrangement (Size/Pitch/Hook)	D/R (D/D, S/D, C/N)			
		57	B	Diagonal bar arrangement (Size/Number/Hook)	D/R (D/D, S/D, C/N)			
		58	B	Concrete covering size for column (Spacer size)				
	Rebar (Girder/Beam /Sub-beam)	59	B	Anchoring of Girder/Beam/Sub-beam rebar into Column (Position/Length/Hook)	D/R (D/D, S/D, C/N)			
		60	B	Main rebar arrangement (Size/Number/Spacing)	D/R (D/D, S/D, C/N)			
		61	C	Main rebar arrangement (Bent/Curbture/Twist)	ML			
		62	B	Splicing concition (Position/Length)	D/R (D/D, S/D, C/N)			

Category	Kind of Works	No	Priority	Items	Reference Cord and/or Stipulation	Checking Result		
						Acceptable	Revise/Repair	N/A
Cnstruction	Rebar (Girder/Beam /Sub-beam)	63	B	Stirrup arrangement (Size/Pitch/Direction/Hook)	D/R (D/D, S/D, C/N)			
		64	B	Web bar/tie bar arrangement (Size/Number/Pitch)	D/R (D/D, S/D, C/N)			
		65	B	Concrete covering size for Girde/Beam/Sub-beam(Spacer size)	D/R (D/D, S/D, C/N)			
	Rebar (Slab /Canopy)	66	B	Slab main rebar arrangement (Size/Pitch in esch Layer)	D/R (D/D, S/D, C/N)			
		67	B	Anchoring condition of slab main rebar (Position/Length/Hook)	D/R (D/D, S/D, C/N)			
		68	B	Splicing condition of slab main rebar (Position/Length)	D/R (D/D, S/D, C/N)			
		69	B	Slab distribution rebar arrangement (Size/Pitch in esch Layer)	D/R (D/D, S/D, C/N)			
		70	B	Anchoring condition of slab distribution rebar (Position/Length)	D/R (D/D, S/D, C/N)			
		71	B	Splicing condition of slab distribution rebar (Position/Length)	D/R (D/D, S/D, C/N)			
		72	C	Side concrete covering size for slab (Spacer size)	D/R (D/D, S/D, C/N)			
		73	C	Bottom concrete covering size for slab (Spacer size)	D/R (D/D, S/D, C/N)			
		74	C	Top concrete covering size for slab (Setting level)	D/R (D/D, S/D, C/N)			
	Rebar (Stircase)	75		Main bar arrangement for stircase (Size/Numbar/Pitch)	D/R (D/D, S/D, C/N)			
		76		Anchoring condition (Position/Length)	D/R (D/D, S/D, C/N)			
		77		Splicing condition of mainbar (Position/Length)	D/R (D/D, S/D, C/N)			
		78		Distribution bar arrangement for stircase (Size/Numbar/Pitch)	D/R (D/D, S/D, C/N)			
		79		Tip bar arrangement (Size/Number)	D/R (D/D, S/D, C/N)			
		80		Concrete covering size for bottom of stir (Spacer size)	D/R (D/D, S/D, C/N)			
	Rebar (Wall)	81		Vertical rebar arrangement for Wall (Size/Pitch in each side)	D/R (D/D, S/D, C/N)			
		82		Splicing condition of vertical bar for wall (Position/Length)	D/R (D/D, S/D, C/N)			
		83		Horizontal rebar arrangement for Wall (Size/Pitch in each side)	D/R (D/D, S/D, C/N)			
		84		Splicing condition of Horizontal bar for wall (Position/Length)	D/R (D/D, S/D, C/N)			
		85		Tie bar arrangement (Size/Number/Pitch)	D/R (D/D, S/D, C/N)			
		86		Concrete covering size for outside rebar (Spacer size)	D/R (D/D, S/D, C/N)			
	Rebar (Pile cap /Foundation)	87		Main bar arrangement for Pile cap/Foundation (Size/Numbar/Pitch)	D/R (D/D, S/D, C/N)			
		88		Distribution bar arrangement for Pile cap/Foundation (Size/Numbar/Pitch)	D/R (D/D, S/D, C/N)			
		89		Vertical rebar arrangement for Pile cap/ Foundation (Size/Pitch in each side)	D/R (D/D, S/D, C/N)			
		90		Horizontal rebar arrangement for Pile cap/Foundation (Size/Pitch in each side)	D/R (D/D, S/D, C/N)			
		91		Tie bar arrangement for Pile cap/Foundation (Size/Pitch in each side)	D/R (D/D, S/D, C/N)			
		92		Checking concrete covering size for outside rebar (Spacer size)	D/R (D/D, S/D, C/N)			
		93		Checking concrete covering size for bottom rebar (Spacer size)	D/R (D/D, S/D, C/N)			
		94		Checking concrete covering size for top rebar (setting level)	D/R (D/D, S/D, C/N)			
	Formwork (All position)	95		Shuttering material (Recycle times/Kinds/Strength)	BNBC			
		96		Construced condition of shuttering Panel (Demension/Setting level)	D/R (D/D, S/D, C/N)			
		97		Construced condition of shuttering Panel (Bent/Cirbture/Twist)	D/R (D/D, S/D, C/N)			
		98		Strength of supporting material such as timber and/or steel pipes	BNBC			
		99		Supporting material such as timber and/or steel pipes (Scrach/Lack/Peel/Rust)	ML			
	Shoring work	100		Strength of Shoring Materials (Support/Sill/Joist)	BNBC			
		101		Construction condition (Strength/Faltness/Stability)	-			
	Concrting	102		Splinkling water	ML			
		103		Conveying/Vibrating/Tamping	ML			
		104		Curing	ML			
	Fire privention	105	A	Location of Staircase (Distance/Number)	D/R (D/D, S/D, C/N)			
		106	A	Sizing of Stircase (Width)	D/R (D/D, S/D, C/N)			
		107	B	Copndition of Fire door (Fabricated condition/Installed condition)	D/R (D/D, S/D, C/N)			
		108	C	Setting condition of smoke detector/heat sensor/Gas sensor(Location/Fitting)	D/R (D/D, S/D, C/N)			
		109	B	Keeping fire zoon	D/R (D/D, S/D, C/N)			
		110	B	Condition of Fire Hydraunt (Location/Piping)	D/R (D/D, S/D, C/N)			
		111	B	Condition of Fire Hydraunt pump (Number/Setting)	D/R (D/D, S/D, C/N)			
		112	B	Condition of Splinkler system (Nozzl/Layout/System)	D/R (D/D, S/D, C/N)			

Defenition:
BNBC

D/R: Design Requirment
D/D: Design Drawing
S/D: Specification Document
C/N: Construction Notes
ML: Manual

Inspection Date
Inspection Time
Building Name
Owner Name

Inspector Name

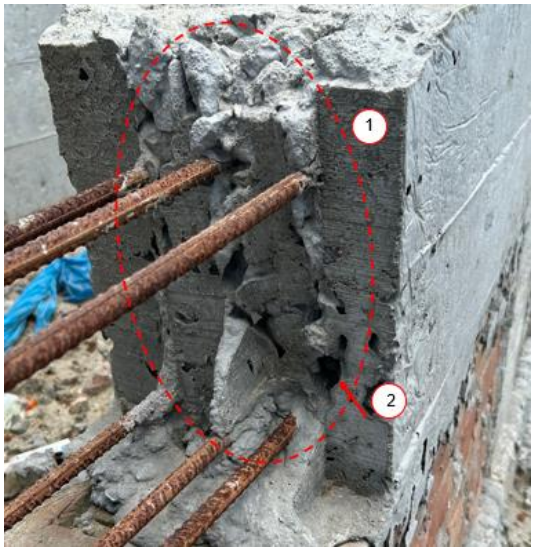
Receiveved Sign

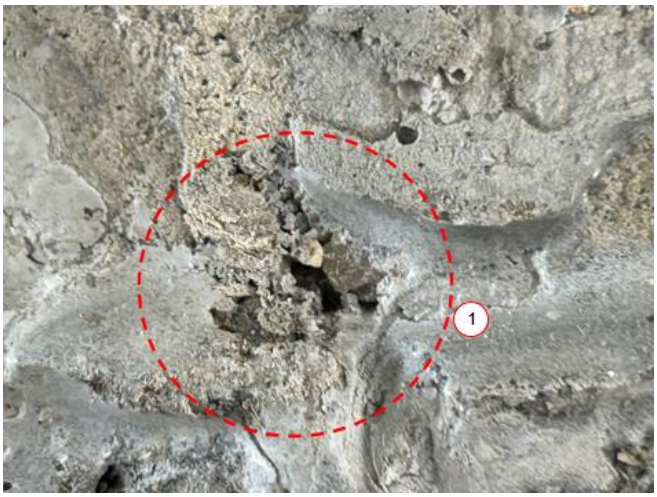
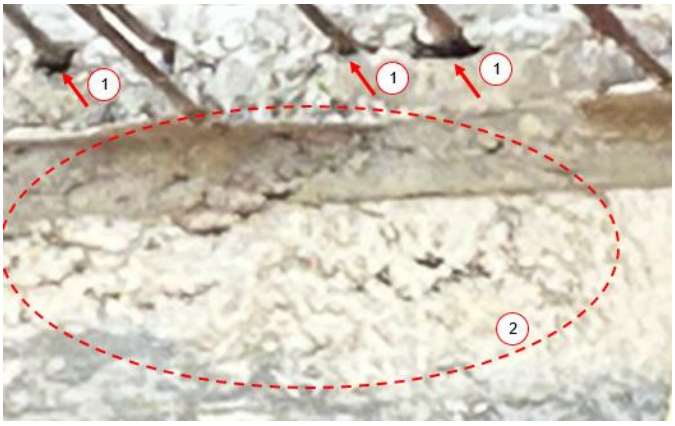
ANNEX D

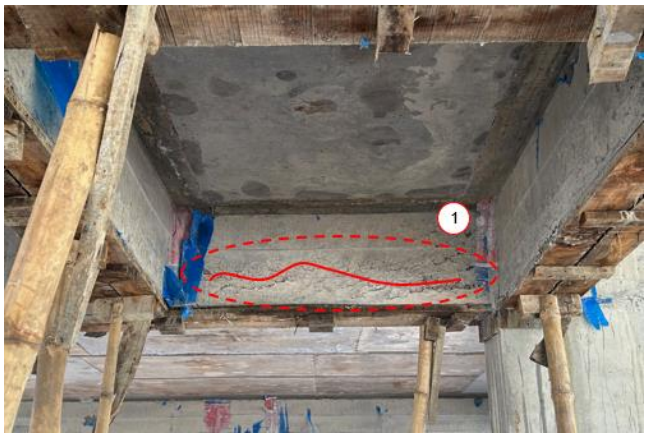
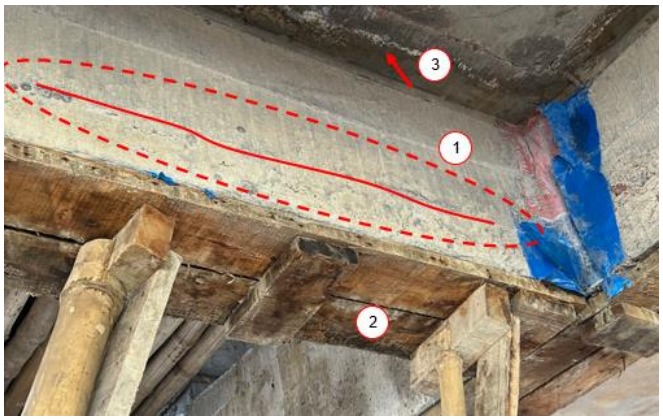
Samples of Constructed Condition on Site

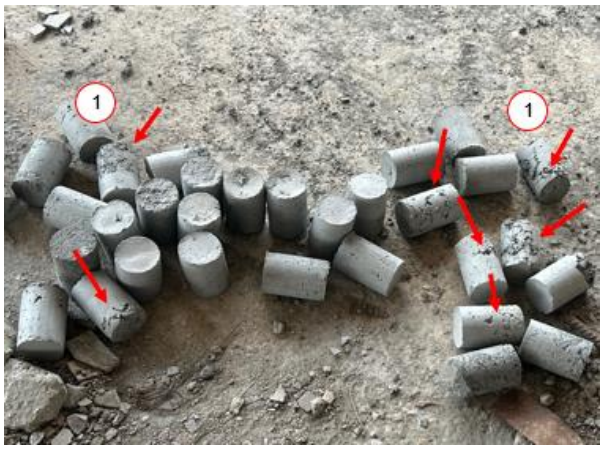
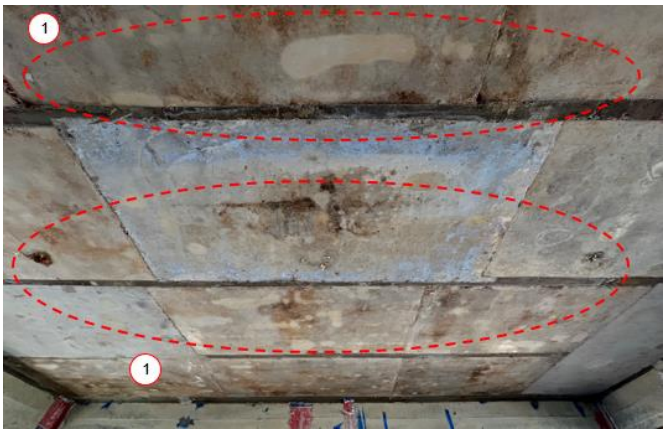
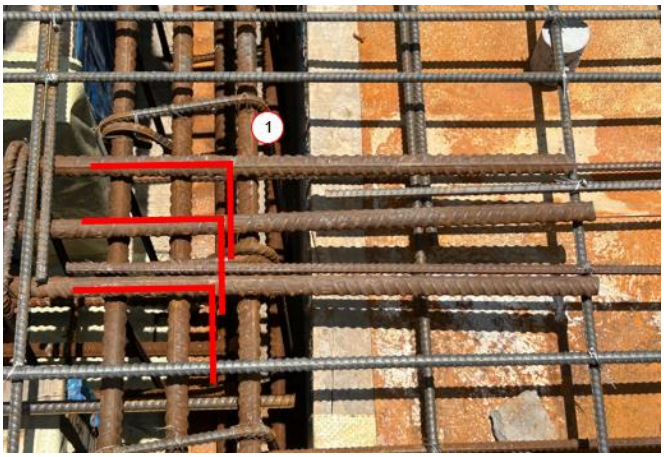
Attachment on

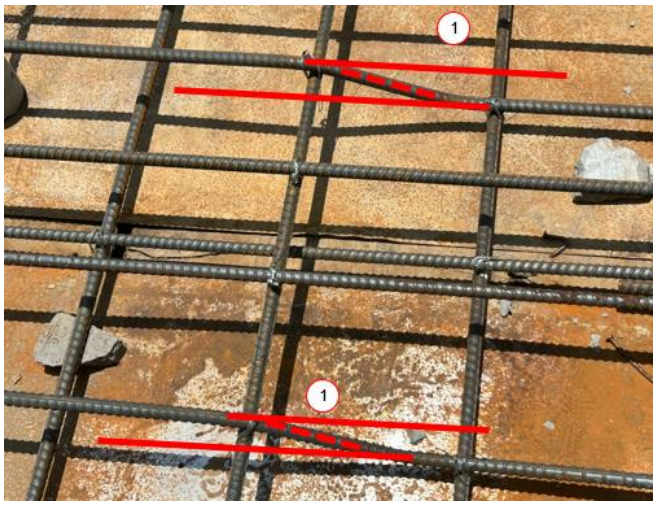
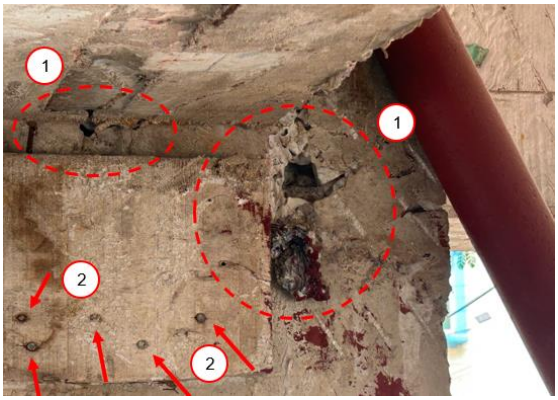
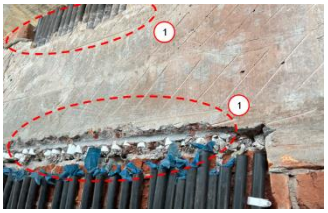
November, 2025

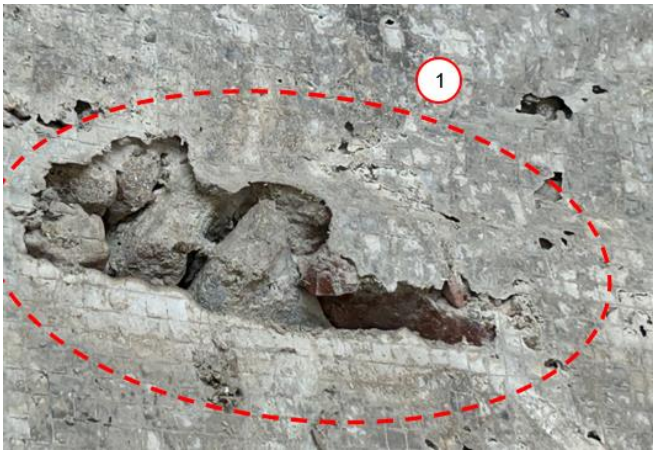
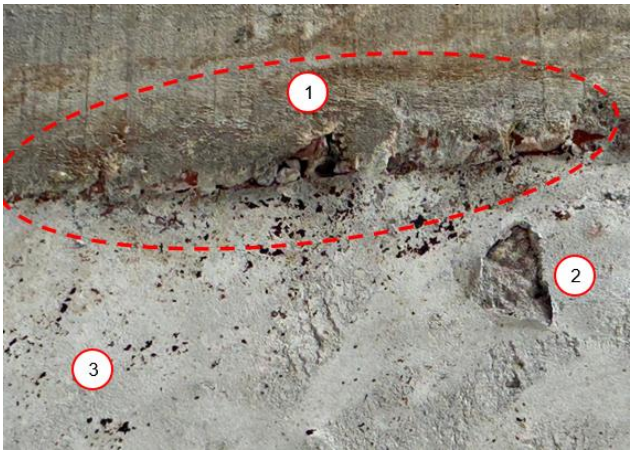
Actual Working Condition	Point/Factor	Cause
	① Honeycomb *Insufficient vibrating *Concrete separation (Wrong placing/Laying) ② Incorrect space *Wrong concrete stop	Concreting Concreting
	① Unacceptable construct joint *Incorrect concrete condition ② Concrete Cavities *Insufficient vibrating *Incorrect shuttering	Concrete-Material Concreting

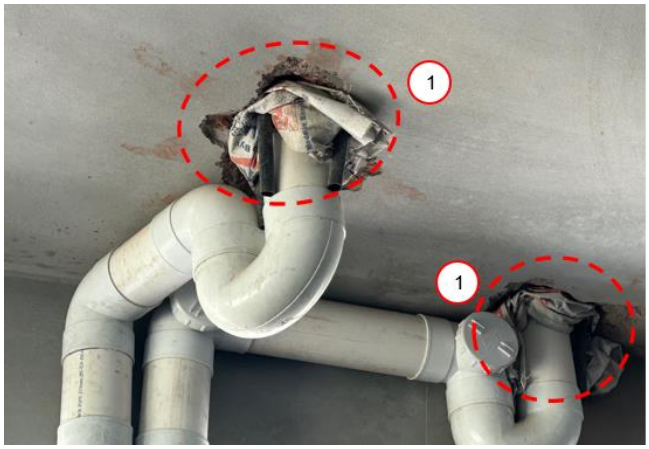
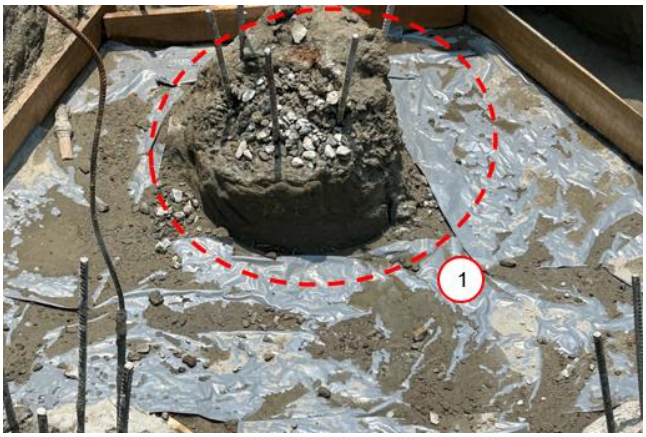
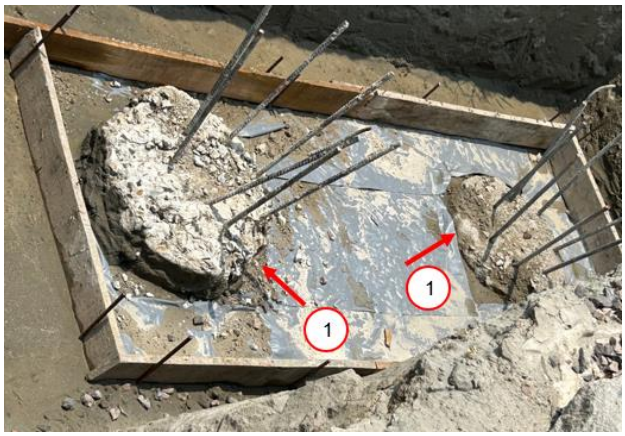
	① Concrete Cavity （Porous concrete） *Insufficient Vibrating *Strength of shuttering	Concreting
Actual Working Condition	Point	Reference
	① Chink（Gap） *Insufficient Vibrating *Incorrect water-cement ratio(Too much water) ② Porous concrete (Not rigid) *Insufficient Vibrating *Not enough shuttering strength	Concreting Concrete-Material Concreting Formwork
	① Unacceptable working condition *Lack of cleaning *Incorrect material handling	Site Arrangement

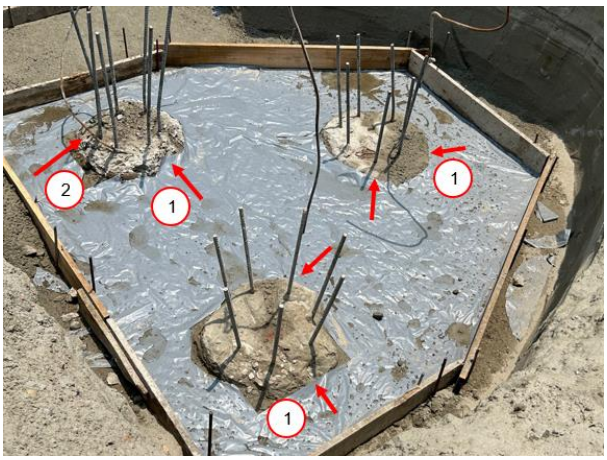
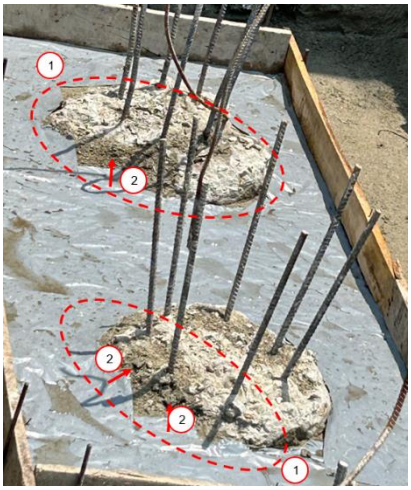
	① Cold Joint *Too much interval of casting *Insufficient Vibrating	Concreting
Actual Working Condition	Point	Reference
	① Cold Joint *Too much interval of casting *Insufficient Vibrating ② Low quality shuttering panel *Impact to concrete ③ Impurities on concrete surface (Degradation of concrete) *Insufficient Vibrating *Using bad shuttering	Concreting Formwork/ Shuttering materials Concreting Formwork/ Shuttering materials

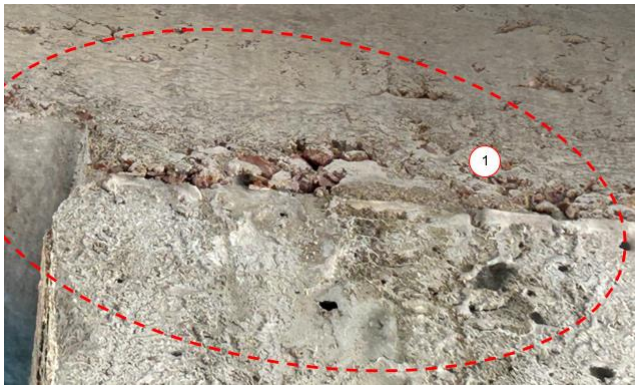
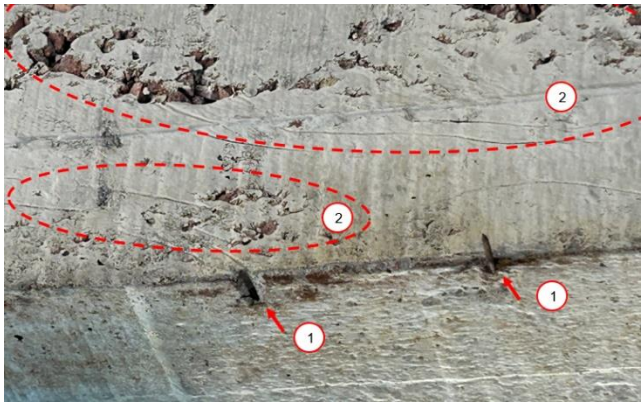
	① Low quality concrete spacer *Impact to structural strength	Concrete Spacer
	① Impurities on concrete surface (Degradation of concrete) *Insufficient Vibrating *Using incorrect shuttering	Concreting Formwork/ Shuttering materials
Actual Working Condition	Point	Reference
	① Wrong anchoring Miss fabrication *Miss bending schedule	Rebar fabrication

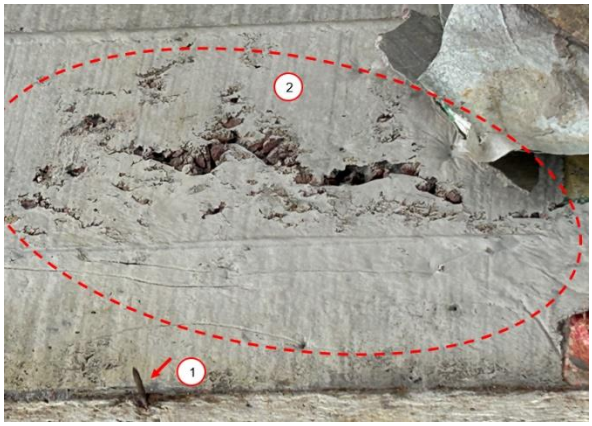
	① Wrong fabrication Miss Bending schedule	Rebar fabrication
	① Huge Concrete Cavity *Insufficient Vibrating *Too much casting interval *Insufficient strength of shuttering panel ② Exposure of rebar *Wrong bending schedule *Miss fabrication	Concreting Formwork Rebar Work
Actual Working Condition	Point	Reference
 a 	① Wrong Embedded Pipe *Lack of Beam Width *Lack of consideration	Electrical design

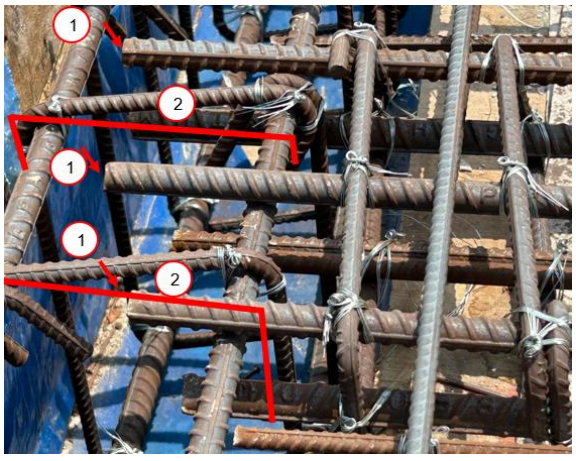
	① Concrete Cavity *Insufficient Vibrating *Insufficient Tamping *Too much casting interval	
	① Incorrect Concrete Joint *Insufficient cleaning *Insufficient Vibrating ② Concrete Cavity *Insufficient Vibrating/ Tamping ③ Porous Concrete *Insufficient Vibrating/ Tamping	Concreting Concreting Concreting
Actual Working Condition	Point	Reference
	① Low quality shuttering material. *Impact to concreting and concrete.	Shuttering Materials

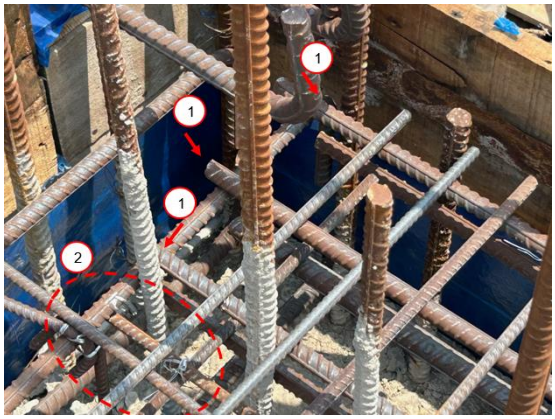
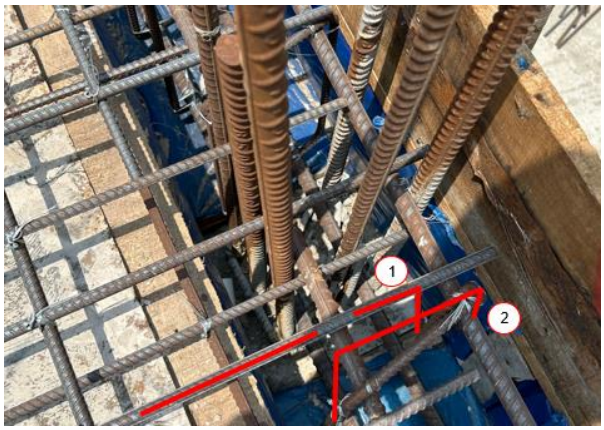
Actual Working Condition	Point	Reference
	① Insufficient Filling Materials *Impact to Fire Prevention	Plumbing Work
	① Impure Pile Concrete *Incorrect pile concrete *Insufficient removal of slime	Bore Pile
	① Lack of Pile Head *Insufficient connection into Pile Cap	Bore Pile

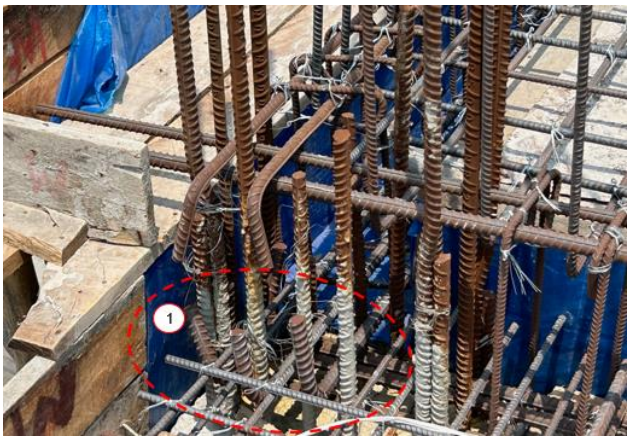
	① Lack of Pile Head *Insufficient Connection into Pile Cap ② Impure Concrete *Lost Pile Strength	Bore Pile
	③ Lack of Pile Head *Insufficient Connection into Pile Cap ④ Impure Concrete *Lost Pile Strength	Bore Pile
Actual Working Condition	Point	Reference
	① Incorrect Material Stock *Unplanned Sire arrangement *Unsafe site condition	Site Arrangement

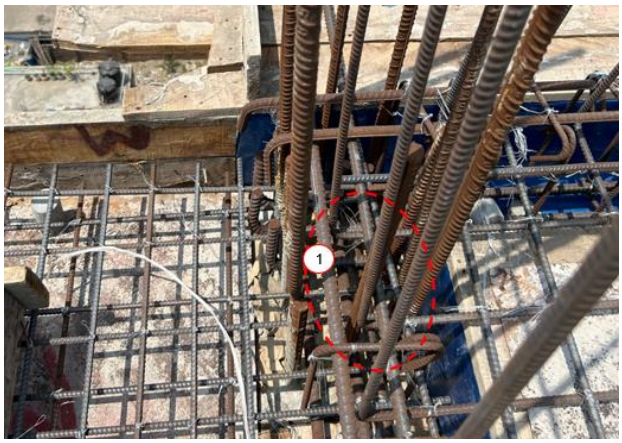
	① Insufficient Casting concrete *Unsuitable shuttering	Formwork
	① Incorrect Casted Concrete *Insufficient cleaning of shuttering panel *Lack of shuttering strength	
Actual Working Condition	Point	Reference
	① Remained Nail *Miss-fabrication of shuttering panel ② Separated Concrete *Wrong Placing *Insufficient Vibrating *Insufficient sprinkling water on the shuttering panel	Formwork Concreting Preparation of concreting

	① Remained Nail *Miss-fabrication of shuttering panel ② Separated Concrete *Wrong Placing *Insufficient Vibrating *Insufficient sprinkling water on the shuttering panel	
	① Porous Concrete *Insufficient Vibrating *Pour Concrete materials *Insufficient strength of shuttering panel *Rebar arrangement in muddle	Concreting Concrete mixing Formwork Rebar work
Actual Working Condition	Point	Reference
	① Insufficient strength of Slab shoring. *Unsuitable materials *Wrong shoring plan	Formwork

	① Incorrect anchored position *Insufficient anchoring strength *Peeling the cover concrete.	Rebar work (Arrangement)
	① Incorrect Beam Rebar arrangement *Miss-bending schedule *Miss-fabrication of rebar ② Not right angle setting of Stirrup against Beam direction *Decrease of resistance against sharing force	Rebar work Fabrication Fabrication Placing
Actual Working Condition	Point	Reference
	① Incorrect Beam Rebar arrangement *Miss-bending schedule *Miss-fabrication of rebar ② Not right angle setting of Stirrup against Beam direction *Decrease of resistance against sharing force	Rebar work Fabrication Fabrication Placing

	① Incorrect Beam Rebar arrangement *Miss-bending schedule *Miss-fabrication of rebar ② Rebar arranged in muddle *Rebar placing	Rebar work Fabrication Placing
	① Insufficient concrete cover *Rebar placing	Rebar work
Actual Working Condition	Point	Reference
	① Wrong anchoring of slab main bar *Insufficient connecting strength *Peeling concrete *Miss placing ② Wrong stirrup direction *Insufficient resistance against sharing force *Incorrect size	Rebar work Miss fabrication, or Bending-schedule

	① Wrong stirrup direction *Insufficient resistance against sharing force *Incorrect size ② Wrong anchoring of slab main bar *Insufficient connecting strength *Peeling concrete *Miss placing	Rebar work Miss fabrication, or Bending-schedule
	① Missing Hoop *Incorrect work procedure	Rebar work Placing
Actual Working Condition	Point	Reference
	① Rebar arranged in muddle. Placing procedure	Rebar work Arrangement

	① Rebar arranged in muddle. Placing procedure	Rebar work Arrangement