CNCRP

Project for Capacity Development on Natural Disaster Resistant Techniques of Construction and Retrofitting for Public Buildings

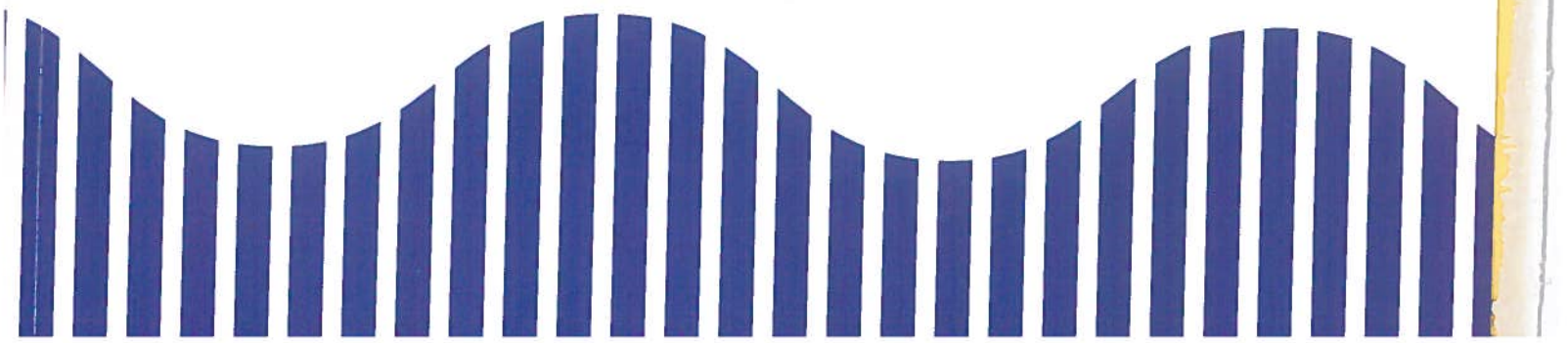
JICA

MANUAL FOR

RETROFIT CONSTRUCTION AND SUPERVISION

OF REINFORCED CONCRETE BUILDINGS

Public Works Department



MANUAL FOR RETROFIT CONSTRUCTION AND SUPERVISION OF REINFORCED CONCRETE BUILDINGS

PUBLIC WORKS DEPARTMENT

GOVERNMENT OF BANGLADESH

PREPARED UNDER

PROJECT FOR CAPACITY DEVELOPMENT ON NATURAL DISASTER RESISTANT TECHNIQUES OF CONSTRUCTION AND RETROFITTING FOR PUBLIC BUILDINGS (CNCRP)

A TECHNICAL COOPERATION PROJECT BETWEEN PWD AND JICA

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Foreword

Bangladesh is a disaster prone country. The country is frequently affected by floods, cyclones and cyclone induced storm surges and tornados. The country is also under threat of moderate to strong earthquakes due to the geographical position. Due to its proximity to the plate boundaries, active faults and track records of historical damaging earthquakes in and around Bangladesh, probability of occurrence of strong earthquake is high.

The risks of loss of life and damage to property due to earthquake are almost entirely associated with manmade structures. Earthquake doesn't kill people, buildings do. The rapid urbanization of several cities especially Dhaka, Chittagong and Sylhet during the last 25 years with most of the buildings being non-engineered is a big concern.

Public Works Department (PWD) with a history of over 150 years is the Government Department which owns almost all the public buildings of the country in connection with construction and maintenance. The department inherits the legacy from British India through Pakistan period to present independent Bangladesh. A major portion of the huge building stock is unreinforced brick masonry buildings with low concrete strength, inadequate column section and non ductile RC framed structures. The Bangladesh National Building Code (BNBC) was formulated in 1993 and enacted in 2006. PWD has been following American Concrete Institute (ACI) code till 1993 and the BNBC subsequently for structural design purpose. But strict adherence to the code especially the seismic provisions came into practice very recently. As a result, a staggering number of existing buildings do not meet the seismic demand and capacity requirements of the current BNBC 2015 (Final Draft, July 2015).

The Government of Bangladesh has taken a strong stand with disaster risk reduction. Government's success in certain areas of disaster risk mitigation such as flood, cyclone is acclaimed by the world and taken as role model in many countries. In case of earthquake disaster, the country is not sufficiently prepared to reduce the risk. The main reason is that earthquake is not a frequent phenomenon in Bangladesh. The country had experienced the last devastating earthquake in 1897 (The Great Indian Earthquake with magnitude 8.9). In the Standing Order on Disaster (SOD) of the Government, PWD is entrusted with the task to promote seismic resistant building and to retrofit public buildings which are vulnerable to earthquake.

Due to the lack of technical know-how, PWD could not undertake projects for retrofitting. To overcome this deficiency, PWD has undertaken a project with the technical cooperation of JICA titled "Project for Capacity Development on Natural Disaster Resistant Techniques of Construction and Retrofitting for Public Buildings (CNCRP)". The main purpose of the four year long project is to enrich the technical knowledge and working capacity of the engineers of PWD for seismic assessment, retrofitting design and construction of existing RC framed public buildings.

One of the outputs of this project is to develop 6 (six) individual manuals and guidelines as stated under for future references:

1. Manual for Seismic Evaluation of Existing Reinforced Concrete Buildings
2. Manual for Seismic Retrofit Design of Existing Reinforced Concrete Buildings
3. Manual for Retrofit Construction and Supervision of Reinforced Concrete Buildings
4. Guidelines for Quality Control of Design and Construction of Reinforced Concrete Buildings
5. Manual for Seismic Design of Reinforced Concrete Buildings

6. Manual for Vulnerability Assessment and Damage Prediction of Reinforced Concrete Buildings against Non Seismic Hazards

The series of manuals and guidelines are the outcome of four year long experiences of CNCRP project. The engineers of PWD with technical assistance of the JICA experts tried to adapt the Japanese retrofit technology to local construction conditions and practices. Seismic retrofitting is a specialized type of job. The professionals and practicing engineers are requested to go through the manuals carefully and apply their engineering judgments before application.

The current edition of the manuals and guidelines are a modest beginning. Extensive research on local conditions such as construction materials, techniques, and practices in the light of local seismicity are necessary to upgrade the manuals. We, as professionals, believe that manuals are only a guide or outline and it is the expert who will have to take the final decision about actual extent of work to be done. We expect feedback from all quarters to enrich the future editions of the manuals.

The Bangladesh National Building Code (BNBC 2015) does not contain any special provision for retrofit construction. Throughout the project duration the engineers of PWD studied and practiced the retrofit construction techniques right from planning to supervision of the work. Retrofit construction is somewhat different from normal construction because of its job nature. In comparison with normal building construction work, retrofitting is generally carried out under some restrained conditions. In most of the cases the construction is done keeping the building operational. So the work has to be done part by part within a time limit. Environmental issues such as dust and noise control is of utmost importance. Safety for workers as well as inmates of the building is to be ensured. Special attention is needed not to interrupt the building services and not to incur any damages to utility service lines such as electricity, water, gas etc. Selection of right materials and construction techniques considering the availability and suitability to local conditions are major concern. PWD engineers learnt a lot especially through actual retrofitting works of one pilot project, a fire station and one garment factory building and various test works while working hand in hand with Japanese counterpart. This "Manual for Retrofit Construction Supervision of Reinforced Concrete Buildings" is the outcome of hard work during the project tenure. The manual is equally applicable for normal construction supervision.

We deeply acknowledge the Editorial Advisory Board for their valuable contribution. The authors from JICA expert team needs special mention for formulating the manuals. We also thank all the CNCRP team members for their hard work which eventually helped in publishing these manuals and guidelines. Finally I want to thank the Government of Japan and JICA for their whole hearted support and cooperation in all phases of the project CNCRP.

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PREFACE

This manual has been prepared to assist the engineers in Bangladesh in the construction and supervision of the retrofit works specially for RC buildings.

This Manual consists of two parts. Part-I describes the retrofitting construction technology where Part-II covers to improve the supervision skills of the field engineers.

Although there are a number of publications in this regard available on the subject of seismic strengthening work outside Bangladesh like FEMA, ASCE, JBDPA guideline, those are not suitable in the Bangladeshi context. Considering this issue, through the technical cooperation project CNCRP, between PWD and JICA, this initiative has been taken to publish a manual on seismic retrofit construction and supervision.

The manual has been prepared based on the studies of the international manuals and guidelines on this aspect and subsequently from the comprehensive experience gained through the implementation of retrofit test work and a pilot project retrofit construction and supervision work through the project CNCRP.

The retrofitting materials and methods recommended in this manual are compatible with the sustainable use of the most commonly available materials and workmanship we are conversant with in Bangladesh.

The manual contains sketches and detailed step by step instructions and actual retrofit construction photographs that will be required by the engineers as well as the contractors. It also contains case study of building that were restored and retrofitted through the project CNCRP, to facilitate better understanding of the concepts and the system.

In principle, a construction supervisor is responsible for checking construction performance against design documents and building codes, the work of whom covers a wide range of areas such as schedule management, quality control of buildings, and safety management and checking the quality of building materials to be used.

In the current BNBC (BNBC 2006) construction supervision are not described in detail. In reality, a method of construction supervision varies from one supervisor to another, as the supervisors rather refer to their own experience when supervising. Consequently, the quality control for buildings is inconsistent in the country.

Considering the reality of construction supervision in Bangladesh, as one of the first outputs of the Project namely CNCRP, this Manual picks up and introduces the minimum requirements of supervision and most important items for the construction supervisors. The Project shall further develop a new manual, the contents of which shall focus more on "how-to-practice" the supervision work, by showing examples and actual experiences.

It is therefore hoped that this manual will be useful to engineers, architects, contractors, masons and people who may be planning to retrofit existing houses and public buildings to reduce their vulnerability to future earthquakes.

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CONTENTS

PART-I: RETROFIT CONSTRUCTION

CHAPTER 1. GENERAL

This part of the manual covers only the construction of the retrofitting works. No design of retrofitting is discussed in this manual. It is suggested that the retrofitting design of an existing building shall be carried out by a qualified structural engineer. He may take necessary guideline from the "Manual for Seismic Retrofit Design of Existing Reinforced Concrete Buildings" published by CNCRP. The retrofit construction work shall be implemented as per retrofit design through the material specification and work procedure discussed in this manual. The specification and issues not covered in this manual shall be cosidered according to the latest version of "Schedule of Rates of PWD" and "Bangladesh National Building Code BNBC".

In comparison with general building construction work, retrofitting work is generally carried out under some restrained conditions. Because, in most of the cases, this construction has to be done on buildings that are in use. So the work shall be done part by part within a time limit considering environmental issues such as dust and noise control.

Sufficient measures shall be taken for the safety of the occupants and users. In addition, special attention has to be given so that the building services are not interrupted due to construction work. Moreover it shall be ensured that there is no damage in utility service lines such as electric line, gas line, water line etc.

An adequate 'Construction Plan' for retrofitting work shall be done with the following considerations:

i) Limited access to the building and part by part construction.

ii) Reduction of time period

iii) Minimum dust and noise control.

iv) Adequate survey of existing piping and electrical wiring system, ensuring safety.

CHAPTER 2. MATERIALS

The selection of the right materials to be used in the seismic retrofitting of a given structure considering the quality, availability, suitability to the local condition has been a major challenge. The selection of materials to be used depends on many aspects including applicability and suitability of materials for the target structures. Using standard and innovative retrofit materials, appropriate technology, workmanship, and quality control during implementation are the key factors for a successful repair, strengthening and restoration of vulnerable or damaged structures.

Some of materials that have been used for seismic retrofitting in different seismic retrofitting methods are specialized and different from traditional materials which are normally used for new building construction. In these section materials that are specially used for seismic retrofit construction have been discussed. For materials that are common for seismic retrofitting as well as new building construction, specifications in BNBC and PWD "Schedule of Rates" shall be used.

2.1 CONCRETE

The cement and fine aggregates to be used in concrete for seismic retrofitting work are the same as used for new building construction and the specification in BNBC and PWD Schedule of Rates shall be followed. But for coarse aggregate it is desirable to use a slightly smaller diameter than which has been used for new building construction as there are major restrictions on concrete casting and consolidation in retrofitting work.

2.2 STEEL REBAR

Steel rebar material shall be the same as used for new building construction and specification shall be as indicated in BNBC and PWD Schedule of Rates.

2.3 STEEL PLATES

Steel plates that are to be used for retrofit construction especially for steel frame bracing shall conform to either ASTM A36 or ASTM A572.

2.4 CONNECTION BOLTS

Structural connection bolts to be used for retrofit construction shall conform to ASTM A307, ASTM 325 or ASTM A449 as specified by the structural designer.

2.5 ADMIXTURE

Mortar and concrete to be used for retrofitting works are required to have good workability, higher strength while aggregate must have minimal segregation and voids, as well as minimal water content. To ensure these, in normal situations water reducing admixture may be used.

The major reasons for using admixtures in retrofit construction concrete are:

- To make the concrete workable in the restricted area.
- To ensure proper compaction in restricted area.
- To maintain the quality of concrete during the stages of mixing, transporting, placing, and curing in adverse weather conditions
- To overcome certain emergencies during concreting operations

Despite these considerations, it should be borne in mind that no admixture of any type or amount can be considered a substitute for good concreting practice. The effectiveness of an admixture depends upon factors such as type, brand, and amount of cementing materials; water content; aggregate shape, gradation, and proportions; mixing time; slump; and temperature of the concrete.

Admixtures being considered for use in concrete should meet applicable specifications as in ASTM C494 (Type A to Type G) along with BDS EN 934-1:2008 for conventional mixes, ASTM C 260 for Air-entraining admixtures and ASTM C 1017 for flowing concrete. Trial mixtures should be made with the admixtures and the job materials at temperature and humidity anticipated on the job. In this way the compatibility of the admixture with other type admixtures and job materials, as well as the effects of the admixture on the properties of the fresh and hardened concrete, can be observed. The amount of admixture recommended by the manufacturer or the optimum amount determined by laboratory tests should be used.

2.6 NON-SHRINK GROUT

For the purpose of specifications, "non-shrink grout" can be defined as a high-strength mortar or grout which does not shrink in the plastic state, is dimensionally stable in the hardened, and bonds permanently to a clean metal plate and concrete substrate.

Retrofit construction like creating walls inside existing frames, gaps between existing connections and attached surfaces can easily be open due to drying shrinkage of the concrete. It is important to use non shrink concrete in this context in these locations.

2.6.1 Materials

Non-shrink, non-metallic, non-corrosive cement-based grout shall conform to the following requirements:

- Applicable Standards: ASTM C1107
- Grout shall be manufactured specifically for use in supporting heavy loads (loads in excess of 300 pounds per square foot concentrated load or 100 pounds per square foot uniform load). Grout: ASTM C1107, Grade A, B, or C, as appropriate for the condition or circumstance.
- Shrinkage at 28 days: No shrinkage before hardening (0.00 shrinkage when tested in accordance with ASTM C827); no shrinkage after hardening (0.00 shrinkage when tested in accordance with ASTM C827).
- Compressive strength, minimum:
    a) At seven days: 3500 psi
    b) At 28 days: 5000 psi.
- Initial setting time, after addition of water: approximately one hour at 70 degrees F.
- Flow ability should be ensured as necessary for the particular application.

2.6.2 Submittals

a) Product Data: Submit manufacturer's product data and installation instructions.
b) Certification: Submit certificates of compliance or laboratory test reports which indicate the following:
- Materials used in the grout are free from metallic components and corrosion-producing elements.
- Materials meet specified shrinkage and compressive strength requirements.

2.7 MICRO CONCRETE

For repair sections generally deeper than 100mm it may be necessary to mix the non-shrink grout (see section 2.6) with properly graded 5mm to 12mm silt-free aggregate to minimize temperature rise. The quantity of aggregate required may vary depending on the nature and configuration of the repair location. The typical results with a few aggregate proportions, for various applications are furnished below for guidelines.

Non shrink Grout Powder: Coarse aggregate (SSD) (By weight)=1 : 0.75

Water: Powder ratio (By weight) =0.16 (shall not be increased in any circumstances).

Table 2.7. 1 Compressive strength of Micro Concrete

Compressive strength (N/mm²) (Tested on 70.7mm cubes as per BS 4551-80)			
1D	3D	7D	28D
10	30	40	50
Tensile strength		2.0N/mm² @ 28 days	

The micro concrete in the flowable consistency should achieve a compressive strength of not less than 10N/mm^2 after 24 hours, 40N/mm^2 after 7 days and 50 N/mm^2 after 28 days at 300 C. Most importantly, the cured micro-concrete shall contain no metallic aggregates, or chlorides and shall be shrinkage compensated in the plastic state. The unrestrained expansion shall be between 1 - 4%. The flexural strength shall not be less than 5 N/mm^2 @ 28 days. The micro-concrete shall have a coefficient of thermal expansion similar to that of the host concrete. The mixed density of micro-concrete shall exceed 2100 kg/m^3 at 27°C.

2.8 BONDING AGENT FOR OLD CONCRETE TO NEW CONCRETE

Fresh wet concrete does not normally bond well to existing dry concrete. So it is usual to apply bonding agent on old concrete before laying new concrete and bonding fresh, plastic concrete to old, hardened concrete increases the strength of the composite material. Fresh patches, concrete adjacent to construction joints, and overlays all benefit from bonding to the hardened concrete substrate. Bond is not, however, guaranteed. It must be ensured through proper surface preparation, material choice and use, and curing. Ignoring one of these components may result in the total loss of bond.

Material specification shall conform to

- ASTM C1059: Standard Specification for Latex Agents for Bonding Fresh to Hardened Concrete.
- ASTM C1583: Standard Test Method for Tensile Strength of Concrete Surfaces and the Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull off Method).
- ACI 503R-80: Use of Epoxy Compound with Concrete.

2.9 ANCHORING ADHESIVE FOR POST-INSTALLED ANCHOR

Adhesive to be used for anchoring stud-type anchors consisting of threaded steel rod, nut, and washer or deformed reinforcing bar etc. as indicated in drawings and specifications shall be epoxy adhesive conforming ASTM C881 Type I, II, IV and V, Grade 3, Class B and C. Adhesive shall be a cartridge type, two-component, solid epoxy based system dispensed and mixed through a static mixing nozzle supplied by the manufacturer. Acceptable installation and performance temperature ranges shall be verified with manufacturer's literature prior to installation.

2.10 POST-INSTALLED ANCHORS

There are two types of post-installed anchors: Mechanical and Bonded anchor.

Mechanical anchors comprise undercut anchors, expansion anchors and screw anchors. In their usual form, undercut anchors interlock with the concrete at the base of the drilled hole. They derive tension resistance by bearing. Expansion anchors derive tension resistance via the friction generated by expansion forces against the wall of the drilled hole. Screw anchors derive tension resistance via the interlock of the screw threads with the concrete.

Adhesive anchors are anchors in concrete or masonry that derive their resistance to applied tension load by adhesion or bond. The adhesive for attaching bolts, rods, etc. to the concrete is available in both cartridge and capsule configurations. Each type consists of two essential parts, a resin and a hardener. In the cartridge format, the two components are contained in separate parallel tubes connected on the end by a manifold that allows the materials to be proportioned in the proper ratio and mixed together. The cartridge tool forces the materials out of the tubes, through the manifold, into and through a mixing nozzle and into the drilled hole. The mixing nozzle assures that the components are well mixed and the adhesive resin is activated by the hardener. With a capsule anchor, the resin and hardener are kept separate, but are contained within a single glass or foil capsule. The entire capsule is inserted into the drilled hole. The anchor element, usually a threaded rod, is then inserted into the pre-drilled hole with a rotational motion using a rotary drill. The rotary motion of the anchor breaks the capsule causing the resin and hardener to mix, initiating the chemical reaction that hardens the adhesive. Adhesive anchors are available in a variety of chemistries, each with its own specific characteristics and capacities. The adhesive materials include epoxies (many different formulations), acrylates, vinyl esters, polyesters,

hybrid mortars, and others. The specifier, installer, and end user should become familiar with the requirements of the specific application to ensure the selected adhesive anchor and adhesive material is appropriate for the given application.

Applicable Standard and specifications for post installed anchor:

- ASTM A615: Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement when deformed rebars shall be used as anchor.
- ASTM 307, ASTM 449: Standard specification for externally threaded bolts and studs.
- ACI 355.2: Qualification of Post-Installed Mechanical Anchors in Concrete
- ACI 355.4: Qualification of Post-Installed Adhesive Anchors in Concrete
- ASTM E488: Standard Test Methods for Strength of Anchors in Concrete Elements.
- AC 193: Acceptance Criteria for Mechanical Anchors in Concrete Elements.
- AC 308: Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements

2.11 SHEAR STUD

Standard mild steel studs to be used for transfer of shear into concrete or metal by welding shall be in accordance with ASTM A –108 specifications. Physical properties and chemical composition of mild steel studs shall be in accordance with AWS D1.1.

2.12 CFRP (CARBON FIBER-REINFORCED POLYMER)

The CFRP materials that are commonly used for seismic retrofitting work are carbon fiber, aramid fiber and glass fiber as continuous fiber, and epoxy resin as adhesive resin for impregnation. In Bangladesh till date only carbon fiber sheet has been used for strengthening of deficient RC columns.

Physical properties of CFRP Materials such as density, coefficient of thermal expansion shall conform to CI 440.2R-08, Guide for the Design and Construction of Externally Bonded FRP Systems for Strengthening Concrete Structures.

Other relevant standards are:

- ASTM D7565, Standard Test Method for Determining Tensile Properties of Fiber Reinforced Polymer Matrix Composites Used for Strengthening of Civil Structures.
- ASTM D3039, Standard Test Method for Tensile Properties of Polymer Matrix Composite Materials.
- ASTM D7522, Standard Test Method for Pull-Off Strength for FRP Bonded to Concrete Substrate.
- ASTM D4541, Standard Test Method for Pull-off Strength of Coating Using Portable Adhesion Testers.

2.13 CURING COMPOUND

Curing compound shall conform to ASTM C 309, Type 1-D with fugitive dye or Type 2 white pigmented as approved by the Engineer.

Type 2 white pigmented shall only be used on the surfaces of bridge decks, approach slabs, structural slabs, on surfaces that will not be exposed to view, or on surfaces where their use has been approved by the Engineer.

CHAPTER 3. COMMON OPERATIONS REQUIRED IN RETROFIT WORKS

The construction procedure for retrofitting is different from the general new building construction work in many ways. Some of the construction procedures are discussed below.

3.1 PREPARATION FOR RETROFITTING WORK: DISMANTLING AND REMOVAL:

To facilitate the retrofit work, the interior decoration, fixtures, partition walls etc. adjacent to the construction area shall be dismantled or removed. Appropriate measures shall be taken to minimize the noise, vibration and dust generated by the work. During dismantling or removal work, sufficient attention shall be given for the safety issues as well.

The plaster of RCC member to be retrofitted shall be removed completely and the RCC surface shall be exposed. Then the surface shall be chipped and roughened carefully to make the surface ready for adding new concrete or so on. The epoxy bonding agent for better bonding of old and new concrete may be used.

The chipping work shall be carried out carefully to ensure that no existing reinforcement is exposed or it does not produce any cracks on other part.

After chipping, blowers and suction devices etc. shall be used to adequately remove chipping residues and fine powders.

3.2 POST-INSTALLED ANCHOR WORK

Retrofitting work is generally, carried by adding and strengthening members of existing structure, so the connection of new element with existing structure is of extreme importance. In most of the cases the connection is carried out by post-installed anchor work. Therefore, post-installed anchor shall be installed by skilled technician or engineer with enough knowledge of construction techniques. The quality of connection is also important to ensure the performances of the anchor.

Since there are two types of anchoring system i) Mechanical expansion anchor and ii) Chemically bonded anchor, it is strongly recommended that for retrofitting purpose chemically bonded anchor shall be used to ensure better performance of work and no loss of strength of existing member.

3.2.1. Procedure of post-installed anchor work

The following figures shows the procedure of post-installed anchor work

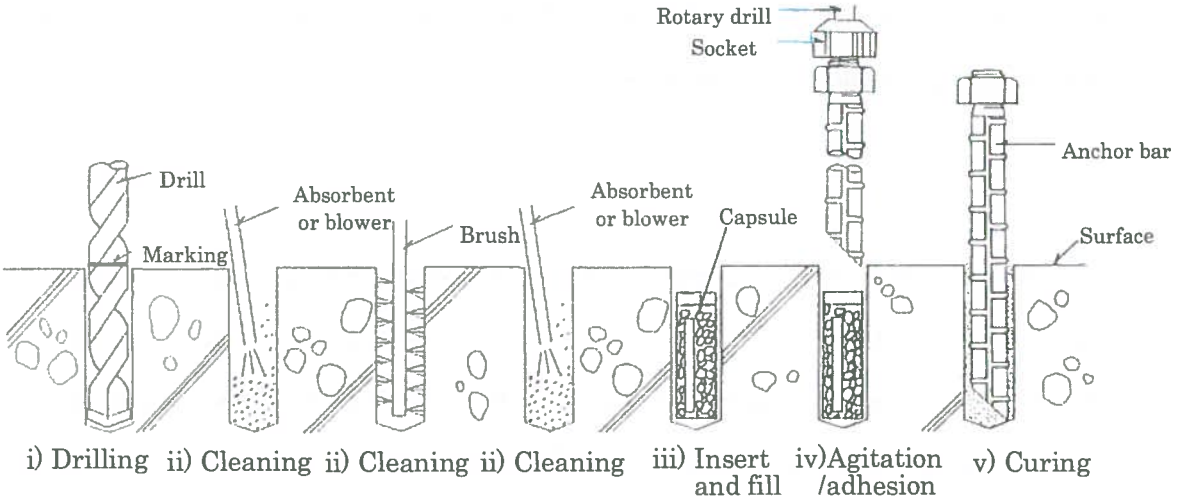


Figure 3.2.1: The Standard Procedure of Post-Installed Anchor Work

i) **Drilling:**

Drilling shall be at right angle to the construction surface. Drilling shall be done carefully so that there is no damage to the existing steel bar. If steel bar is hit while drilling, the drilling process shall be moved to another nearby position and the partly drilled hole shall be appropriately repaired. If possible it is suggested that the existing position of rebar is identified by rebar detector scanner before starting of drilling work.

The drilling depth shall satisfy the structural provisions suggested by structural engineer for post-installed anchor. In controlling the drilling depth, the drilling depth shall be marked to the drill bit for making the desired depth.

ii) **Cleaning Holes**

Cleaning of the drilling hole shall be carried out very carefully by using blower and brushes. If there are some dust or loose materials in the hole the epoxy chemicals to be used for the anchor work will not get sufficient bonding with the existing member hence the performance of the anchor will be hampered. So this cleaning procedure shall be carried out several times to ensure that there is no dust or loose materials in the holes.

iii) **Applying epoxy bonding agent.**

After cleaning the drilled hole up to a satisfactory level, epoxy bonding agent shall be applied carefully to the hole. It is preferable to use the capsule type bonding resin. Otherwise, the epoxy bonding agent shall be applied by using gun machine to ensure that adequate amount of chemical has been applied. This work shall be done by qualified technician. The application method shall be done according to the instruction of the chemical manufacturer's guideline.

iv) **Installing the anchoring bar or bolt.**

The anchoring bar or bolt shall be installed slowly with rotation with sufficient care by a skilled worker.

v) **Curing**

Curing shall be done according to the instruction of manufacturer's guideline.

3.2.2. Strength confirmation and inspection of anchor work

i) The pull out test shall be done to confirm the strength of the post-installed anchor.

ii) Hammering Sound Inspection shall be done to check their degree of adhesion and whether or not these anchors are suitably adhered. If adhesive strength inspection results show failings, measures shall be taken in accordance with instruction from the supervisor or engineer-in-charge.

3.3 REINFORCEMENT WORK

Reinforcement work shall be done conforming "Bangladesh National Building Code- BNBC" and "Code of Practice of PWD".

When rebar is used for anchoring purpose this shall be done by skilled technician.

3.4 CONCRETE WORK

Concrete mixing, placing, vibrating, curing shall be done conforming "Bangladesh National Building Code BNBC" and "Code of Practice of PWD,"

Since the retrofit is made in various parts of a building and the small amount of concrete is cast in the retrofit work, concrete shall be mixed in mixture machine in accordance with standard specification and placed carefully to secure the required quality of concrete at each casting.

During retrofitting, in most of the cases concrete work is done in narrow places such as for column

jacketing, increasing wall thickness, inserting shear wall etc. So concrete used for retrofitting works are required to have good workability as well as good strength while it must have minimal segregation and breathing. So it is suggested that air entraining water reducing agent or high performance air entraining water reducing agent shall be used. For casting of narrow thickness concrete it is suggested to use well graded 12mm downgraded stone chips as coarse aggregate.

For retrofitting work the following specification for concrete work shall be followed.

i) Specified compressive strength of concrete shall not be less than desired strength of existing concrete nor 21 N/mm^2

ii) Well graded stone chips shall be used as coarse aggregate.

iii) Minimum unit volume of cement shall be 270 kg/m^3

iv) Maximum unit volume of water shall be $185/kg/m^3$

v) Maximum W/C ratio shall be 0.65

vi) Slump value shall not be greater than 18 cm.

3.5 NON-SHRINK GROUT WORK

In retrofitting construction, concrete shall be first cast up to around 20 cm below the beam, and then the remaining portion shall be carried by non-shrink grout work with pressure not to leave unfilled gaps and/or openings. Premix type non-shrink grout as per ASTM C1107 is suggested to use according to the manufacture's guideline or instruction. Several brands of non-shrink grouts are available. In most of the cases the grout is premix type, only certain amount of water is used for grout work. This type of grout is used by pressurized grout machine.

There is an option to mix some small size (12mm downgraded) stone chips with the premix grout to make the grout work economical. In that case no pressurized grout machine can be used, the grout shall be poured from top side by making some hole in the slab. So non-shrink grout work can be done by following two methods.

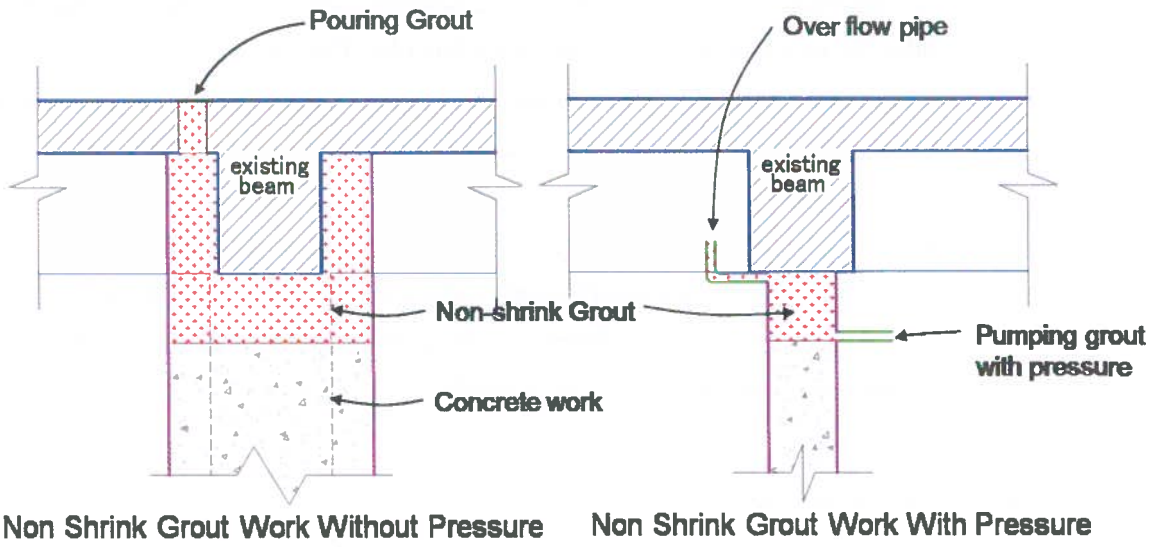


Figure 3.5.1 Methods of Non-Shrink Grout Work

3.6 STRUCTURAL STEEL WORK FOR STEEL FRAME BRACING

This section specifies the general requirements for fabrication of steel frame bracing work in the seismic retrofit construction.

Typically retrofit construction bracing frame can be hot-rolled sections like H, I, channel or pipe as designed by the structural designer. In case of non-availability of hot-rolled sections, built-up sections (sections made from steel plates welding/bending to a desired shape) may be used if permitted by the structural designer and engineer in charge. In either cases bracing frame shall be fabricated in the workshop/fabrication factory. Important issues require attention of the engineer in charge are:

3.6.1. Welding:

- All welding shall be in accordance with AWS 1.1 except otherwise directed in the Specification and the Contract Drawings.
- Cutting, drilling and welding on site is not permitted unless shown on drawings or otherwise approved. Suitable, safe working conditions shall be ensured. Welding is prohibited when surfaces are wet or when the ambient temperature is below 0 degree Celsius.
- The Contractor shall determine the welding procedure to meet the requirements of the Specification, including the requirements of Inspection and Quality Control.

- For pre-engineered sections, the welding shall be continuous for full length and on both sides. Intermittent or partial welding shall not be allowed.
- Where the steelwork is to be sand blasted and metal sprayed or galvanised after fabrication, cleats and other solid attachments welded to the member shall be welded all round to seal the unprotected surface.
- Welded attachments for fabrication or erection purposes shall be subject to the Engineer's approval and shall be clearly shown on the fabrication drawings.
- In addition to the above requirements, all welds on steelwork shall be ground smooth.
- Minimum size of welds should be **6** mm fillet.

3.6.2. Fixing of headed stud:

- Headed stud which are to be fixed with web of the internal steel frame bracing shall be fixed by stud fixing gun or welding as recommended by the stud manufacturer.
- When requested by the Engineer in charge and before production welding of studs commences, procedure trials shall be carried out. The trials shall be made on samples of materials and studs representative of those to be used in the Works. The samples of materials and studs shall be subject to the approval of the Engineer.
- It is required to submit report of successful test program for stud base qualification as required by AWS D1.1.

3.6.3. Marking:

- It is required to submit details of proposed methods of identifying and recording materials and components to ensure correct use and location in the structure.
- Marks to be placed in positions such that they will be visible for checking after erection.

3.6.4. Storage and Handling Requirements:

- Headed stud which are to be fixed with web of the internal steel frame bracing shall be
- Store and handle materials in accordance with the direction of engineer in charge.
- Do not store materials directly on ground.
- Store materials on flat, level surface, raised above ground, with adequate support to prevent sagging.
- Protect materials and finish during storage, handling, and installation to prevent damage.
- Maintain environmental conditions (temperature, humidity, and ventilation) within limits as directed by the engineer in charge.

3.6.5. Fixing of connection bolts:

- High strength bolts are tightened to a bolt tension not less than 70% of their minimum tensile strength. Tightening is done with properly calibrated wrenches, by turn-of-nut method or by use of direct tension indicators (bolts or washers). Tighten bolts in connections are identified as slip-critical using Direct Tension Indicators.
- Bolts shall not be less than 16 mm diameter except permitted by the design engineer.
- Not less than two bolts are to be used in any connection except permitted by the design engineer.
- Bolting up with close Tolerance Bolts: Holes for close tolerance bolts shall be drilled and reamed. Where the holes are not drilled through all thickness in one operation, the parts to be joined together shall be accurately lined up with parallel drifts of a diameter not greater than the nominal size of the hole and not smaller than 0.15 mm less than the nominal diameter and the holes are then reamed. A close tolerance bolt shall be fitted in each hole reamed and tightened before the next hole is reamed. All bolts shall be re-tightened after the last bolt has been fitted.
- Correcting hole alignments: Drifting to align holes shall not enlarge the holes or distort the metal. Holes which cannot be aligned without distortion shall be a cause for rejection unless enlargement by reaming is specifically approved by the Engineer.

3.6.6. Surface coatings (paint):

- At least one coat red oxide or equivalent primer shall be applied to the fabricated steel members at workshop.
- Steelwork shall be dry and cleaned.
- Steel surfaces to be embedded in concrete shall be left unpainted and need not be blast cleaned. The painted surface shall continue 80 mm below the concrete surface.
- Where steelwork is to be protected against corrosion with a paint coating system, it shall be in accordance with BS EN ISO 12944 and the Project Documentation.
- Additional stripe coats of primer or undercoat shall be applied in the following circumstances:
  - Welded surfaces where a weld-through primer has been used
  - Steelwork which will be exposed externally in the finished works
  - All edges, corners and bolt holes
  - Seal gaps between adjacent components such as shop and site bolted connections.
- Work shall not precede when the steel surfaces are wet or the ambient temperature, or dew point is not within the range recommended by the paint manufacturer.

- Painting of site fixed bolts and welding
  - All protruding portions of bolt assemblies and site weld surfaces shall be cleaned to remove traces of oil, dust, welding flux etc.
  - The paint system shall be compatible with the surface treatment system being used on the surrounding surfaces.
  - Bolt assemblies which are supplied with protective treatment need not be painted except where required by the Engineer's architectural drawings

3.6.7. Notes for Erection

- The Engineer shall be notified in writing of the starting date prior to the commencement of field operations.
- Components shall be lifted, placed, and maintained in position using appropriate lifting equipment, temporary bracing, guys, or stiffening devices so that the components are at no time overloaded, unstable, or unsafe. Additional permanent material may be provided, if approved by the Engineer, to ensure that the member capacities are not exceeded during erection.
- For temporary fit ups, main girder splices and connections shall be aligned with drift pins and a sufficient number of fitting up bolts shall be installed to maintain the integrity of the connection.
- Repairs to erected material will only be permitted after the repair procedure has been approved by the Engineer.
- Filling of misplaced holes by welding is permitted only with the written approval of the Engineer.
- Hammering that will damage or distort the members is not permitted.

3.6.8. Responsibility of the fabrication Contractor:

- The contractor has to review the design drawings and make comments, so that if necessary and if the structural design provision permits, contractor can change the length of some of the members to ensure that their weight is going to be light enough for the erection method the contractor is planning to use or the connection type that is the contractor converse with.
- Contractor has to check the actual dimension on site before fabrication.
- If fabrication drawing is the responsibility of the contractor, the drawings shall be submitted to the engineer in charge for approval before actual fabrication work.

CHAPTER 4. RETROFITTING METHODS

Retrofitting work is generally carried out by adding and strengthening members of existing structure to improve its structural performances against earthquake or other loads. There are many methods to make this strengthening works which are termed as Retrofitting Methods.

The following pictures and tables show different types of Retrofitting Methods. These methods are applied to the structure to improve the structural performances of the building such as strength, ductility, structural balance etc.

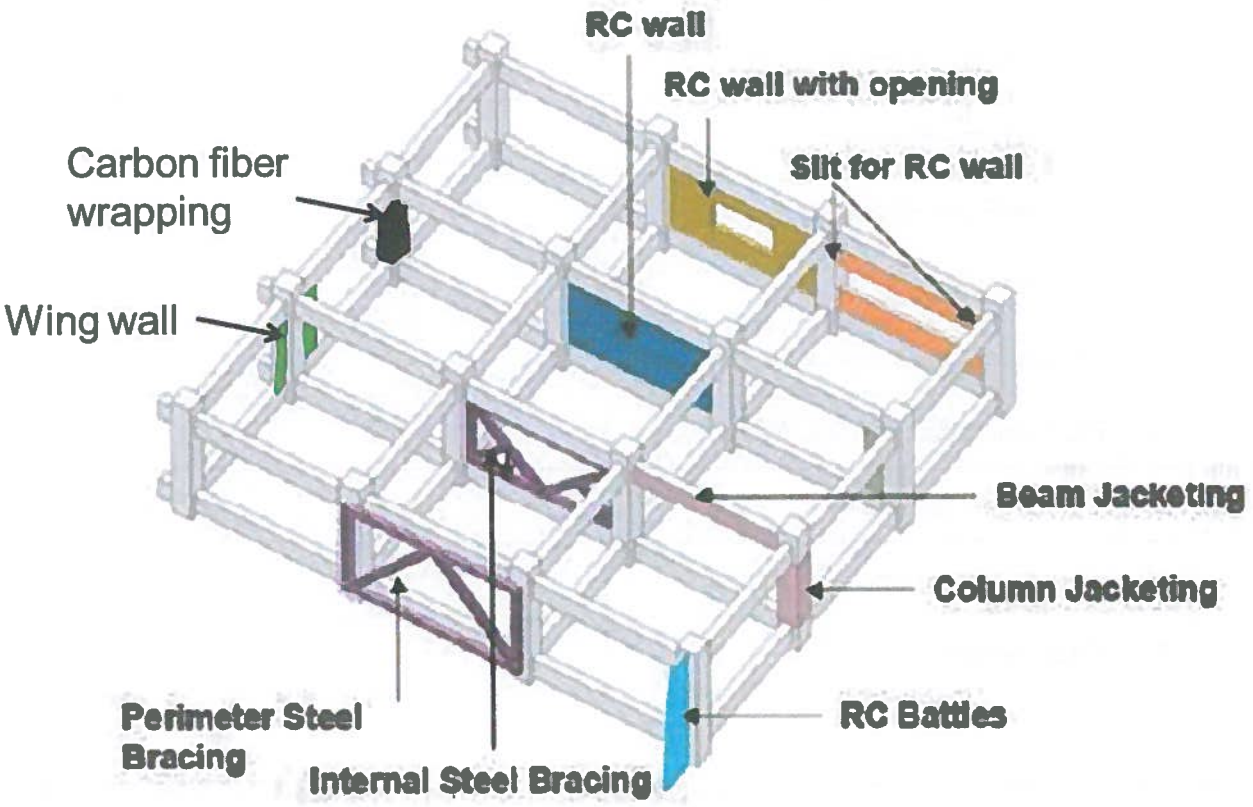


Figure 4.1. Different Types of Retrofitting Methods

Table 4.1 Commonly used Retrofitting Methods

Types of Retrofitting Methods				
	Description of Retrofitting Methods	Improvement of strength	Improvement of ductility	Improvement of structural balance
1	RC Column Jacketing	√	√	
2	Installing RC Shear Wall	√		√
3	Constructing RC Wing Wall	√		
4	Steel Frame Bracing	√		
5	Carbon Fiber Wrapping		√	
6	Structural Slit		√	√
7	RC Beam Jacketing		√	
8	RC Lamination of Brick Wall	√		
9	Steel Plate Jacketing		√	
10	Constructing External Buttress	√		
11	Base Isolation			

Following sections will cover the construction procedure of different retrofitting methods, which are very common and useful for Bangladesh. These retrofitting methods will improve the structural performance of the building but the methods must be compatible with the existing structure. So the methods to be applied in building must be selected by qualified structural engineer with detail assessment and retrofit design.

4.1 RETROFITTING WITH RC COLUMN JACKETING

This is a retrofitting method by jacketing around the existing column with reinforced concrete or reinforced mortar, whose thickness is around 10 to 15 cm. This method is to upgrade flexural strength and axial strength as well as ductility. Four faces of existing column shall be enclosed monolithically

by RC Jacket which is tightly fixed with existing column. Careful detail such as shear key or epoxy bonding agent shall be provided for better bonding of old and new concrete. The new main rebar shall be anchored from the foundation and tie or hoops shall be placed according to the provision of structural drawing to well confine the existing column. Hoops or tie shall be continued through beam column joint by anchoring the tie or hoop in to the beam. The figure 4.1.1 and figure 4.1.2 show the typical details of a RC Column Jacketing

After assembling the reinforcement, concrete shall be first cast up to around 20 cm below the beam and then the remaining part with beam column joint shall be carried out by non-shrink grout work. This grout work shall be done either with the help of pressurized grout machine or grout shall be poured from top side of slab by making some hole. Thickness of RC Jacket shall not be less than 10 cm for concrete and not less than 6 cm for mortar.

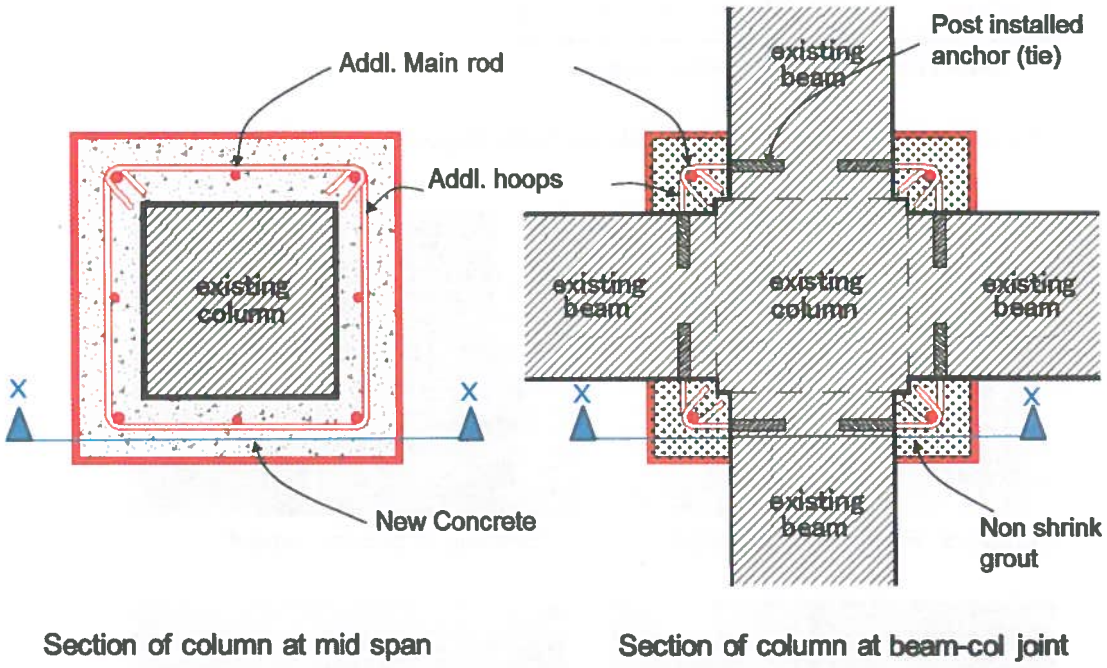


Figure 4.1.1 Typical Details of Column Jacketing Showing Cross Section

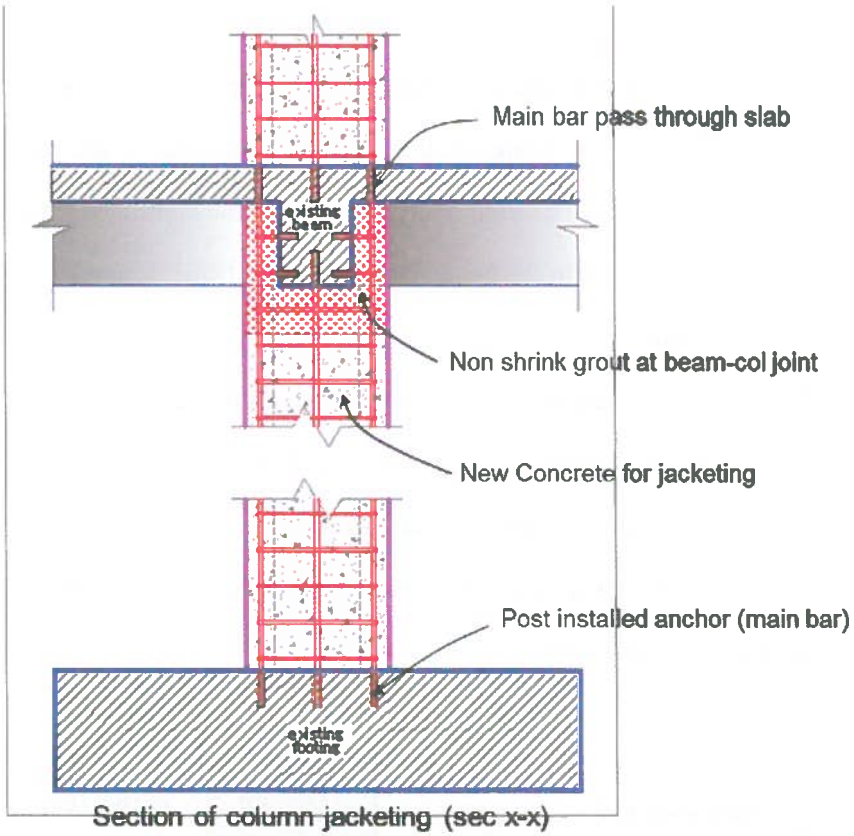


Figure 4.1.2 Typical Details of Column Jacketing Showing Vertical Section

Photos of RC column jacketing

Checking of Reinforcement

Chemical Applying on old Column Surface

Column Jacketing Work at site

Figure 4.1.3 Photographs of Column Jacketing (During Construction of Pilot Work of CNCRP)

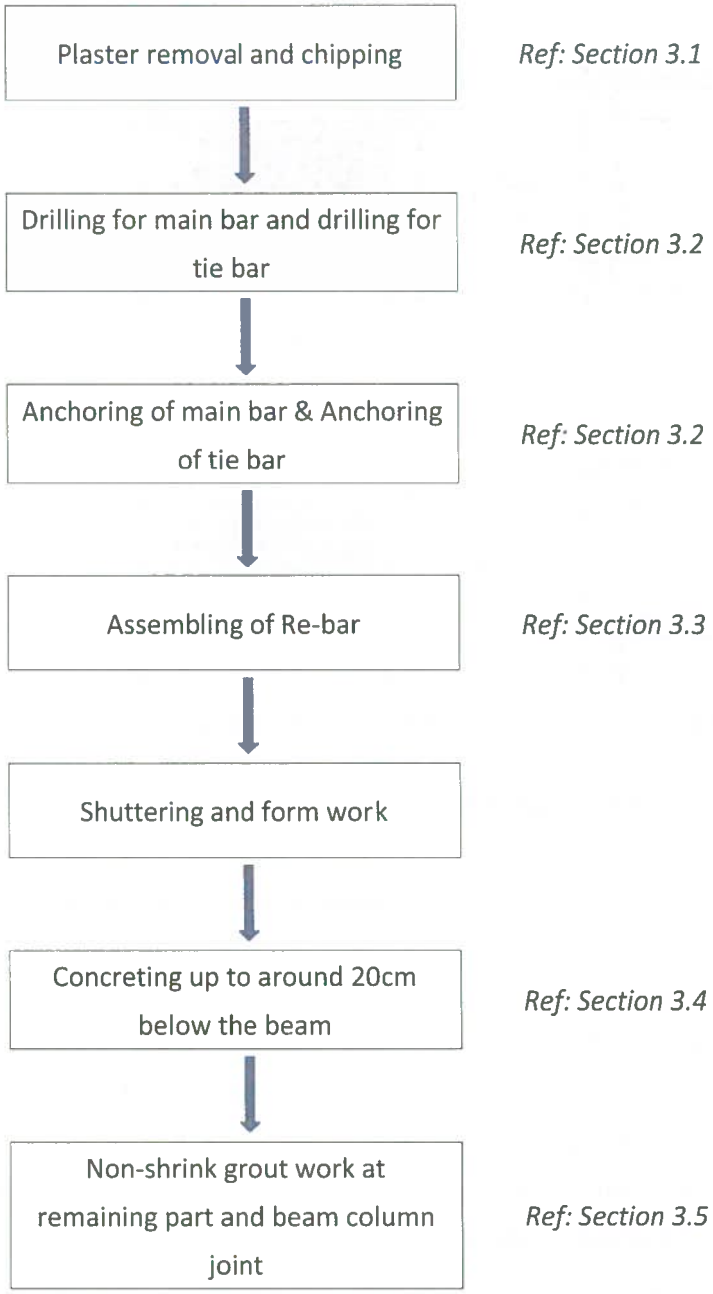
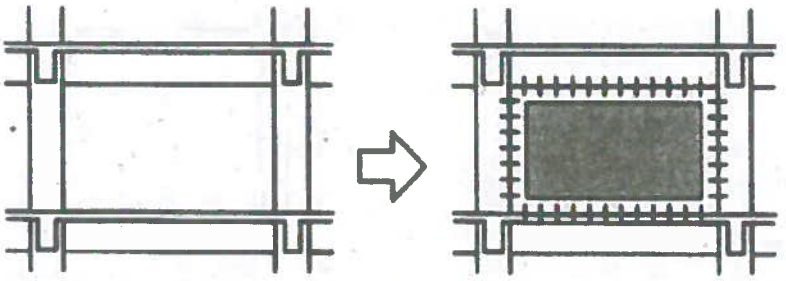


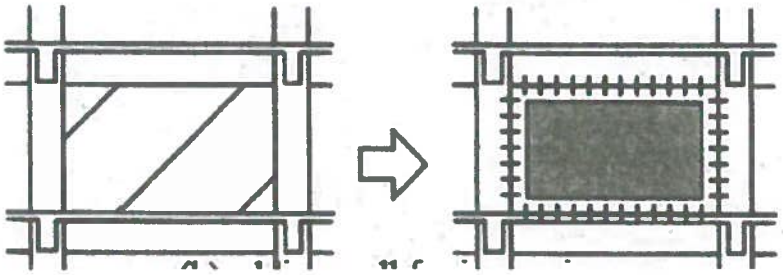
Figure 4.1.4 Standard Construction Flow Chart for RC Column Jacketing

4.2 RETROFITTING WITH RC SHEAR WALL

Installing Shear Walls is a retrofitting method which is suitable to increase the strength of existing building by infilling new shear walls in to open frame of existing building or replacing the existing infilled brick wall by a RC shear wall (see figure 4.2.1).



(a) Infilling shear wall in to an open frame



(b) Replacing infilled brick wall by RC shear wall

Figure 4.2.1 Retrofitting by Installing Shear Wall

In general post-installed anchors are placed along boundary columns and beams to make the connection between the new installed shear wall and the existing beam column frame. Strengthening against concrete splitting shall be sufficiently provided by using spiral hoops (see figure 4.2.4) or ladder-shaped reinforcing bar (see figure 4.2.5).

Figure 4.2.2 and figure 4.2.3 show the typical details of retrofitting by installing shear wall.

After completion of reinforcement work the concrete casting of shear wall shall be done up to around 20cm below the beam. The remaining part of shear wall shall be carried out by non-shrink grout work with pressure not to leave unfilled gaps and/or opening below beam.

In most of the cases shear wall is started from the foundation level. At that case, dismantling and removal work shall be done carefully as per provision of section 3.1 of this manual. When steel frame bracing is placed in an open frame as retrofitting method the bottom part of the frame i.e. the part below grade beam to foundation may be filled by RC shear wall.

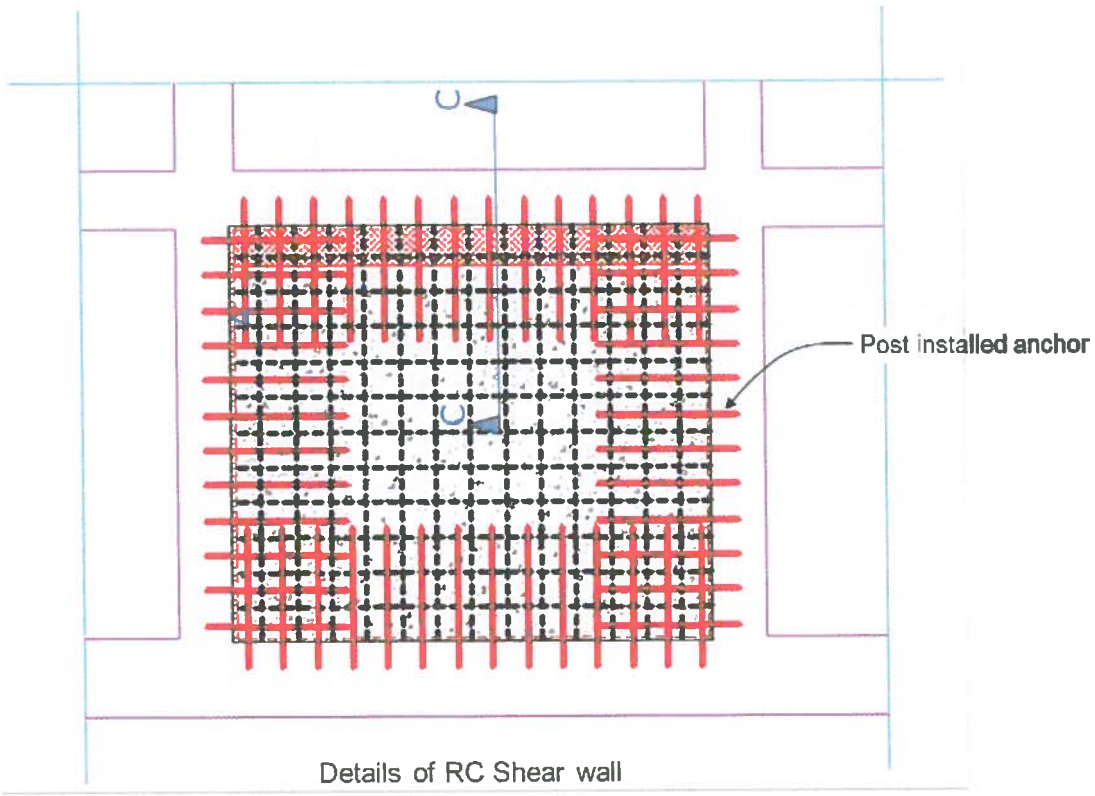


Figure 4.2.2 Typical Details of Shear Wall

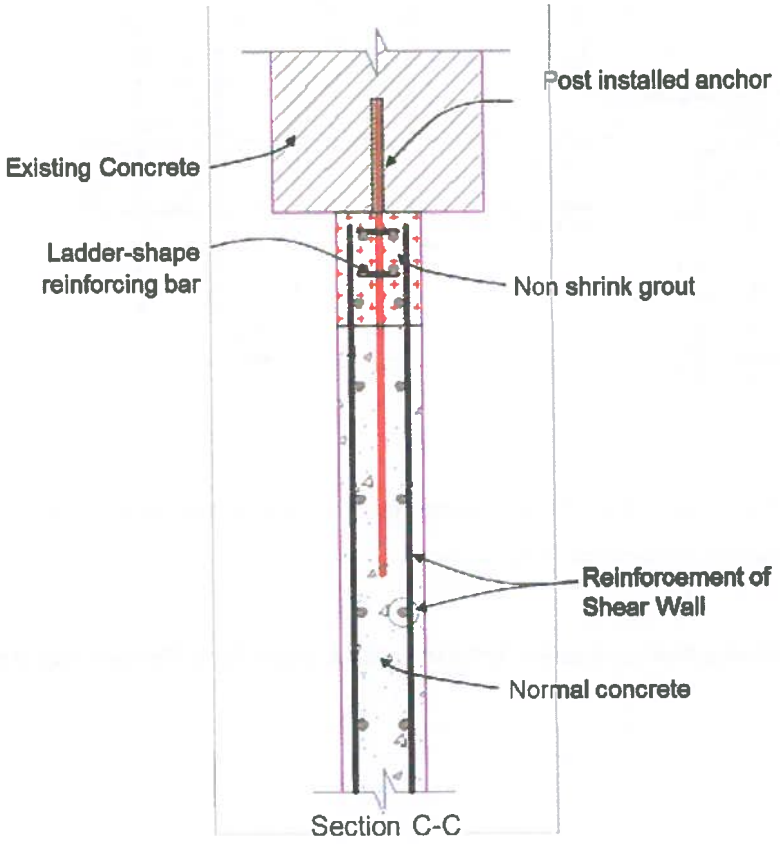
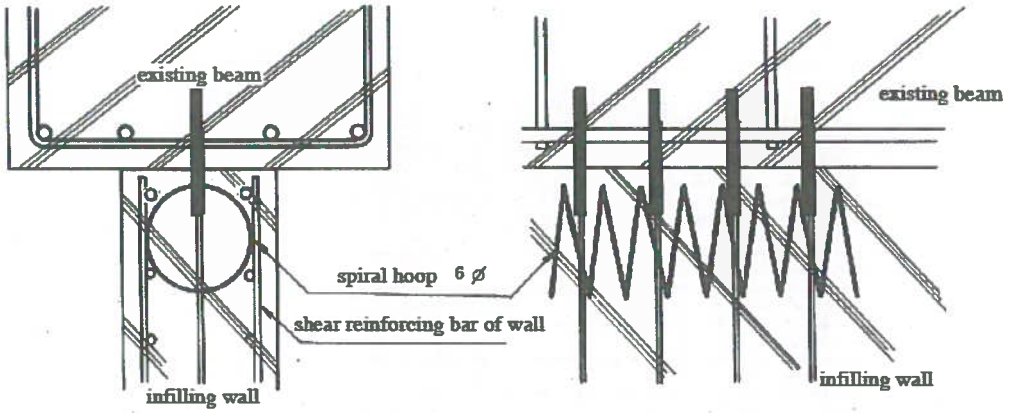
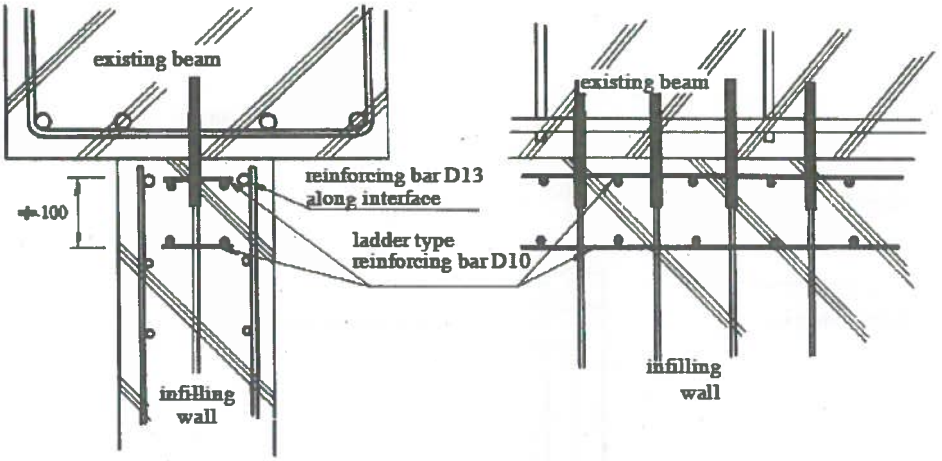


Figure 4.2.3 Connection Details of Shear Wall with Existing Beam



SOURCE: Guidelines for Seismic Retrofit of Existing Reinforced Concrete Buildings, 2001. Published by-The Japan Building Disaster Prevention Association

Figure 4.2.4 Strengthening against Splitting with Spiral Reinforcing Bars



SOURCE: Guidelines for Seismic Retrofit of Existing Reinforced Concrete Buildings, 2001. Published by-The Japan Building Disaster Prevention Association

Figure 4.2.5 Strengthening against Splitting with Ladder Type Reinforcing Bars

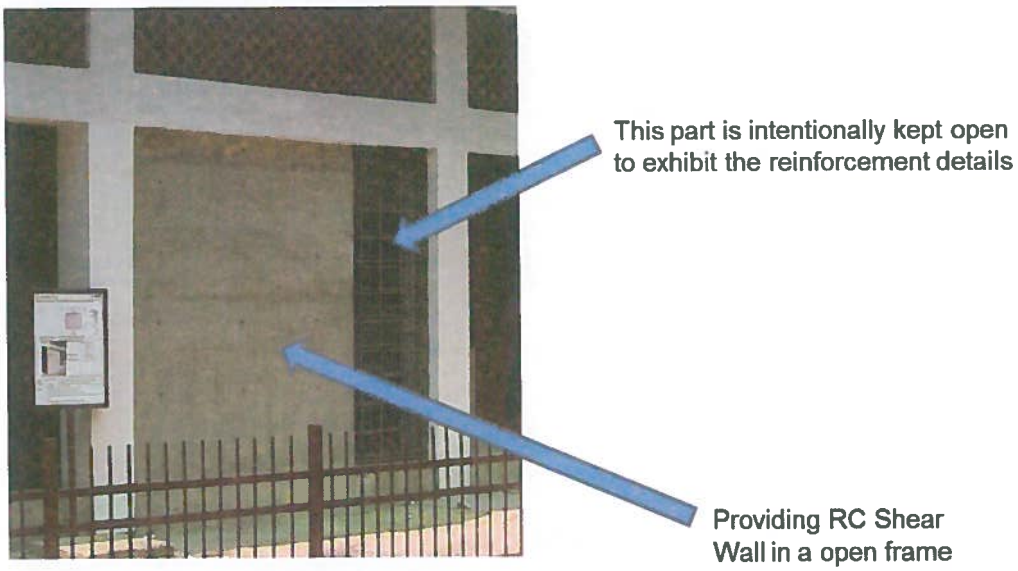


Figure 4.2.6 Photograph of RC Shear Wall Insertion

Figure 4.2.7 Photograph of RC Shear Wall Insertion during Construction of Pilot Work of CNCRP

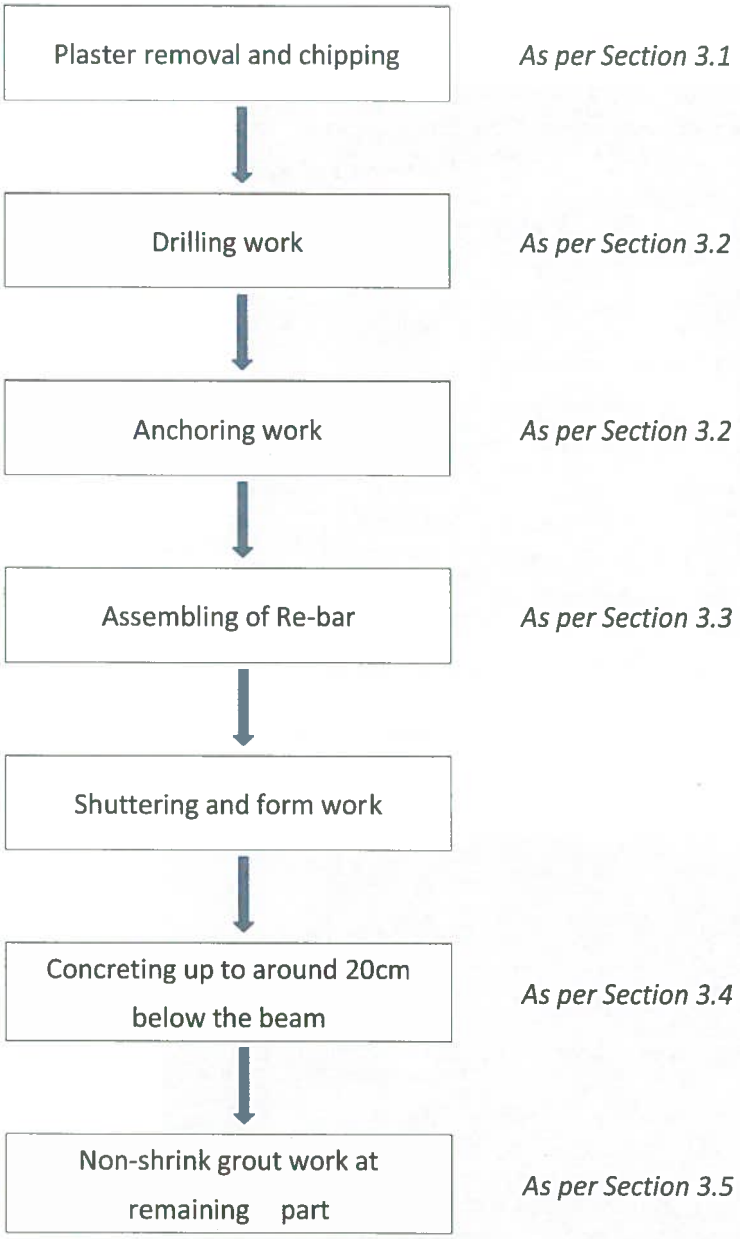
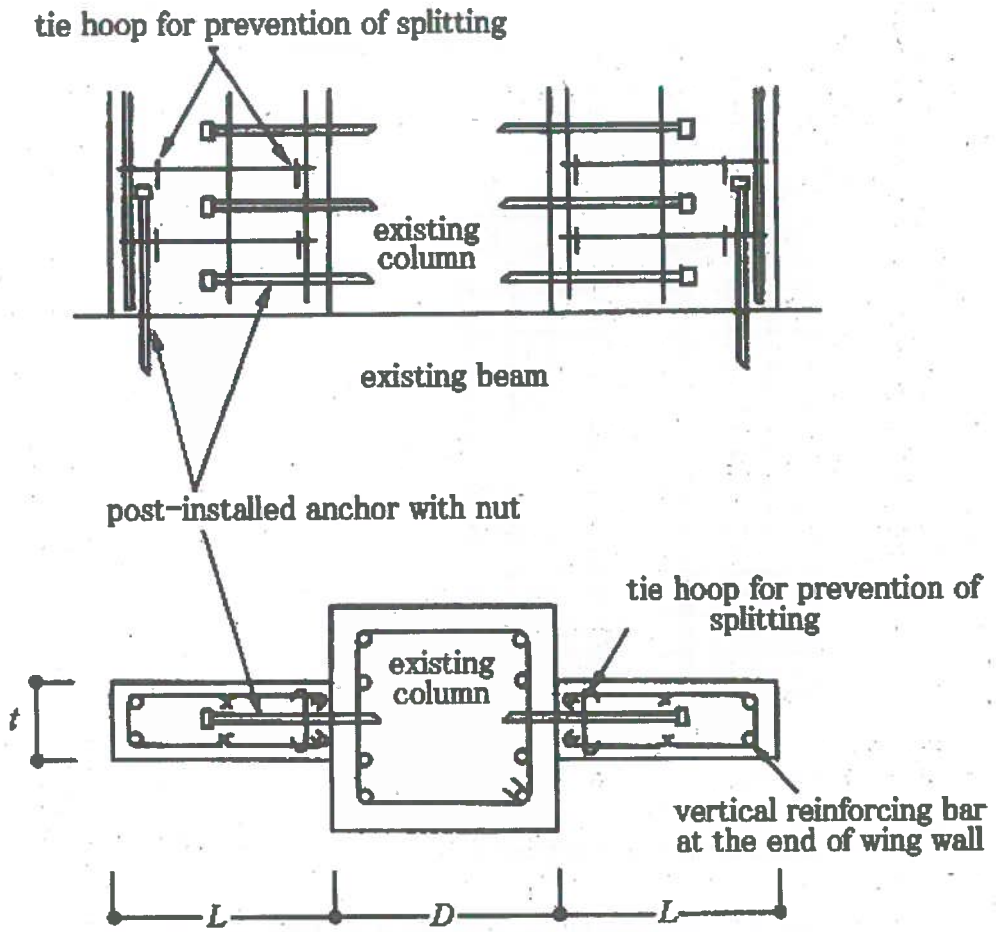


Figure 4.1.4 Standard Construction Flow Chart for Retrofitting by Shear Wall

4.3 RETROFITTING WITH RC WING WALL

In this retrofitting method small panels are installed with column which may not be considered as shear wall (see figure 4.3.1). The objective of this retrofitting method is to increase seismic performance of existing building by changing the existing independent columns to columns with wing wall for upgrading their strength.



SOURCE: Guidelines for Seismic Retrofit of Existing Reinforced Concrete Buildings, 2001. Published by- The Japan Building Disaster Prevention Association

Figure 4.3.1 Retrofitting by Installing Wing Wall

These wing walls are generally connected with the existing column and beam by using post-installed anchor work. Tie hoop can be used for prevention of splitting. The concrete work and non-shrink grout work shall be same as discussed in RC shear wall method. Figure 4.3.2 and figure 4.3.3 show the typical details of this method.

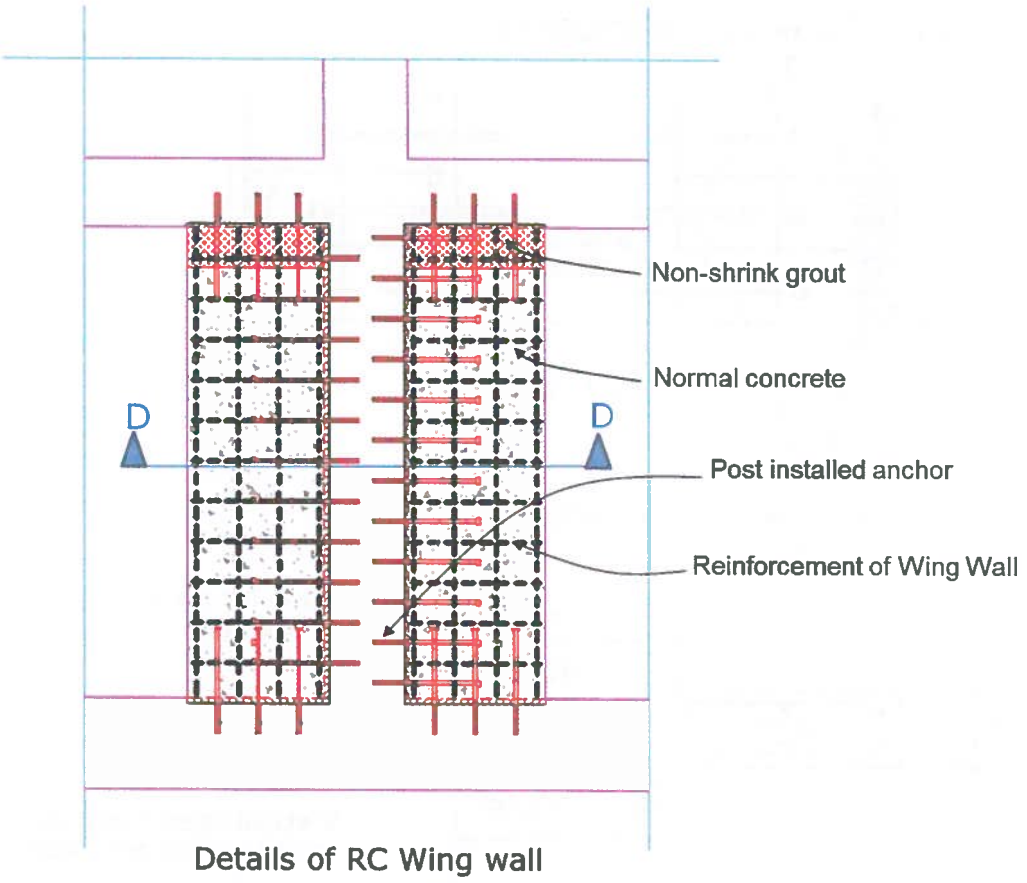


Figure 4.3.2 Retrofitting by Installing Wing Wall

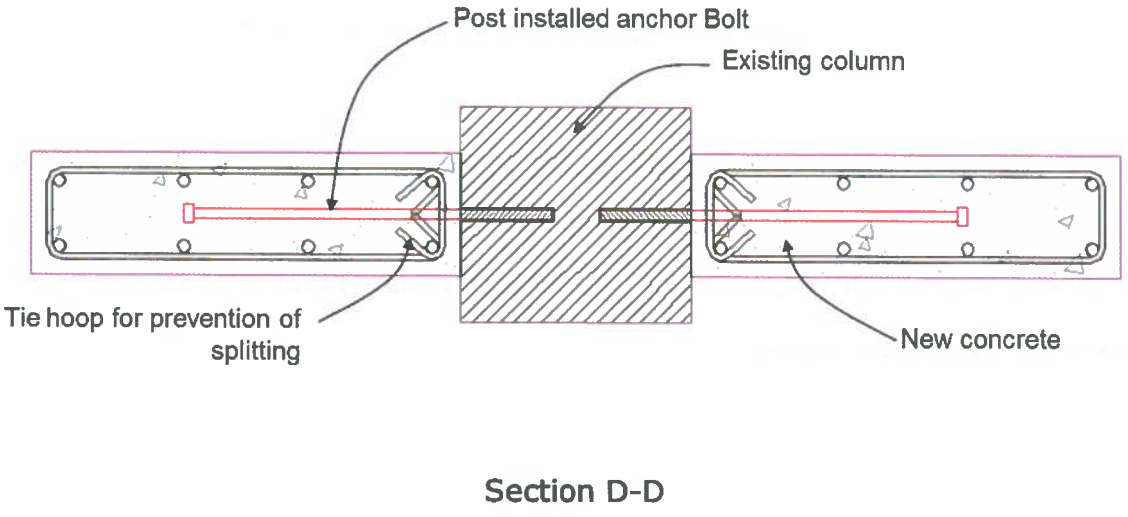


Figure 4.3.3 Retrofitting by Installing Wing Wall

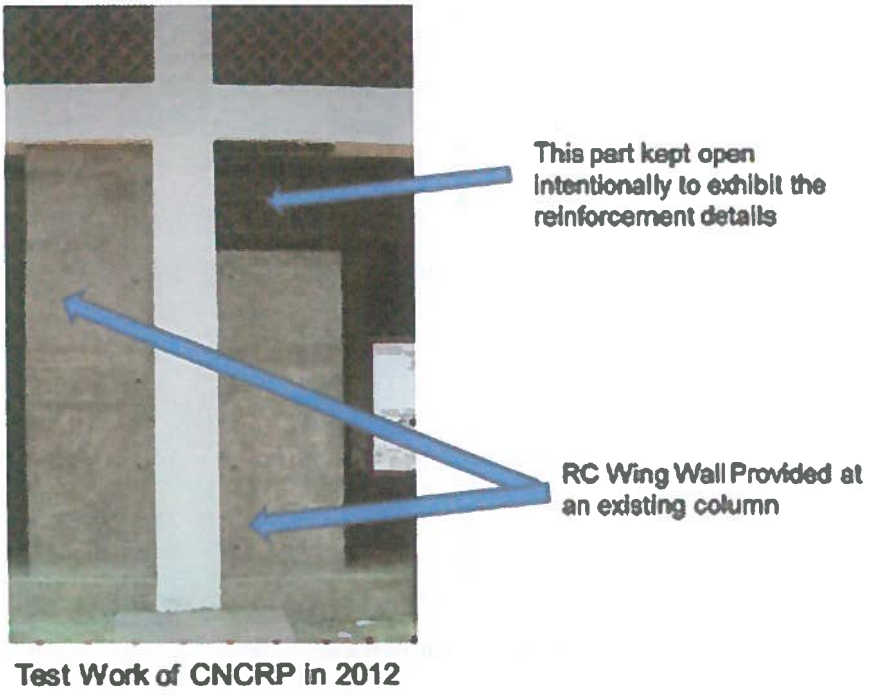


Figure 4.3.4 Photograph of Wing Wall

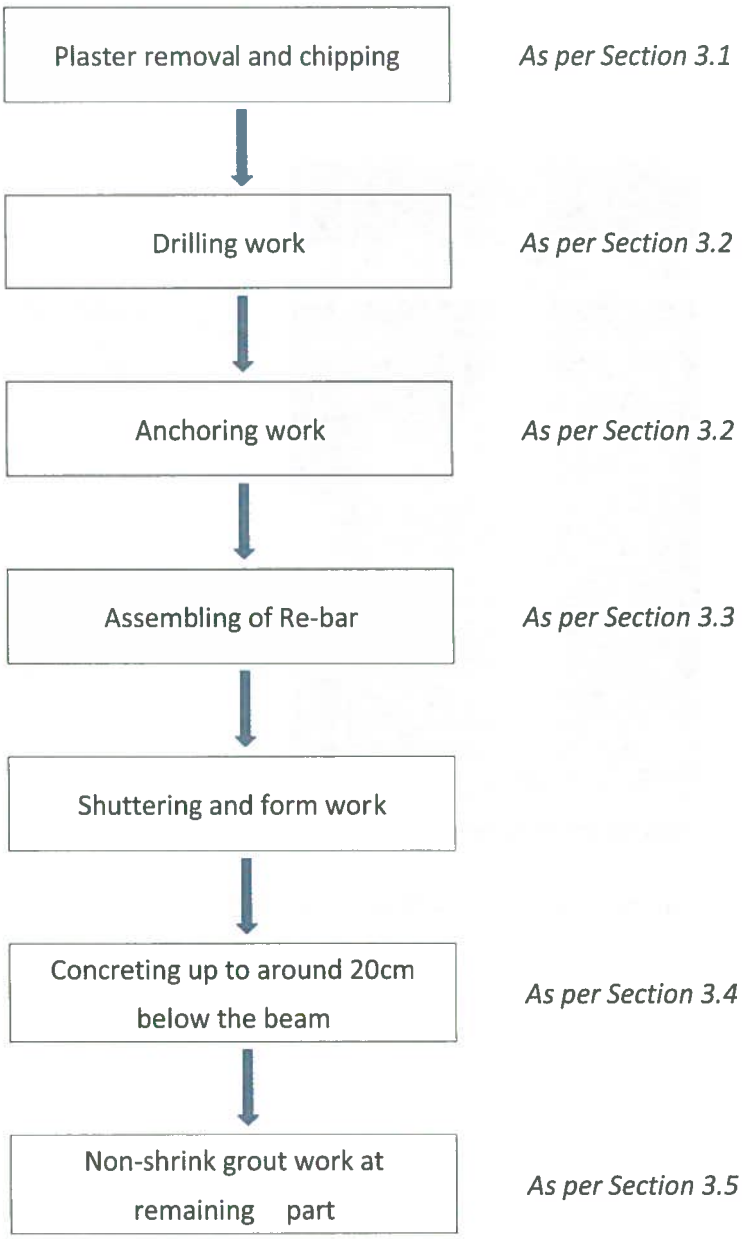


Figure 4.3.5 Standard Construction Flow Chart for Retrofitting by Wing Wall

4.4 RETROFITTING WITH STEEL FRAME BRACING

Retrofitting with steel sections is a seismic upgrade technique of existing RC frames by steel braces or steel panels. Connection details may have the following two schemes; direct connection bolting, welding or other methods and indirect connection through mortar and anchors provided between RC frame and steel frame. To ensure the secured connection, it is strongly recommended to use the second one i.e., indirect connection with existing RC members along their four interfaces of steel frame using post-installed anchor and non-shrink grout.

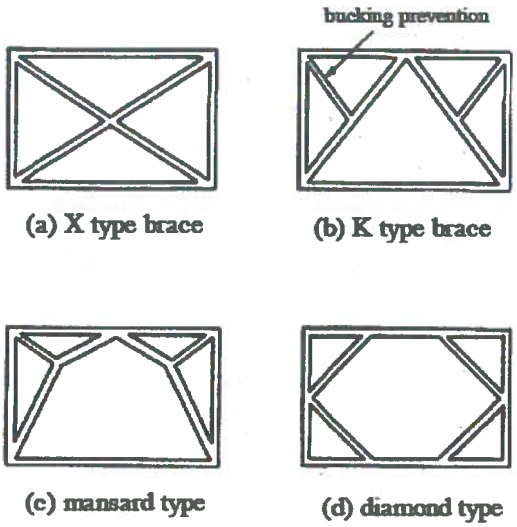


Figure 4.4.1 Different Types of Steel Frame Bracing

Steel frame bracing may be internal steel frame bracing or external steel frame bracing. In both cases, the connection detail shall be same. Post-installed anchor shall be placed along boundary columns and beams. Headed stud shall be connected with the peripheral members of the steel frame bracing. Spiral hoops or ladder-shaped reinforcing bars shall be used to prevent splitting at the connections of all four sides. The interfaces between the existing RC frame and steel frame shall be filled by non-shrink grout. The typical connection details of a steel frame bracing is shown in figure 4.4.2 to figure 4.4.4.

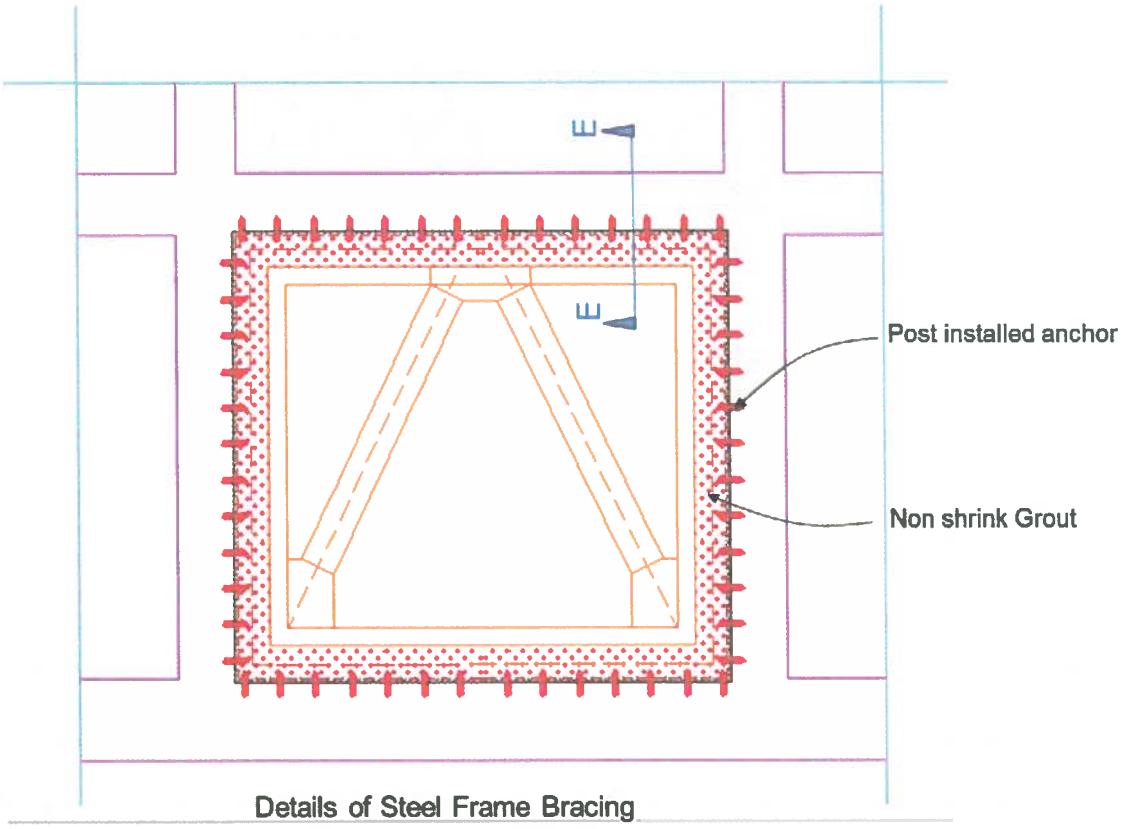


Figure 4.4.2 Details of Steel Frame Bracing

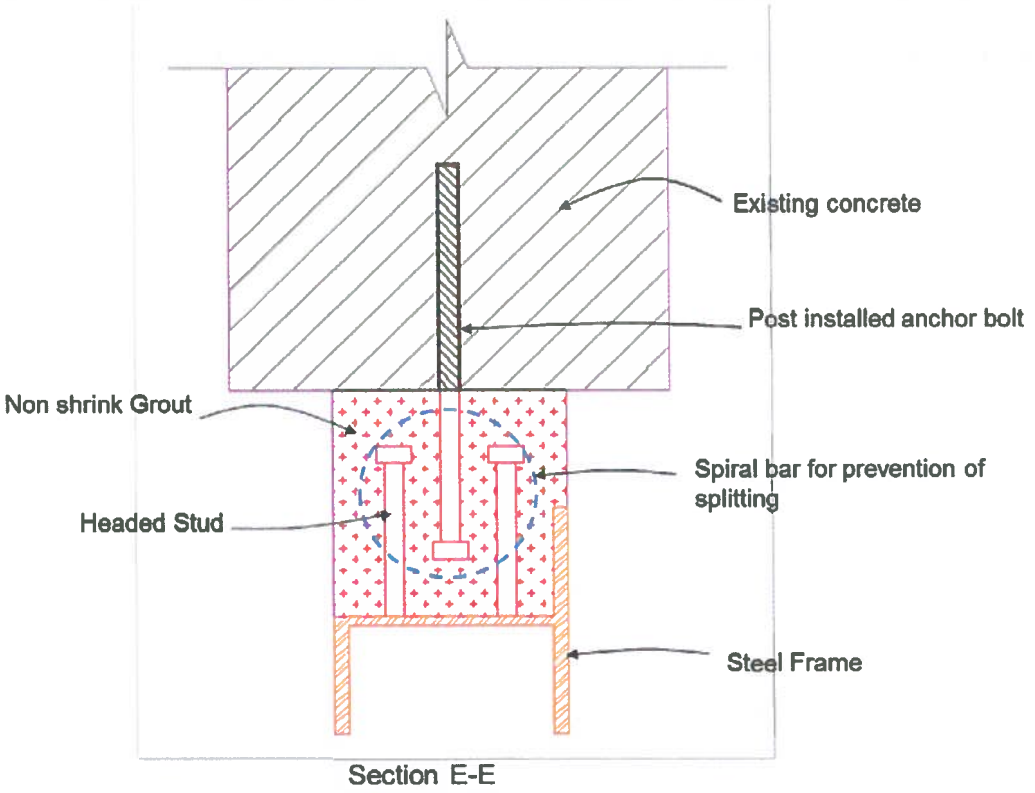


Figure 4.4.3 Connection Details between Existing RC Frame and Steel Frame Bracing

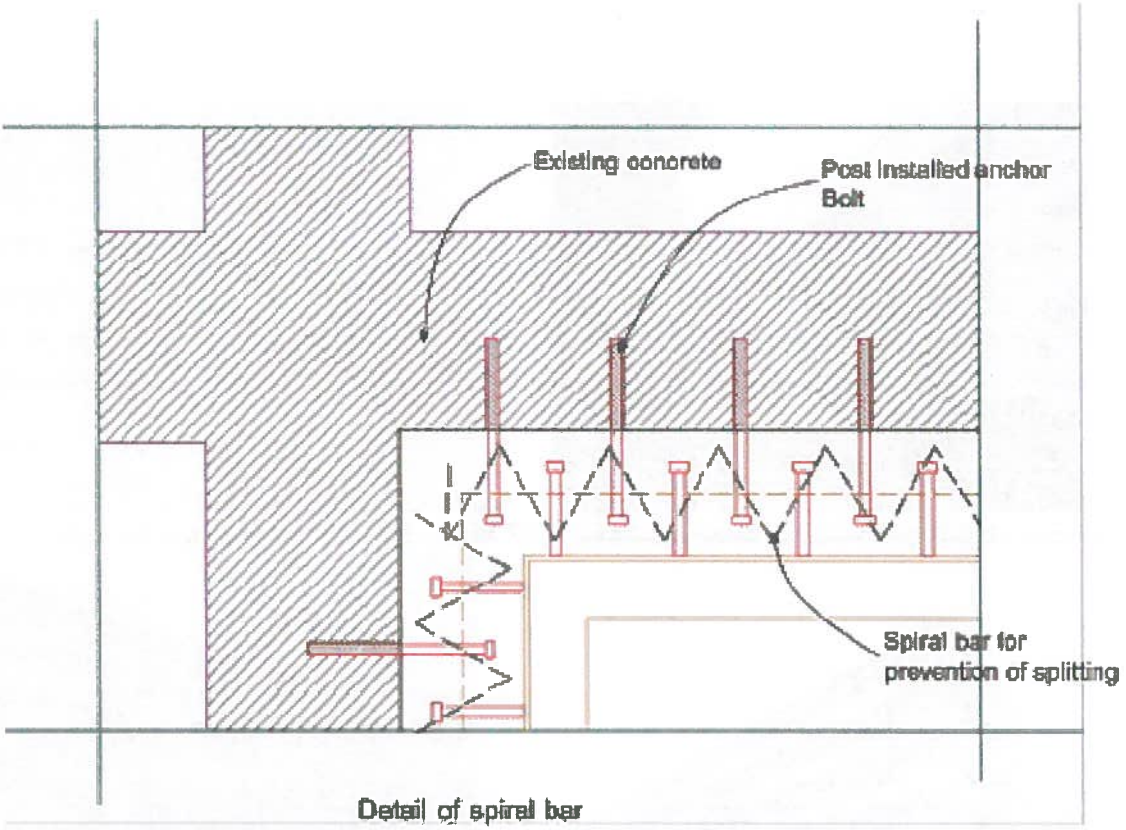


Figure 4.4.4 Details of Spiral Hoops to Prevent Split

Internal Steel Frame Bracing under construction

Internal Steel Frame Bracing after construction

Figure 4.4.5 Photographs of Steel Frame Bracing from Pilot Work of CNCRP

a)Junior High School Building (School Colored)

b) Junior High School Building (Designed by Students)

c)University Building (with Exterior Panels)

d)Elementary School Building (with Balconies)

Figure 4.4.6 Photographs of Steel Frame Bracing

External Steel Frame Bracing is applied as retrofitting in a building of Tohuku University

Figure 4.4.7 Photographs of Steel Frame Bracing (External)

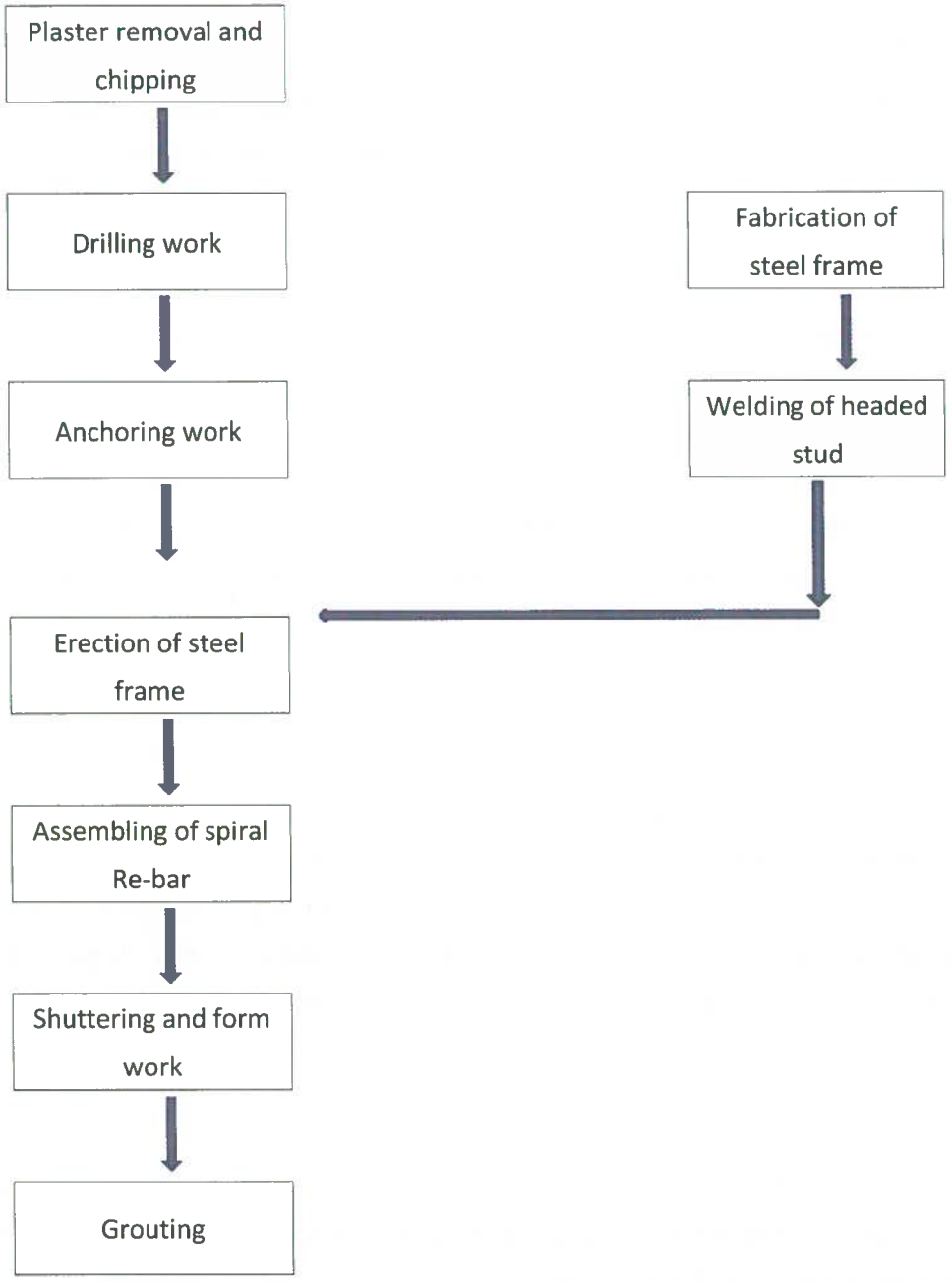


Figure 4.4.8 Standard Construction Flow Chart for Steel Frame Bracing

4.5 RETROFITTING WITH CARBON FIBER WRAPPING

Procedures for installing Fiber Reinforced Polymer (FRP) systems have been developed by the system manufacturers and often differ between systems. In addition, installation procedures can vary within a system, depending on the type and condition of the structure. Contractors trained in accordance with the installation procedures developed by the system manufacturer should install FRP systems. Deviations from the procedures developed by the FRP system manufacturer should not be allowed without consulting with the manufacturer.

4.5.1 Temperature, humidity, and moisture considerations

Temperature, relative humidity, and surface moisture at the time of installation can affect the performance of the FRP system. Conditions to be observed before and during installation include surface temperature of the concrete, air temperature, relative humidity, and corresponding dew point.

- Primers, saturating resins, and adhesives should generally not be applied to cold or frozen surfaces. When the surface temperature of the concrete surface falls below a minimum level as specified by the FRP system manufacturer, improper saturation of the fibers and improper curing of the resin constituent materials can occur, compromising the integrity of the FRP system.
- Resins and adhesives should generally not be applied to damp or wet surfaces unless they have been formulated for such applications.
- FRP systems should not be applied to concrete surfaces that are subject to moisture vapor transmission. The transmission of moisture vapor from a concrete surface through the uncured resin materials typically appears as surface bubbles and can compromise the bond between the FRP system and the substrate.

4.5.2 Substrate repair and surface preparation

The behavior of concrete members strengthened or retrofitted with FRP systems is highly dependent on a sound concrete substrate and proper preparation and profiling of the concrete surface. An improperly prepared surface can result in de bonding or delaminating of the FRP system before achieving the design load transfer. The general guidelines presented in this chapter should be applicable to all externally bonded FRP systems. Specific guidelines for a particular FRP system should be obtained from the FRP system manufacturer.

4.5.2.1 Substrate repair

All problems associated with the condition of the original concrete and the concrete substrate that can compromise the integrity of the FRP system should be addressed before surface preparation begins. All concrete repairs should meet the requirements of the design drawings and project specifications. The FRP system manufacturer should be consulted on the compatibility of the FRP system with materials used for repairing the substrate.

4.5.2.2 Corrosion-related deterioration

Externally bonded FRP systems should not be applied to concrete substrates suspected of containing corroded reinforcing steel. The expansive forces associated with the corrosion process are difficult to determine, and could compromise the structural integrity of the externally applied FRP system.
The cause(s) of the corrosion should be addressed, and the corrosion-related deterioration should be repaired before the application of any externally bonded FRP system.

4.5.2.3 Injection of cracks

Cracks that are 0.010 in. (0.3 mm) and wider can affect the performance of the externally bonded FRP system through delamination or fiber crushing. Consequently, cracks wider than 0.010 in. (0.3 mm) should be pressure injected with epoxy before FRP installation in accordance with manufacturers guideline. Smaller cracks exposed to aggressive environments may require resin injection or sealing to prevent corrosion of existing steel reinforcement.

4.5.2.4 Surface preparation

Surface preparation requirements should be based on the intended application of the FRP system. Applications can be categorized as Bond-critical or Contact-critical.

Bond-critical applications, such as flexural or shear strengthening of beams, slabs, columns, or walls, require an adhesive bond between the FRP system and the concrete.

Contact-critical applications, such as confinement of columns, only require intimate contact between the FRP system and the concrete. Contact-critical applications do not require an adhesive bond between the FRP system and the concrete substrate, although it is often provided to facilitate installation.

- ***Bond-critical applications***

  Surface preparation for bond-critical applications should be in accordance with recommendations of ACI 546R and ICRI 03730.

  - The concrete or repaired surfaces to which the FRP system is to be applied should be freshly exposed and free of loose or unsound materials.
  - Where fibers wrap around the corners of rectangular cross sections, the corners should be rounded to a minimum 0.5 in. (13 mm) radius to prevent stress concentrations in the FRP system and voids between the FRP system and the concrete. Roughened corners should be smoothed with putty.
  - Obstructions, inside corners, concave surfaces, and embedded objects can affect the performance of the FRP system, and should be addressed. Obstructions and embedded objects may need to be removed before installing the FRP system.
  - Inside corners and concave surfaces may require special detailing to ensure that the bond of the FRP system to the substrate is maintained.
  - All laitance, dust, dirt, oil, curing compound, existing coatings, and any other matter that could interfere with the bond of the FRP system to the concrete should be removed.
  - Bug holes and other small surface voids should be completely exposed during surface profiling.

- After the profiling operations are complete, the surface should be cleaned and protected before FRP installation so that no materials that can interfere with bond are re-deposited on the surface.
- The concrete surface should be prepared to a minimum concrete surface profile (CSP) 3 as defined by the ICRI surface-profile chips. The FRP system manufacturer should be consulted to determine if more aggressive surface profiling is necessary. Localized out-of-plane variations, including form lines, should not exceed 1/32 in. (1 mm) or the tolerances recommended by the FRP system manufacturer. Localized out-of-plane variations can be removed by grinding, or can be smoothed over using resin-based putty if the variations are very small.
- Bug holes and voids should be filled with resin based putty.
- All surfaces to receive the strengthening system should be as dry as recommended by the FRP system manufacturer.
- Water in the pores can inhibit resin penetration and reduce mechanical interlock. Moisture content should be evaluated in accordance with the requirements of ACI 503.4.

- ***Contact-critical applications***

In applications involving confinement of structural concrete members, surface preparation should promote continuous intimate contact between the concrete surface and the FRP system. Surfaces to be wrapped should, at a minimum, be flat or convex to promote proper loading of the FRP system. Large voids in the surface should be patched with a repair material compatible with the existing concrete. Materials with low compressive strength and elastic modulus, such as plaster, can reduce the effectiveness of the FRP system and should be removed.

4.5.3 Primer and putty

Where required, primer should be applied to all areas on the concrete surface where the FRP system is to be placed. The primer should be placed uniformly on the prepared surface at the manufacturer's specified rate of coverage. The applied primer should be protected from dust, moisture, and other contaminants before applying the FRP system. Putty should be used in an appropriate thickness and sequence with the primer as recommended by the FRP manufacturer. The system compatible putty, which is typically a thickened resin-based paste, should be used only to fill voids and smooth surface discontinuities before the application of other materials. Rough edges or trowel lines of cured putty should be ground smooth before continuing the installation. Before applying the saturating resin or adhesive, the primer and putty should be allowed to cure as specified by the FRP system manufacturer. If the putty and primer are fully cured, additional surface preparation may be required before the application of the saturating resin or adhesive. Surface preparation requirements should be obtained from the FRP system manufacturer.

4.5.4 Mixing of resins

Mixing of resins should be done in accordance with the FRP system manufacturer's recommended procedure. All resin components should be at the proper temperature and mixed in the correct ratio until there is a uniform and complete mixing of components. Resin components are often contrasting colors, so full mixing is achieved when color streaks are eliminated. Resins should be mixed for the prescribed mixing time and visually inspected for uniformity of color. The material manufacturer should supply recommended batch sizes, mixture ratios, mixing methods, and mixing times. Mixing equipment can include small electrically powered mixing blades or specialty units, or resins can be mixed by hand stirring, if needed. Resin mixing should be in quantities sufficiently small to ensure that all mixed resin can be used within the resin's pot life. Mixed resin that exceeds its pot life should not be used because the viscosity will continue to increase and will adversely affect the resin's ability to penetrate the surface or saturate the fiber sheet. Fumes can accompany the application of some FRP resins. FRP systems should be selected with consideration for their impact on the environment, including emission of volatile organic compounds and toxicology.

4.5.5 Carbon-Fiber-Reinforced Polymer (CFRP) layup

The CFRP available in Bangladesh are known as Wet layup FRP systems and are typically installed by hand using dry fiber sheets and a saturating resin, typically per the manufacturer's recommendations. The saturating resin should be applied uniformly to all prepared surfaces where the system is to be placed. The fibers can also be impregnated in a separate process using a resin-impregnating machine before placement on the concrete surface. The reinforcing fibers should be gently pressed into the uncured saturating resin in a manner recommended by the FRP system manufacturer. Entrapped air between layers should be released or rolled out before the resin sets. Sufficient saturating resin should be applied to achieve full saturation of the fibers. Successive layers of saturating resin and fiber materials should be placed before the complete cure of the previous layer of resin. If previous layers are cured, interlayer surface preparation, such as light sanding or solvent application as recommended by the system manufacturer, may be required.

4.5.6 Alignment of CFRP materials

The FRP-ply orientation and ply-stacking sequence should be specified. Small variations in angle, as little as 5 degrees, from the intended direction of fiber alignment can cause a substantial reduction in strength and modulus. Deviations in ply orientation should only be made if approved by the licensed design professional. Sheet and fabric materials should be handled in a manner to maintain the fiber straightness and orientation. Fabric kinks, folds, or other forms of severe waviness should be reported to the licensed design professional.

4.5.7 Protective coatings

Coatings should be compatible with the FRP strengthening system and applied in accordance with the manufacturer's recommendations. Typically, the use of solvents to clean the FRP surface before installing coatings is not recommended due to the deleterious effects that solvents can have on the polymer resins. The FRP system manufacturer should approve any use of solventwipe preparation of FRP surfaces before the application of protective coatings. The coatings should be periodically inspected and maintenance should be provided to ensure the effectiveness of the coatings.

4.5.8 Curing of resins

Curing of resins is a time-temperature-dependent phenomenon. Ambient-cure resins can take several days to reach full cure. Temperature extremes or fluctuations can retard or accelerate the resin curing time. The FRP system manufacturer may offer several prequalified grades of resin to accommodate these situations.

Elevated cure systems require the resin to be heated to a specific temperature for a specified period of time. Various combinations of time and temperature within a defined envelope should provide full cure of the system. All resins should be cured according to the manufacturer's recommendation. Field modification of resin chemistry should not be permitted. Cure of installed plies should be monitored before placing subsequent plies. Installation of successive layers should be halted if there is a curing anomaly.

4.5.9 Multiple plies and lap splices

Multiple plies can be used, provided that all plies are fully impregnated with the resin system, the resin shear strength is sufficient to transfer the shearing load between plies, and the bond strength between the concrete and FRP system is sufficient. For long spans, multiple lengths of fiber material or precured stock can be used to continuously transfer the load by providing adequate lap splices. Lap splices should be staggered, unless noted otherwise by the licensed design professional. Lap splices details, including lap length, should be based on testing and installed in accordance with the manufacturer's recommendations.

4.5.10 Temporary protection

Adverse temperatures; direct contact by rain, dust, or dirt; excessive sunlight; high humidity; or vandalism can damage an FRP system during installation and cause improper cure of the resins. Temporary protection, such as tents and plastic screens, may be required during installation and until the resins have cured. If temporary shoring is required, the FRP system should be fully cured before

removing the shoring and allowing the structural member to carry the design loads. In the event of suspected damage to the FRP system during installation, the licensed design professional should be notified and the FRP system manufacturer consulted.

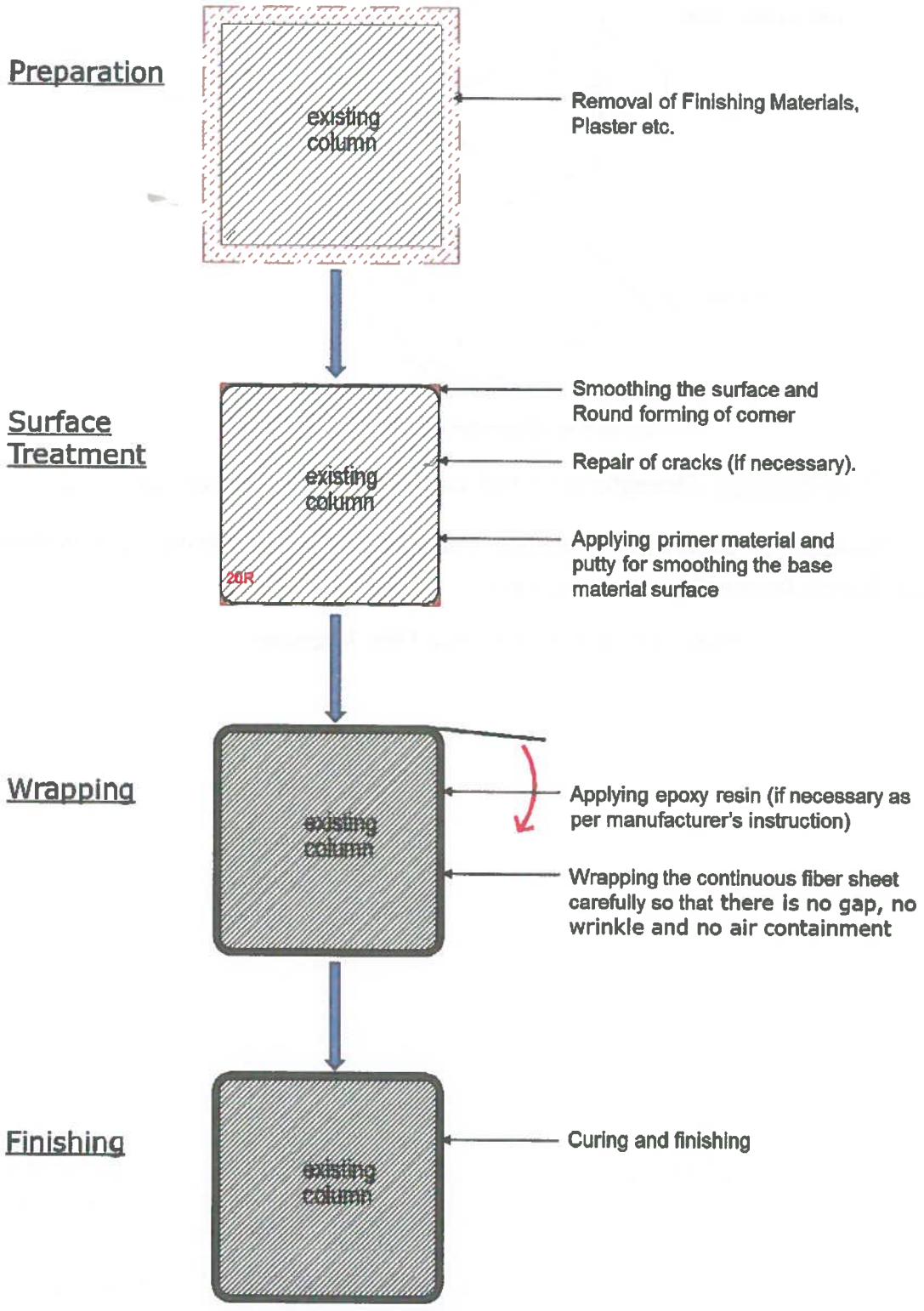
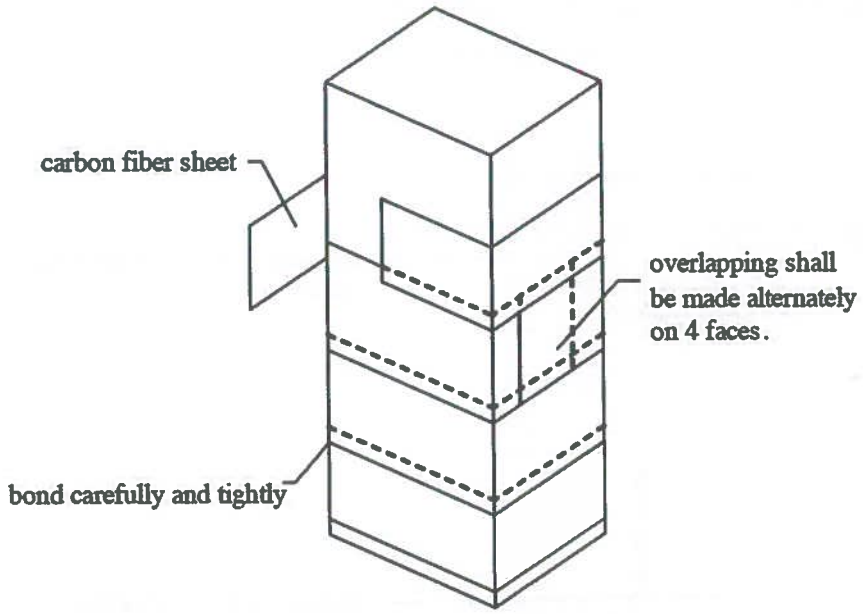


Figure 4.5.1 Steps of Carbon Fiber Wrapping



Strengthening with carbon fiber sheet wrapping

SOURCE: Guidelines for Seismic Retrofit of Existing Reinforced Concrete Buildings, 2001. Published by-The Japan Building Disaster Prevention Association

Figure 4.5.2 Details of Carbon Fiber Wrapping

Figure 4.5.2 Photographs of Carbon Fiber Wrapping

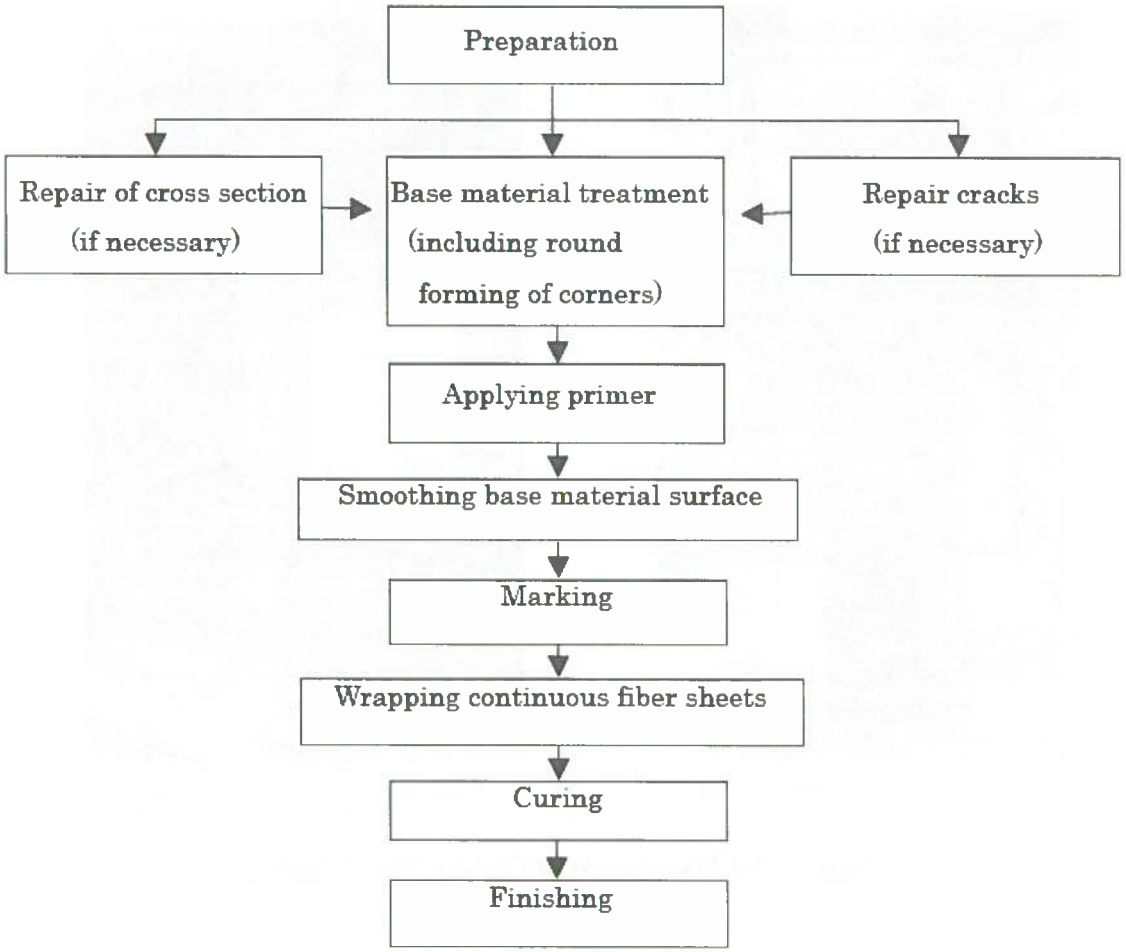


Figure 4.1. 4 Standard Construction Flow Chart for Carbon Fiber Wrapping

4.6 RETROFITTING WITH STURCTURAL SLIT

This is a retrofitting method by making a slit between column and it's adjacent walls. Main purpose of this method is to increase the ductility of the column and make the structural balance. The slit can be classified in to two categories i) Full slit and ii) Partial slit.

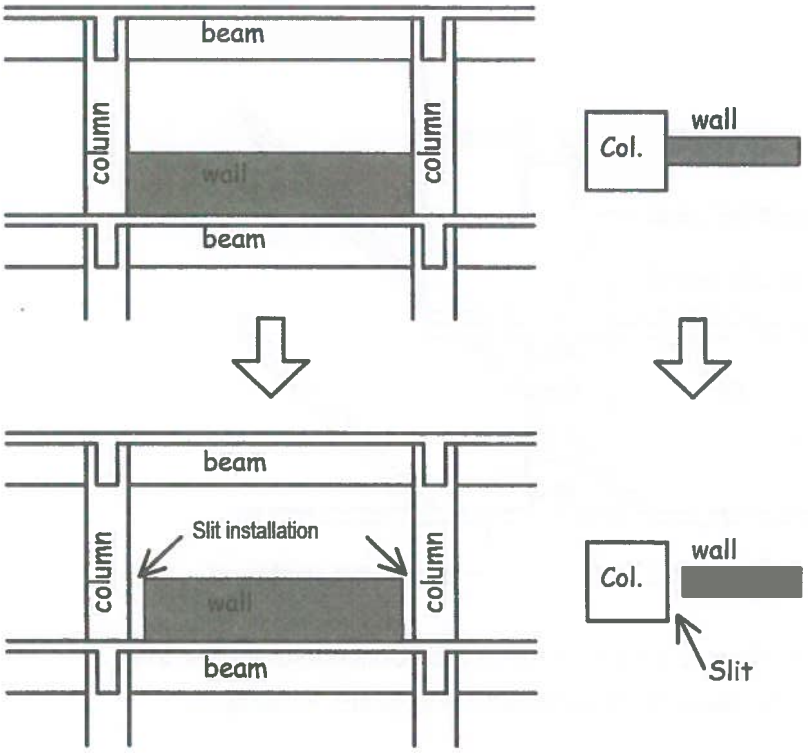


Figure 4.6.1 Example of Seismic Slit

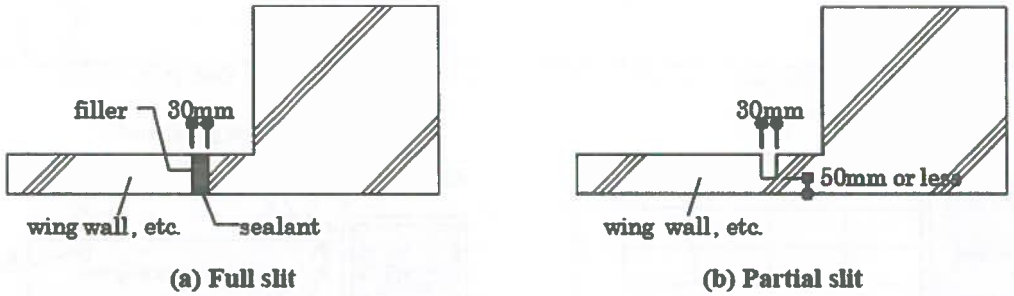
When the structural slit will be applied, the following considerations must be noted

i) Check the adjacent wall against overturning and make necessary measures

ii) Check the waterproofing performance of the wall

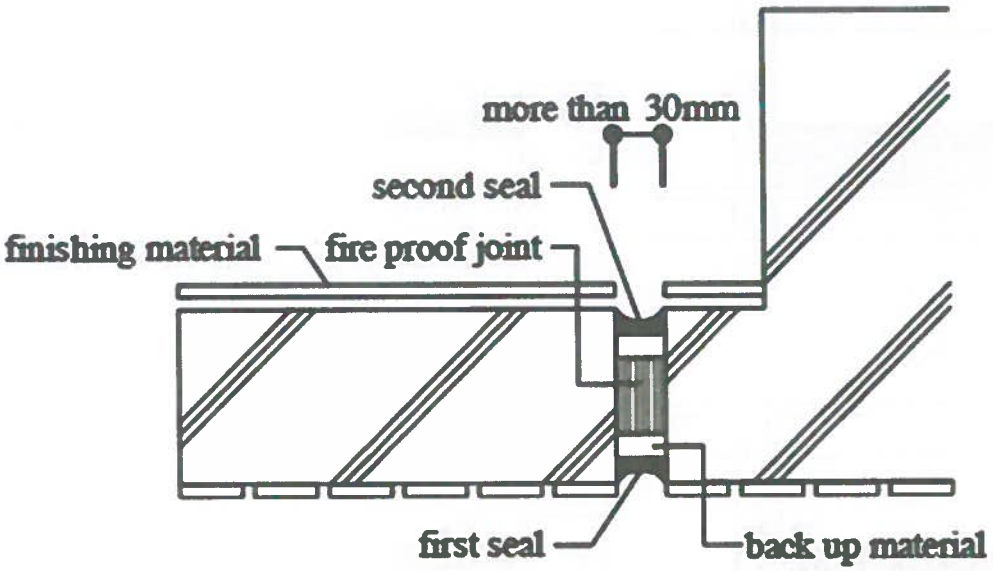
iii) Check the fire proofing performance of the wall

The Typical details of the structural slit is shown in figure 4.6.2. Short column fracture problem and soft story problem may be solved by using this method.



SOURCE: Guidelines for Seismic Retrofit of Existing Reinforced Concrete Buildings, 2001. Published by- The Japan Building Disaster Prevention Association

Figure 4.6.2 Types of Seismic Slit



SOURCE: Guidelines for Seismic Retrofit of Existing Reinforced Concrete Buildings, 2001.
Published by- The Japan Building Disaster Prevention Association

Figure 4.6.3 Details of a Full Seismic Slit

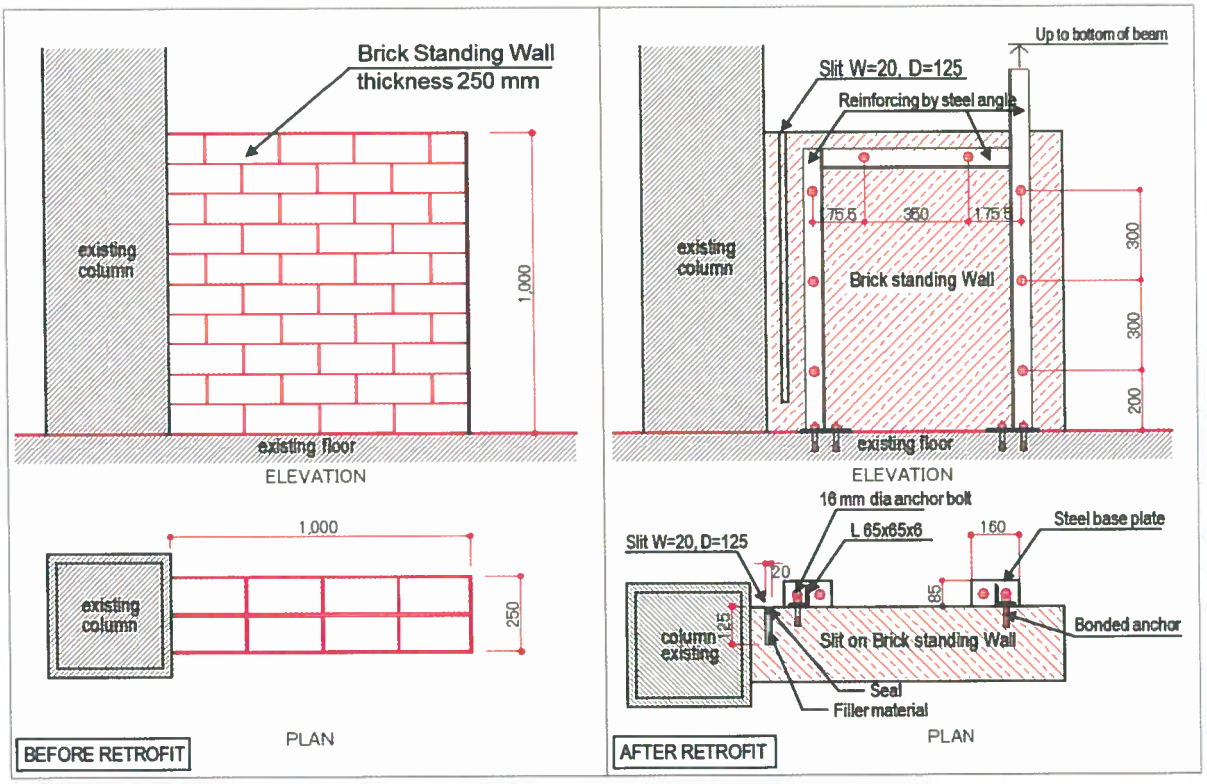


Figure 4.6.4 Details of a Structural Slit (Drawing for Test Work of CNCRP Project)

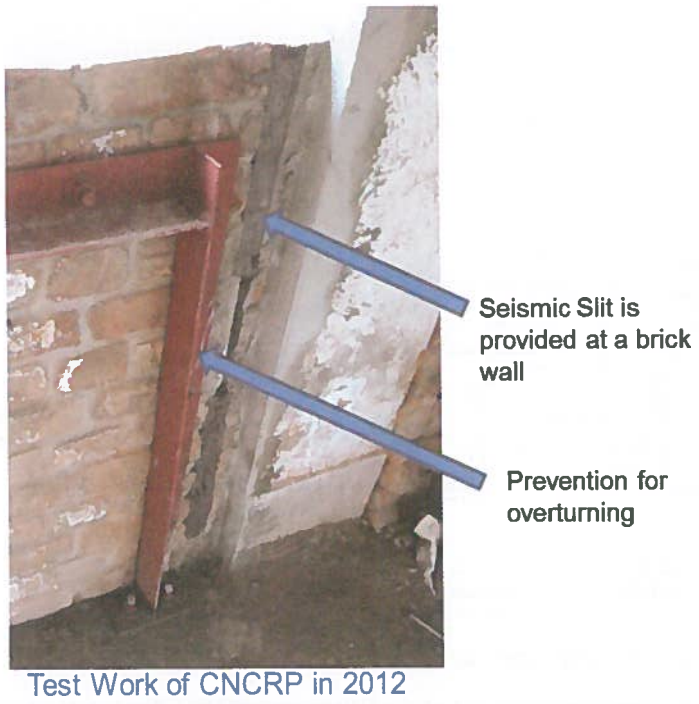


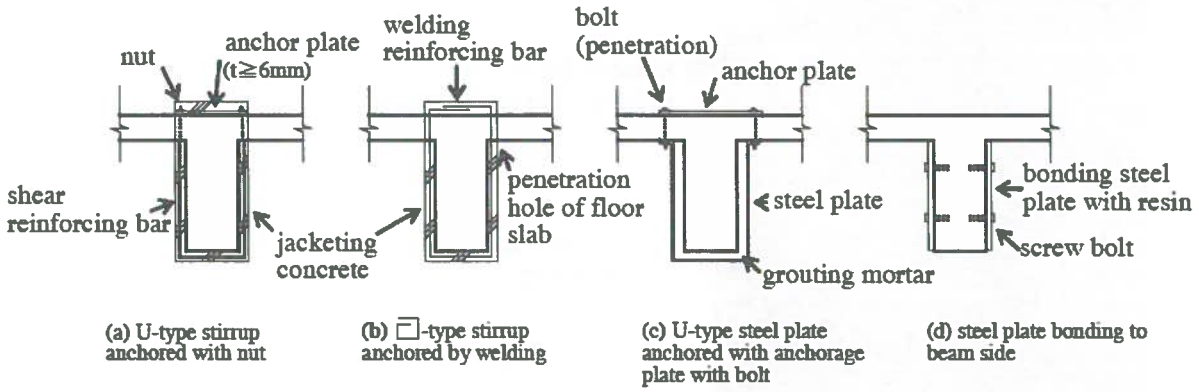
Figure 4.6.5 Photograph of a Structural Slit

Figure 4.6.6 Photograph of a Structural Slit

4.7 RETROFITTING WITH RC BEAM JACKETING

In this method a beam is jacketed around its surfaces by reinforced concrete or reinforced mortar. The main objective of this method is to improve ductility. Beam jacketing may be used for repair purpose also.

The newly added shear reinforcement shall be covered by concrete or mortar and concrete shall not be less than 20 mm. Ends of newly added stirrup shall pass though the slab and be closed by welding or anchoring with plate (see the figure 4.7.1)



Examples of Beam Strengthening

(quoted from the figure on page 224 in the commentary of 3.5.4 of the Guidelines of 2001 Japanese version)

SOURCE: Guidelines for Seismic Retrofit of Existing Reinforced Concrete Buildings, 2001.
Published by- The Japan Building Disaster Prevention Association

Figure 4.7.1 Examples of Beam Jacketing

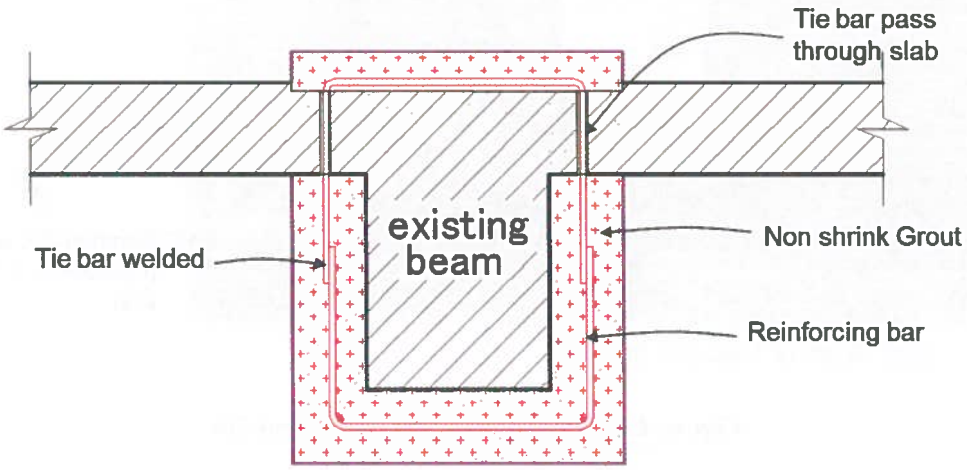


Figure 4.7.2 Details of RC Beam Jacketing

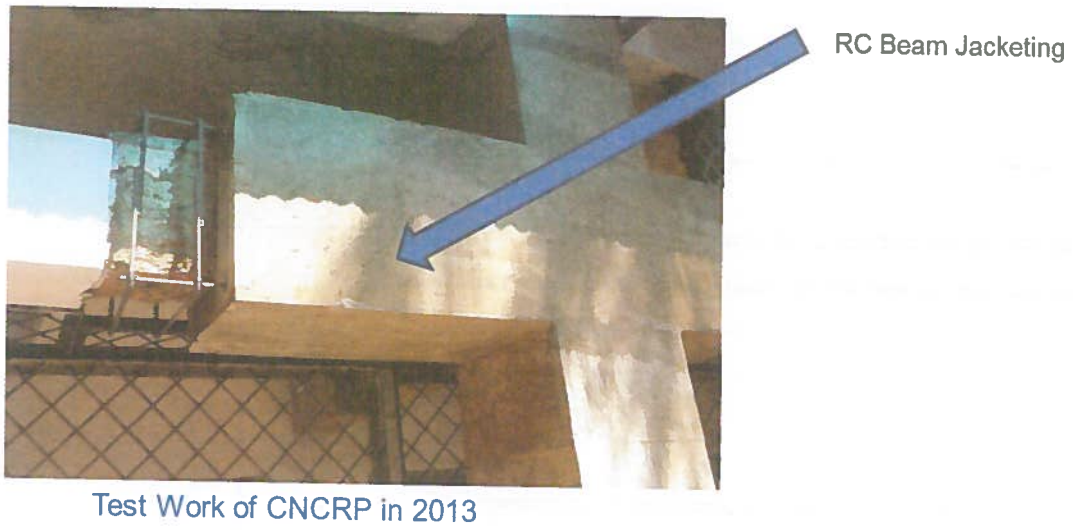
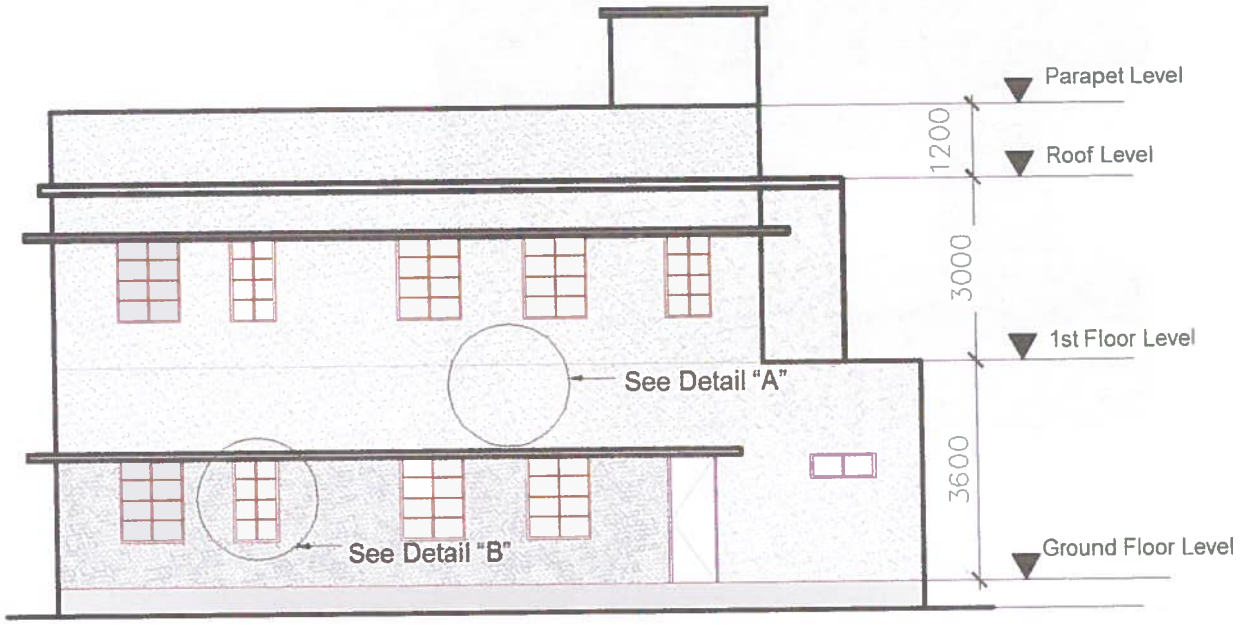


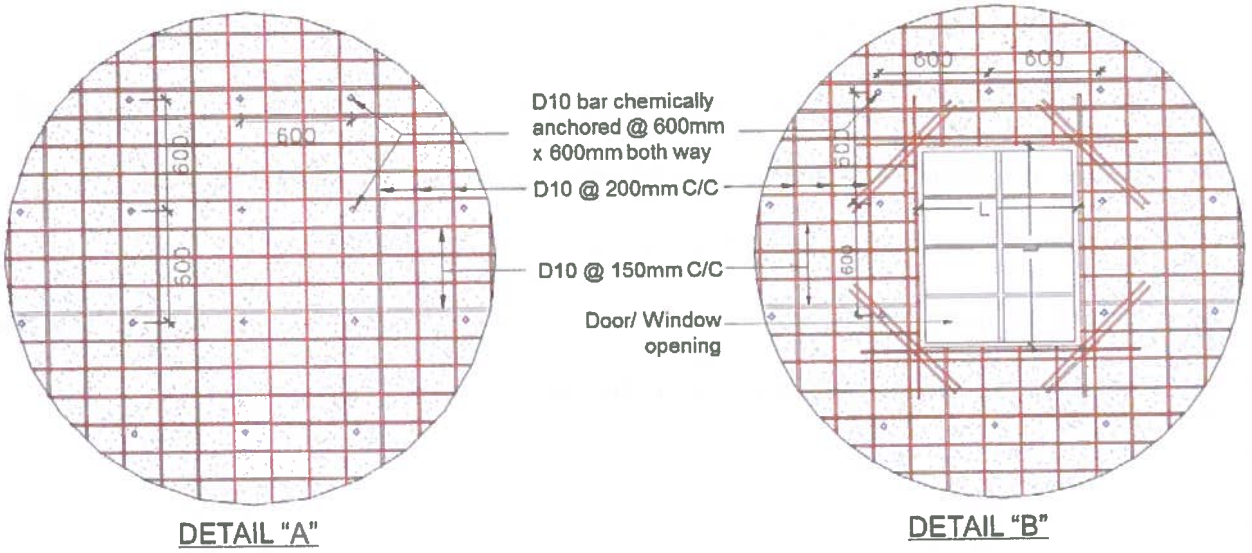
Figure 4.7.3 Photograph of a RC Beam Jacketing

4.8 RETROFITTING WITH RC LAMINATION OF BRICK WALL

In this method the existing load bearing brick wall is strengthened by a RC lamination. The main purpose of this method is to increase the strength of the existing building. The connection between brick wall and RC lamination is very important. Sufficient numbers of post-installed anchor shall be provided to make the surface between new RCC and old brick wall more integrated. The minimum thickness of laminated concrete shall be 100 mm. Since this type of lamination work is very thin and spread over a large surface of the wall, the shuttering work is very important to make the surface of the concrete plane and true to plumb. It is suggested to make the shutters in position by using tie rod through the brick wall and anchored from other side of the wall.



SOUTH ELEVATION



DETAIL "A" DETAIL "B"

Figure 4.8.1 Details RC Lamination (Drawing for Pilot Work of CNCRP Project)

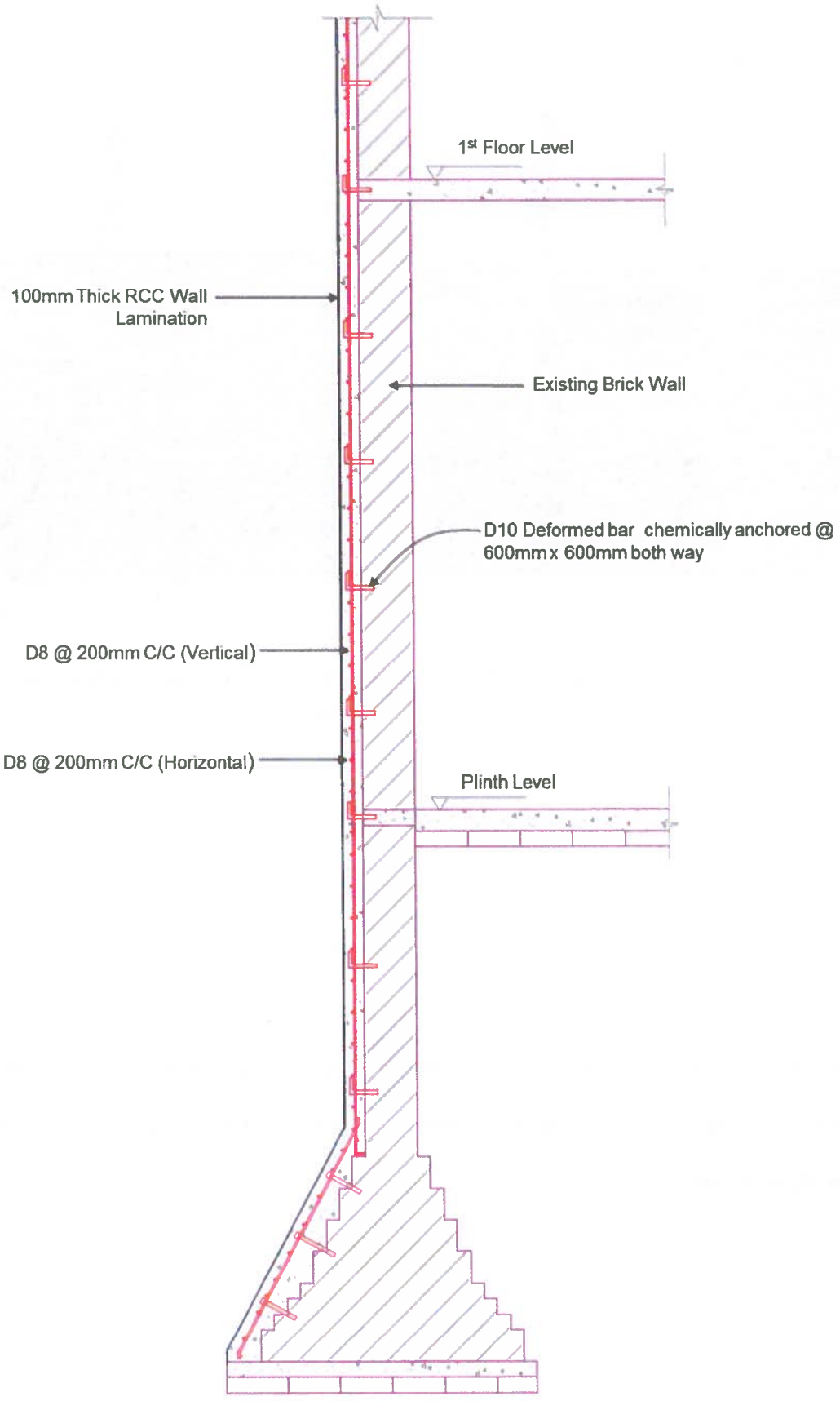


Figure 4.8.2 Typical Section of RC Lamination (Drawing for Pilot Work of CNCRP Project)

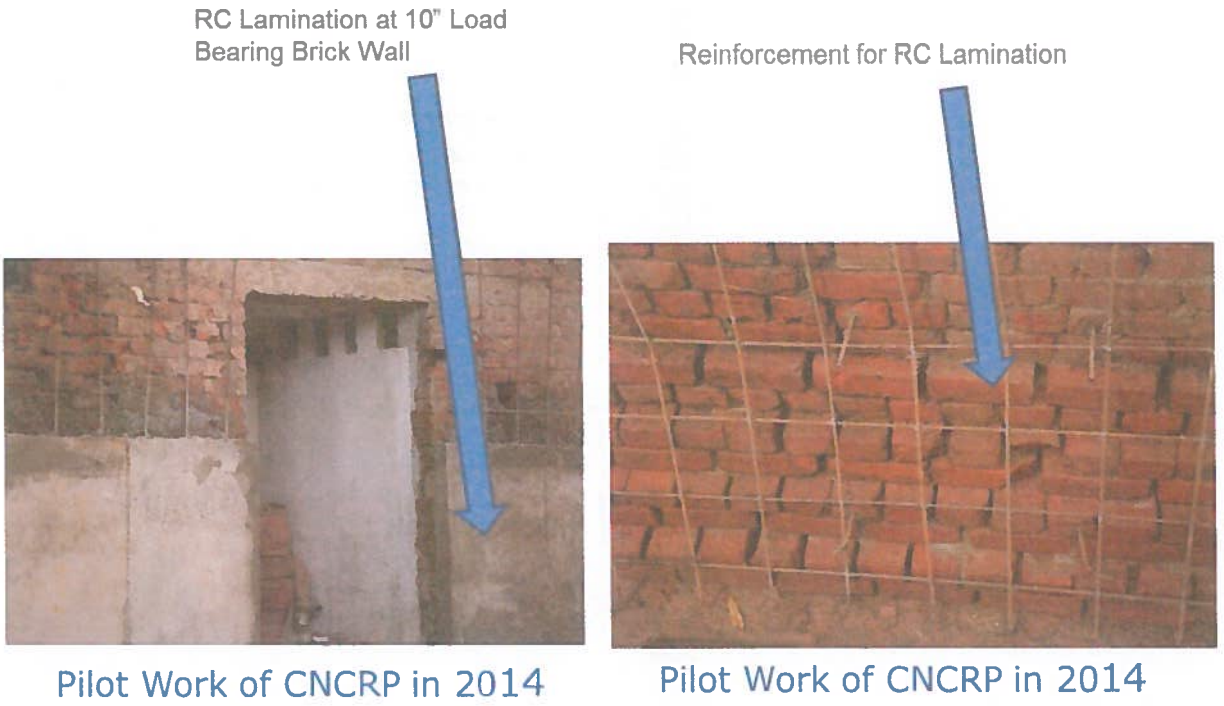
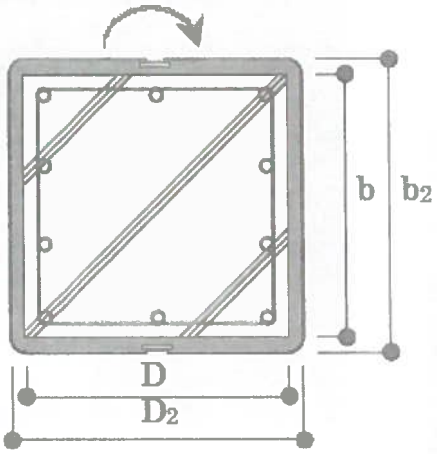


Figure 4.8.1 Photographs of RC Lamination (During construction of Pilot Work of CNCRP Project)

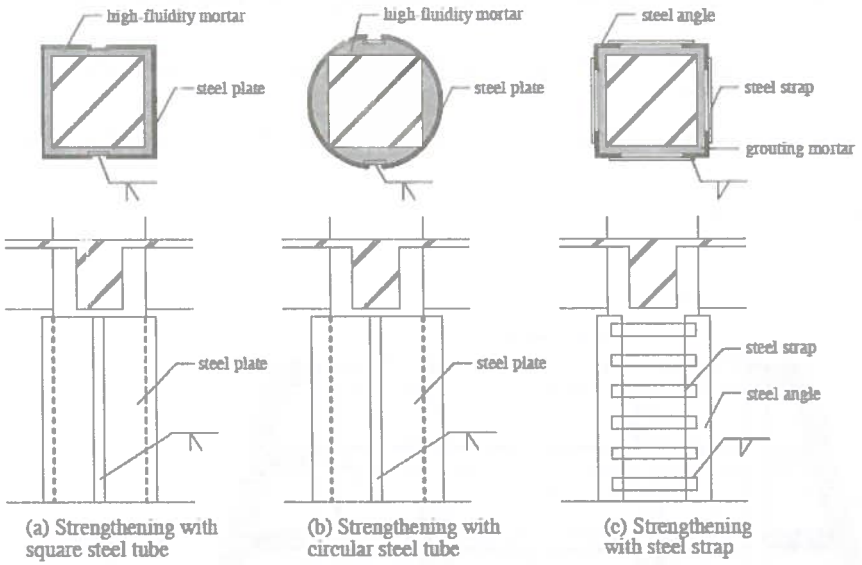
4.9 RETROFITTING WITH STEEL PLATE JACKETING

This is a retrofitting method where the existing RC column is jacketed by a thin steel plate and grouting mortar in to the gap between steel plates and existing concrete. The purpose of this method is to improve the ductility of column by increasing the shear strength and also to improve the axial strength by confining the existing column. The four faces of the existing column shall be enclosed monolithically by steel plate jacket so the gap between existing column and steel plate shall be filled appropriately by injecting non-shrink grout mortar. The corners of the column shall be rounded to improve the confinement.



SOURCE: Guidelines for Seismic Retrofit of Existing Reinforced Concrete Buildings, 2001.
Published by- The Japan Building Disaster Prevention Association

Figure 4.9.1 Cross Section of Jacketed Column with Steel Plate



Steel Jacketing

(quoted from the figure on page 155 in the commentary of 3.3.5 of the Guidelines of 2001 Japanese version)

SOURCE: Guidelines for Seismic Retrofit of Existing Reinforced Concrete Buildings, 2001.
Published by- The Japan Building Disaster Prevention Association

Figure 4.9.2 Examples of Steel Jacketing

Preparation of Column Steel Jacketing in a School at Chiba City

Column Jacketing with Steel Plate in Stadium at Chiba City (After Construction)

Figure 4.9.3 Photographs of Column Jacketing with Steel Plates

4.10 RETROFITTING WITH EXTERNAL BUTTRESS

Adding external buttress with existing frame of a building is a retrofitting method to increase the lateral strength of the building. The buttress shall be arranged to connect with existing structural frames symmetrically at both ends of the building and at all floor levels. The buttress shall have columns on its both ends and beams in each floor level

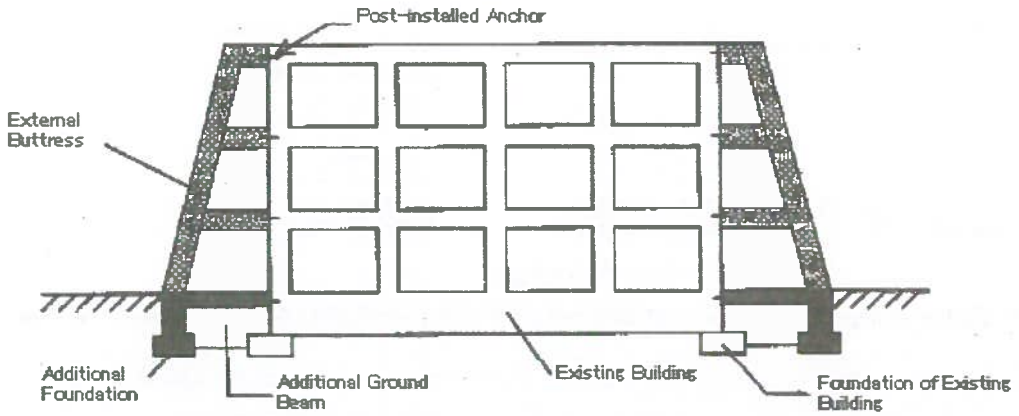


Figure 4.10.1 Example of External Buttress

PART-II: CONSTRUCTION SUPERVISION

CHAPTER 5. GENERAL

5.1 PURPOSE OF PART-II OF THIS MANUAL

This Part of the Manual is to guide construction supervisors to carry out adequate supervision work that meets indicators specified in the Quality Control Guidelines.

This Manual particularly focuses on checking the construction works against drawings and specifications with some examples.

5.2 DEFINITION OF TERMS

Definition of terms used in this Manual are as follows:

5.2.1 Construction supervision:

To check the construction works with building codes, drawings and specifications.

5.2.2 Construction supervisor:

A person who is entrusted by a governmental and/or private client to supervise construction work

5.2.3 Client:

A person or entity who places an order for a construction work.

5.2.4 Contractor:

A company which is entrusted with a construction work.

5.2.5 Drawings and specifications:

A set of documents which are necessary for construction of a building or any structure.

5.2.6 Quality control record:

Documents that record the quality control implementation in the process of construction of a building. Quality control documents include inspection records, construction progress record, test certificates and quality certificates on materials.

5.2.7 Attendant inspection:

An on-site inspection by the construction supervisor at every construction stage, or check by the construction supervisor to see if a contractor's self-inspection was implemented according to the drawings and specifications.

5.2.8 Document Check:

Check by the construction supervisor if the quality control documents meet requirements of the drawings and specifications. This document check is for the sake of assuring the quality of every construction stage.

5.2.9 Work performed:

Work items that have been completed and/or the completed portions of work items already begun but not yet completed.

5.3 PRINCIPLES AND BASIC WORKFLOW OF THE CONSTRUCTION SUPERVISION

5.3.1 Principles of the construction supervision

The contractor is responsible for the quality control which meets the drawings and specifications on the one hand. On the other hand, the construction supervisor is responsible for: 1) ensuring adequate construction works, and: 2) carrying out inspections to ensure the quality of a constructed building and to confirm the completion of works. The followings are items for which the construction supervisor is responsible.

1) **Ensuring adequate construction works through:**

a. Checking construction schedule and conditions
b. Checking construction materials [including inspecting materials and confirming certificates, etc.]
c. Checking quality control implementation
d. Checking safety control implementation

2) **Carrying out inspections by:**

a. Confirming if inspections and construction are implemented according to the drawings and specifications
b. Attending various inspections on-sites
c. Implementing interim inspections [work performed check on parts which will be invisible after completion.]
d. Implementing the completion inspection [work performed check at the time of completion.]
e. Implementing the defect inspection [work performed check after the defect liability period specified as per the contract.]

5.3.2 Basic work flow of the construction supervision (Refer to Figure 5.3.1)

The following diagram shows the basic work flow and the position of the construction supervision during the construction period.

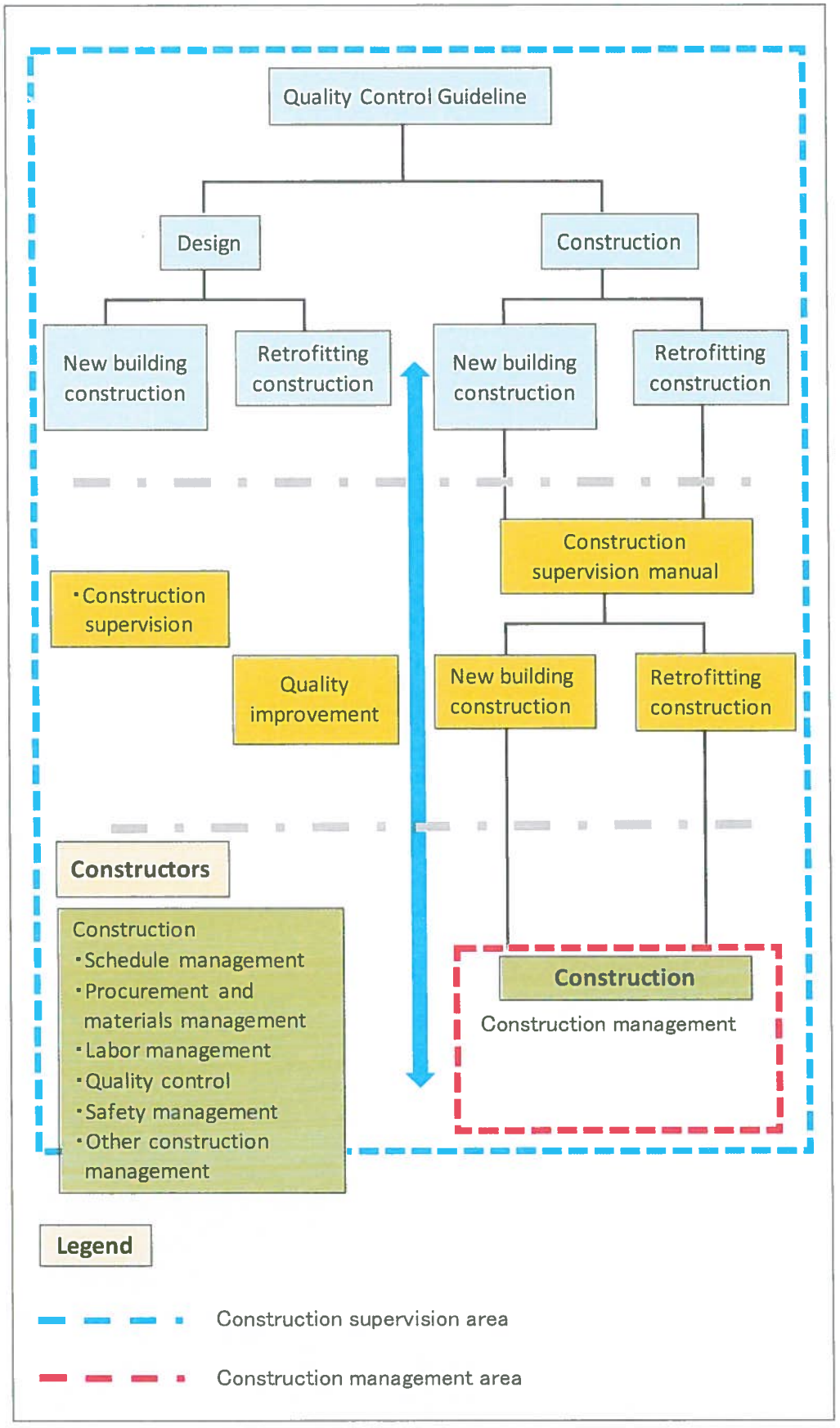


Figure 5.3.1 Flowchart of Construction

CHAPTER 6. CONSTRUCTION PLANNING

6.1 POINTS TO CONFIRM BEFORE CONSTRUCTION

6.1.1 Construction planning

In order to carry out the planned construction works efficiently without making an error, it is important to make sure the contents of the specifications and the planned documents before starting construction works. The points need to be confirmed are as follows.

- Outstanding Issues unsolved from the Design Stage.
- Schedule Planning.
- Work Implementation and Execution Structure.
- Construction Method.
- Planning of Temporary Installations.
- Quality Control (QC) Program.
- Procurement Planning.
- Safety and Security Control Planning.
- Issues related to Environmental Planning.

Following confirmation of the above points, it is required for the supervisor to submit the following items to relevant higher authority before commencement of the substantial work or each step of works.

- Items to be submitted before commencement of the substantial work/ each step of work
- Work schedules.
- Work Implementation and Execution Structure.
- Plan of Temporary Installation.
- Safety and Security Control Planning.

6.1.2 Outstanding Issues unsolved from the Design Stage

Confirm outstanding issues from the design stage that have not been clearly defined. Also, identify points that need further examination, if any.

Important issues to be confirmed:

Reconfirm the results of the soil quality survey, soil quality test and geological condition survey conducted during the design stage. Then, re-determine the design and the construction methods for retaining work and foundation work.

For pile foundations, make sure if the depth of the bearing layer is correct, corresponding to the results of the boring survey, and ensure that the piles are long enough to reach into the bearing layer.

6.1.3 Schedule Planning

Confirm the entire work description and construction period. Furthermore, confirm the flow of works and respective processes.

Important confirmation points:

- Confirm and endorse the entire work description and the construction period.
- Confirm the flow of works and respective processes.
- Identify what works (critical path) are critical which influences the work schedule.
- Confirm that natural conditions such as a flooding are taken into consideration in the schedule.
- Ensure the official permissions and approvals for construction works
- Pay attention to the building layout of a site.

6.1.4 Organization of Construction

Important confirmation points:

- Confirm the management structure of the construction site, mapping out in a chart, including the client, consultants, the main contractors and subcontractors.
- The organogram of the management structure of the construction site whether names and work assignments are specified in the chart.
- Furthermore, the supervisor needs to confirm with the contractors the following administrative issues before the commencement of works.
  - Confirm the reporting lines (from whom to whom) and frequency.
  - Familiarize to relevant meetings and conferences, including the meeting agenda, the obligations to be met responding to the agreement and the resolution of the meeting, the participants, the frequency, the venue, and the recording of meeting.

6.1.5 Construction work method

Confirm and agree on technical approach and methods to be applied to. In addition, confirm construction work methods and check work items daily.

Important confirmation points:

1) **Earthwork**

a. Check that the excavation work does not hamper neighboring structures.
b. Confirm the retaining system, if necessary, prior to cutting roots.
c. Confirm the dumping and unloading routes.
d. Check ways to minimize dirt/ dust from the earthwork.
e. Check ways to manage in case of seepage of water.

f. Confirm measures to be taken for shore protection, if necessary.

2) **Foundation work**

a. Confirm contingency measures for dewatering, if necessary.
b. Confirm preventive measures to stop seepage of water such as rainfall, spring water etc. inside the foundation trench.
c. Confirm compaction and tamping methods for backfill and embankments.
d. Examine existing pile construction drawings/plans, and results of the soil bearing test or estimation method of soil bearing.
e. Confirm a method to apply to improve the soil.
f. Confirm a method for foundation/ sub-surface retrofitting work.

3) **Reinforcement work**

a. Confirm methods to handle steel bar (transport, loading, collecting, etc.).
b. Check and approve the execution plan.
c. Confirm that bending angle of hoop/ tie for the column jacketing shall be 135 degree.

4) **Post-installed anchor work**

a. Check and approve the execution plan.
b. Inspect and approve materials and equipment
c. Confirm the construction plan.
d. Confirm the methodology of anchor work such as anchorage method.
e. Confirm the methodology to check the appropriateness of anchoring.

5) **Concrete work**

a. Check and approve the execution plan.
b. Inspect and approve materials for form work
c. Confirm the method of form work.
d. Calculate the stability of props or supports of the form work as needed.
e. Examine and approve the concrete mixing plan.
f. Check and approve of the concrete placement specifications [concrete placing sections and order, joint placement points, separator placing gap, amount of concrete placing in a single go, compaction, curing].
g. Confirm the concrete compaction methods in the hot or cold weather and underwater conditions.
h. Confirm the system of concrete plant, its capacity, and its location.

6) **Steel work**

a. Check and approve the execution plan

b. Confirm the factory production instructions.

c. Confirm and witness technical level checks on welding.

d. Check the methods to protect the material during transportation including loading and unloading.

e. Check and approve the steel frame work plan.

7) **Brick & Block Works**

a. Check the brick block construction work on design drawing and Plan

b. Check the manufacturing procedure for the high quality brick & block.

8) **Grouting work**

a. Confirm and approve the execution plan.

b. Confirm and approve the materials of grouting.

c. Confirm the injection method.

9) **Continuous fiber wrapping work**

a. Investigate and approve of execution plan.

b. Investigate and approve of materials as per specification.

10) **Waterproofing work**

a. Check and approve of construction diagrams

b. Check whether the penetration section of the waterproof layer is installed.

c. Check whether the end section, leading edges and complex points are installed.

11) **Plaster work**

a. Check and approve the mortar mixture specifications

b. Check the mortar mixing location and mixing method

c. Foundation treatment

d. Curing method

e. Check and approve the spraying materials

12) **Painting work**

a. Check and approve of construction method

b. Painting with a curing method

13) **Electrical and machinery installation work**

a. Examine and approve manufacturers and the model number of each equipment.
b. Check and approve production drawings and construction diagrams
c. Check anchoring points/ embedded parts for installation
d. Ensure that machinery to be installed is simple and easy to maintain.

6.1.6 Temporary Installation Planning

Temporary installations are divided into: direct temporary installations and common temporary installations.

Direct temporary installations: roping-off, batter boards, laying chalk lines, interior and exterior scaffolding, safety equipment, etc.

Common temporary installations: temporary enclosures and offices, rest areas, toilets, material storehouses, various work areas, etc.

The design of temporary installation should be in line with the work descriptions and site conditions.

The temporary installations listed by this specification fall under the same contract as the main construction work. In the event of necessary design change procedure, read the contents of the construction specification thoroughly and understand the plans.

Important confirmation points:

a. Check and approve the temporary installation planning as per specification
b. Check power supply, water supply, drainage facilities etc., for construction.
c. Check alternative electric power facilities for an emergency or a blackout.
d. Confirm the lavatory installation plan for labor, if necessary.
e. Check the design and structural calculations of important temporary installations.
f. Check security and safety measures.

6.1.7 QC Program and progress management

The construction photographs are very important as evidences for the quality and progress. Therefore the supervisor shall take photographs to record the work progress and the evidence of qualities.

Considering that some procedure is invisible because the materials are covered by other materials [e.g. rebar is covered by concrete]. Therefore, photos are taken in the each process of construction. The photographs to be taken in the construction are as follows:

Important Photographs to be taken:

a. Photos before the commencement of works.
b. Photos recording each step of construction works.
c. Photos of demonstrating security and safety management.
b. Photos of inspection and examination of materials.
c. Photos of QC
d. Photos of completed / procedure at each process.
e. Photos of any disasters or accidents
f. Photos of pollutions, destructed environment, compensation, etc.
g. Photos of the completion of works.

In the QC program, it is particularly essential that the supervisor confirms the QC items for the materials, methods, and the methods of work progress control. It is necessary to take photos to better QC and performed work control as well.

6.1.8 Procurement Planning

Check the subcontractors' general information, their procurement methods for construction machinery and materials and transport plan

Important confirmation items:

a. Confirm that all provisions are carried out in compliance with the construction work process, and that the provisions are within reason.
b. Check the availability of materials during the time of construction.

6.1.9 Security and Safety Control Planning

Confirm the safety measures taken for workers and local residents. Make sure that the crisis management is perfect, and confirm proposed countermeasures for an emergency.

Important confirmation items:

a. Plan the preliminary check for work descriptions on the appointed day
b. Check that there are instructions to wear safety fittings properly.
c. Check that there are manuals for work-related injury or death including transportation routes to hospitals.
d. Check that contact or evacuation procedures during conflicts, riots, monsoons and other emergencies are available.
e. Check that placement of security personnel is planned.
f. Check that accident prevention measures (temporary enclosures, warning signs) are planned.

g. Check that 4S (Sorting, Straightening, Standardizing and Sweeping) are planned.
h. Make sure that someone in-charge of safety and security is appointed.
i. Check that safety inspections are mandatory for heavy equipment and tools.
j. Check what kind of signboards for hazardous areas and materials are available.
k. Check that inspections are mandatory for scaffolding, earth-retaining materials, and other temporary installations.
l. Check that safety measures regarding risk during trial runs and tests are available.
m. Check that safety is considered in schedule planning.

6.2 POINTS TO CONFIRM DURING CONSTRUCTION

6.2.1 Monthly report

The supervisor is required to prepare a monthly report in a regular and timely manner following the "Guidelines of consultant services" and the "References of consultant services." It aims at ensuring the construction works with the quality, the schedule and the safety required as the construction plan and documents, and confirming if the progress is made accordingly. It is also required to attach some photos of each step to the report.

6.2.2 Progress Schedule control

It is required to confirm if construction works meet the quality demanded in the construction plan, and if it follows the schedule with assurance of safety. In the case that the work progress is lagging behind the schedule, identify the cause of delay and make sure if any countermeasure is taken or not.

a. Confirm the required quality and check its consistency with the specifications.
b. Confirm the construction site condition and weather conditions.
c. If the construction schedule is lagging behind the construction schedule, point out the cause of the delay and try to take a countermeasure for the delay.

6.2.3 Quality and performed work progress control

Confirm the consistency between the design specifications in the contract and the construction specifications.

Important confirmation items:

1) **Temporary works**

a. Confirm the reports and actual distance from the construction site
b. Confirm and witness staking out.
c. Confirm and witness benchmarks. Mark the benchmarks at points on permanent locations.
d. Attend the distance survey and confirm the distance.

e. Witness, confirm and suggest the temporary works.
   - Make sure 'no entry' signs are displayed and to keep passage for working.
   - Inspect protective gears of personnel
   - Check that the scaffolding is correctly built (wall ties, handrails, etc.)
   - Check that the trash and material stations are inside the construction site is tidy and clean.

2) **Earthwork**

a. Confirm and witness the excavation areas.
b. Confirm and witness the bottom of excavation.
   - Confirm that the load capacities of the design have been found and leveling is being done on in-situ support layer.
   - Confirm the dimensions of the excavation (at bottom) and the depth of excavation to see if they are in accordance with the Design.
c. Confirm and witness the soil disposal.
d. Confirm and witness the backfill and embankment.
e. Confirm the compaction methods as per specification.
f. Confirm and witness the grading and leveling.

3) **Foundation work**

a. Confirm and witness the compaction of the bottom of the foundation.
b. Confirm and witness the thickness and strength of leveling concrete.
c. Confirm and witness the thickness and compaction of sand filling.

4) **Reinforcement work**

a. Confirm the standard certificate, mill sheet or alternative documents which are equivalent to these.
b. Make sure if the materials are from the same lot indicated in the mill sheet
c. Confirm and Check the placing and layout of reinforcement.
   - Confirm the number of bars, steel bar diameter and spacing.
   - Confirm the lap splice lengths and anchoring lengths.
   - Confirm the splice positions.
   - Confirm the positioning as a binding unit or wire.
   - Confirm the spacing between steel bars.
   - Confirm the spacing, binding, and the initial position of the hoop and stirrup.
   - Confirm the location of the hoop intersection for the columns and beams.
   - Confirm the stirrup intersection for girders and beams.

- Confirm the location and number of inserted rebar, spacers, chairs and blocks.

d. Confirm test pieces.

5) **Post-installed anchor work**

a. Confirm the compressive strength of existing concrete.

b. Confirm the material strength of post-installed anchors.

c. Check and examine the positions of existing reinforcements.

d. Confirm and witness the chalk lines.

e. Check the following points concerning drilling:

- A drilling hole must be about one size bigger than the anchor size.
- The depth of the hole must be checked by using the drill or drilling machine.
- Drilling is at a right-angle to the drilling surface, and sloped drilling is within 30° in relation to this.
- Check that there is no obstacle or honeycomb. If there is anything, report to the site manager and give them an instruction.
- The dust vacuum nozzle is inserted down to the bottom of the hole for dust removal.
- Confirmation of drilling depth by means of anchor bar insertion, etc.
- The inside of the hole has been thoroughly brushed and chips and shavings have been carefully removed.
- If there is water, clay chips and shavings have been carefully removed using waters and brushes.
- Chips and shavings have been removed from inside the hole.

f. Adhesive strength inspection.

- **Construction confirmation test**

  Construction confirmation tests refers to one that confirms the state of adhesion of post-installed anchors constructed at site, and it shall be implemented in accordance with the specification. If there is no description in the specification, the test shall be performed as tensile tests.

  If there is no specific description of the member of anchors to be tested, each diameter constructed in one day shall be taken as one lot, from which testing shall be carried out on three anchors. If in one day the same diameter is constructed by multiple members or on multiple sites, the supervisor shall be able to change the composition of the lot.

  The load of construction confirmation tests shall be in accordance with any specific description. If there is no specific description, tests shall be in accordance with instructions from the supervisor.

  Generally, 2/3 of the calculated anchor strength shall be taken as the confirmed

strength, while non-destructive tests shall be conducted to confirm that there has been no sudden deterioration of stiffness due to slipping, etc.

- **Hammering sound inspection**

All post-installed anchors constructed on-site shall be inspected so as to check their degree of adhesion and whether or not these anchors are suitably adhered.

- **Other**

If adhesive strength inspiration results show failings, measures shall be taken in accordance with an instruction and measures for displaced temporary holes when an anchor has hit a reinforcing bar shall be taken in accordance with instructions from the supervisor.

Diagonal construction and measures for displaced temporary holes when an anchor has hit a reinforcing bar shall be taken in accordance with instructions from the supervisor.

6) **Concrete work**

a. Confirm and witness the laying of chalk lines.
b. Confirm and inspect the formwork process and assembly.
c. Confirm and inspect the vertical accuracy of the formwork
d. Confirm and inspect the formwork and props or supports when placing the concrete.
e. Confirm and witness the removal of formwork.
   - Confirm the strength of the concrete prior to removing the supports.
   - As a rule, do not change the height of the supports.
   - Formwork should be left in place 10 or more days regardless of concrete strength.
   - Fill in the voids and honey-combs generated on the lower beams with grout.
   - Apply a 3 cm wide synthetic resin emulsion paste or mortar over defects in the concrete, cold joints, and joint spots on every floor and grind it in.
   - Be careful of form tie fasteners and underground in-situ materials.
f. Confirm and witness the concrete mixing as per specification.
g. Confirm and witness the preparations for the placing of concrete.
h. Confirm and witness the placing of the concrete.
   - When checking, avoid placing a vibrator on concrete for long time, as it may cause the concrete to segregate.
   - Hit the concrete with a mallet to quickly determine whether or not the concrete is spreading, and do not strike areas where there is no concrete. Strike the perimeter of the sleeve and opening sections multiple times.
   - Confirm as to how the contractor handles the placing of concrete in an event of rain.

i. Confirm and witness curing
   - Check if a system is in-place to deal with rainfall.

j. Confirm and accept concrete strength test records.

k. Confirm and inspect after the removal of formwork.
   - Remove all laitance from work joint surfaces which are critical to structural resistance and waterproofing of columns, beams, etc., by chipping or a different method, and scrub off efflorescence with a wire brush.
   - If there are imperfect areas on work joint surfaces due to mortar leaks or other failures, remove the defective section. This can be done by placing the concrete again or repairing the defective section by injecting it with epoxy resin.
   - Repair voids and honey-combed areas immediately.
   - Remove all laitance and mud off the steel bars before the next placing of concrete.

7) **Steel work**

a. Approve production factories.

b. Confirm and inspect the dimensions of the steel frame.

c. Confirm and inspect anchor bolts.
   - Check at the time of repairing the anchor bolts, that workers do not use gas flame.
   - The anchor bolts fixings determine the position of solid frame irrespective of the formwork.
   - To prevent the anchor bolts getting dirty, cover them when placing the concrete.

d. Confirm and inspect welds.

e. Confirm and accept the erection plan.

f. Confirm and inspect on-site erection.

g. Confirm and witness bolt tightening.
   - Examine the tightening sequence
   - Check that the workers use a wire brush to clean rust and other debris floating before assembly.
   - Check that the workers burn oil and paint with gas flame and clean the friction of the surface using cleaning agents or chemicals.

h. Confirm and inspect the site welds.
   - Cancel work when it is windy or when it is raining.
   - Do not leave weld electrodes directly on the ground.
   - Prepare the drying furnace when using low hydrogen weld electrodes.
   - During the surface inspection, remove slag from the surface using a chipping hammer.

8) **Brick Concrete works**

a. Confirm materials.
b. Confirm product items.
c. Confirm loading of the brick blocks.
d. Confirm the verticality and the level.
e. Confirm the softness and the way of loading of mortar.
f. Inspect the completion of brick block loading.

9) **Grouting work**

a. Mix proportion
b. Grout material shall be pre-mixed non-shrinkage mortar.
c. Consistency shall be determined by part and method of injection.
d. Trial mixing shall be done before injection.
e. Injection with or without pressure
f. Laitance at the joint surface shall be removed completely before injection of grout.
g. Surface of form and joint shall be soaked by spraying water.
h. Water temperature shall be properly controlled at the time of mixture and injection with pressure.
i. Injection with pressure shall be continuously done with appropriate pressure.
j. Mortar shall be injected until the overflow from the air outlet is confirmed.
k. Form Work
    - Forms shall be set leak proof.
    - Forms shall be strong & stiff enough to resist the pressure during mortar injection and to hold the expansion pressure during hardening.
    - Forms shall be removed after the mortar is sufficiently hardened and therefore the holding of the expansion pressure is not necessary.
    - It shall be verified after removing forms that gaps between new member and existing concrete are properly grouted.
l. Curing
    - Three days shall be required for standard curing. Other curing practices shall be the same as concrete works.

10) **Waterproofing work**

a. Confirm the materials for waterproofing
b. Inspect the condition of waterproofing for the foundation.
c. Confirm if the concrete is fully dry.
d. Confirm the evenness and cracks
e. Confirm the water gradient and the position of drain

f. Confirm the detail fitting at the edges and the joint parts
g. Attend and confirm the completion of the waterproofing works and the test of hydraulic leak by filling water.
h. Confirm the water gradient of the pressure layer;
i. Confirm the interval of the elastic joints and the width of the joints.

11) **Continuous fiber wrapping work**

a. Repair of RC structure and crack
   - Repair to exposed parts of steel bars shall be made by removing the surrounding concrete, removing rust from the steel bars and applying anti-rust treatment, and using polymer cement mortar.
   - Cracked parts can cause stress concentration in continuous fiber reinforcing materials, so repairs shall without fail be made by injecting epoxy resin etc.

b. Existing structure treatment
   - Brittle layers and dirt shall be removed from the surface.
   - Columns corner parts shall be rounded to facilitate fiber wrapping.

c. Applying primer
   - Check the atmospheric temperature and base material temperature
   - Measure and mix the main agent and hardening agent in accordance with the manufacturer's instructions (ratios are normally given in terms of weight).
   - Apply uniformly using rollers and brushes. It shall be applied two to three times to give a good finishing look.
   - Control of the time that primer can be used shall as a general rule be based on time measurement.
   - Protective masks, glasses and gloves shall be worn when working.

d. Smoothing base surface
   - Finishing shall be applied by working epoxy putty with a rubber spatula, etc.

e. Marking
   - The standard first layer adhesion position shall be accurately marked, and it shall be ensured that linearity is maintained.

12) **Plaster work**

a. Confirm and inspect the treatment of under layer.
b. Confirm and witness the laying finish chalk lines
c. Confirm and witness crack prevention.
   - Poorly mixed mortars produce more cracks than well mixed mortars.
   - Sufficiently dry the under layer, spraying water on it and cure it. It will reduce cracking.

d. Confirm and witness the plaster coat.
e. Confirm and inspect the completed work.

13) **Fixture work**

a. Attend factory inspection and check products.
b. Check the products with samples.
c. Check installation
d. Carry out final inspection.
e. Plumbing condition.
f. Caulking and water proof treatment.
g. Check cure and damage proof treatment.

14) **Painting work**

a. Investigate and approve paint samples.
b. Confirm and inspect the substrate on which painting will be done.
c. Confirm and witness the painting area.
d. Confirm and witness the curing and protection.
e. Confirm and witness the painting workmanship.
f. Confirm and inspect the completed paint work.

15) **Interior work**

a. Check materials
b. Check substrate
c. Carry out final inspection on:
   - Surface finishing
   - Accuracy of transition
   - Evenness, jointing and gap
   - Installation and adhesiveness.

16) **Landscaping work**

a. Attend and check the work.
b. Check after completion the land leveling and tidying up.

17) **Electrical installation work**

a. Attend and check factory inspection.
b. Attend plumbing work, wiring work and installation work of equipment. (Ensure that there shall be no problem in use and maintenance.)

c. Carry out final inspection on:
   - Attend and check test operation.
   - Check test results.

18) **Machinery installation work**

a. Attend and check factory inspection.
b. Attend and check plumbing work and installation work of equipment.
c. Attend and check heat insulation and condensation.
d. Carry out final Inspection.
   - Attend and check test operation.
   - Attend and check leak of water supply pipes.
   - Attend and check drain pipes.

6.2.4 Design Changes [Variation order] and Concerns

Even on most carefully studied and laid out design drawings, there are times when circumstances involving unforeseeable factors are unavoidable.

It is important to note that all assumptions made are not always correct and accidents take place no matter how careful the study was made at the time of design.

6.2.5 Confirmation and correspondence by documents

Communication regarding any problems such as proposals from the contractor to the supervisor, responses from the supervisor to the contractor, etc. must always be done in writings.

6.2.6 Security and Safety Control

The following are the types of accidents that could occur as a part of a construction.

a. An occupational accident that injures the construction worker.
b. Accidents causing damage or ones that pose a hazard to homes and/or inhabitants near the construction site (pollution).
c. Third party accidents causing injury to persons passing by.
d. Accidents at the construction site.
e. In order to prevent these types of accidents, a network of contacts in case of emergencies according to the construction plans must be confirmed and a manager must always take steps to implement adequate countermeasures.

CHAPTER 7. CONSTRUCTION INSPECTION

7.1 STEPS OF CHECKING CONSTRUCTION WORKS AGAINST DRAWINGS AND SPECIFICATIONS

7.1.1 Basics of checking

The construction supervisor checks construction works against drawings and specifications, which usually specify checking methods. Besides the methods specified in the drawings and specifications, the construction supervisor shall carry out visual check and random-sampling-check and review the quality control records. Details of such methods are specified in this chapter.

7.1.2 Checking Steps

The construction supervisor checks construction works against drawings and specifications by attendance inspections on-site and/or checking documents.

1) **Attendance Inspection on-site**

In principle, items to be inspected at each process of the construction are specified in "Inspection Check List".

2) **Document check**

In principle, the construction supervisor checks if the quality control records accord with the specifications. If the records do not meet the requirement, the construction supervisor shall discuss with concerned parties to rectify the matter.

3) **Record Keeping**

The construction supervisor is responsible for keeping records of his checking history on construction works against the drawings and specifications, and filing such records.

7.2 MAJOR RESPONSIBILITIES OF THE CONSTRUCTION SUPERVISOR

The Construction supervisor is responsible for the following jobs

7.2.1 Quality Control (QC)

During the construction stage, inspect the followings, referring to points specified in Quality and Performed work Control Sheet, and classify countermeasures having been taken, and record and keep them properly. For points not specified in the Quality and Work Performed Control Sheet, give a proper instruction to the contractor.

a. Concrete work
b. Re-bar work
c. Form work

7.2.2 Control of Work Performed

Particularly supervise on the following works by work items, controlling items, measurement method, and frequency of measurement, measurement unit, and allowable limits. In order to control the work performed, refer to the examples/methods specified in Quality and Work Performed Control Sheet.

7.2.3 Schedule management

The construction supervisor confirm the contractor to record, file and retain the following documents.

a. The overall construction schedule
b. Monthly construction schedule
c. Weekly construction schedule

7.2.4 Regular meetings

The construction supervisor must ensure the contractor to record, file and retain documents of the following meetings.

1) **Weekly meeting**

Weekly meetings are to be ensured. In the first weekly meeting of each month, the construction supervisor shall lead discussion by comparing the actual progress and the schedule, after hearing from the contractor on up-coming work plan of the month.

If the progress is delayed, the construction supervisor must analyze causes and address the matter immediately.

In a weekly meeting, the construction supervisor shall confirm the points below in the following order.

a. Construction schedule and progress
b. Any cause to delay the construction progress and its countermeasures
c. Answers to the questions raised by the contractor

2) **Others**

The construction supervisor shall patrol the site to check safety, construction progress, construction progress of temporary works, and other conditions which might disturb the safety control. Should there be any problems, the construction supervisor shall direct the contractor to rectify the problems.

In case of a unique/special problem, the construction supervisor shall immediately take countermeasure.

7.2.5 Safety Control

The construction supervisor shall particularly pay attention to the followings.

a. Accidents of construction workers.
b. Accidents that harm houses and inhabitants in the neighborhood
c. Third party accidents to passer-by, etc.
d. Natural disasters on site

7.2.6 Taking Photographs of the construction works

The construction supervisor shall take the following photographs.

a. Inspections
b. Construction progress (by work/ construction stage)
c. Work performed progress (by work/ construction stage)
d. Others: Safety control management, accidents, natural disasters/pollution, and compensation to the neighborhood, the completed building, etc.

7.3 ITEMS TO BE INSPECTED AND INSPECTION METHOD

(1) The supervision of construction works is carried out by using the inspection matrix attached to the plan of the construction supervision, which is prepared for the supervision of project. The inspection methods vary one from another, depending on each item to be inspected. It is also noted that there are two kinds of inspections: 1) Inspection by progress of construction works and 2) Regular inspection. As for 1), it is further divided into three kinds of inspections: one is on-site ordinary inspection, another is an assessment of work performed, and the other is one to be entrusted to a third institute certified by public authority. The following table shows items to be inspected and respective methods of the inspections.

The methods of the inspections are indicated with a check mark (✓) for each item. Some items may have multiple methods. In addition, the items double-checked (✓✓) are considered as those particularly important in the supervision.

(2) The supervisor explains procedure of the inspections to the contractor regarding the methods of inspections referenced in the below table.

1) **On-site Ordinary Inspection**

In the course of the work schedule, before the contractor moves into the next step of work after the completion of present work, the contractor is required to inform the consultant of the scheduled date of the next inspection at the occasion of a weekly meeting. At that time, if there is any change in the schedule, the contractor shall immediately inform the supervisor.

In case that there is any issue to be concerned about, the supervisor provides an instruction for improvement, and confirm the completion of the improvement work.

2) **Assessment of work performed**

The supervisor assesses performed-works according to the inspection item table.

For the sake of the accuracy of the assessment, follow Control of performed-works table in the Construction Supervision Manual.

3) **Inspection entrusted to a Public inspecting institution**

The contractor entrusts their inspections on the materials of concrete to a Public inspecting institution in Bangladesh to confirm the result to the supervisor.

4) **Regular patrol for Inspection**

The supervisor goes the rounds for ensuring safety and security and delivers important messages and instructions. The supervisor is also obliged to keep a journal of works at each site and record the details of his instructions.

Table 7.1 Methods of inspections

Preparatory works					
Sorts of works	Items to be inspected	Inspection methods			
		Inspections in accordance with the progress of work			Regular patrol for Inspection
		Ordinary Inspection	Assessment of work -performed	Public inspecting institution	
Installation of temporary establishment	Confirmation of temporary establishment installation plan	✓			
Safety and Security	Storage of hazardous substances	✓			✓

	Confirmation of separation of circulation	✓			
	Installation of fire extinguisher equipment	✓			✓
Safety and Security	Posting signs of security and safety slogans, and installation of booths for smoking	✓			✓
	Installation of temporary fence and gate	✓			
Materials for temporary establishment	Confirmation of quality, strength and durability	✓			
	Confirmation of safety and security measures	✓			✓
Installation of temporary establishment	Confirmation of the way of installation				✓
Situation of the site	Confirmation of the boundaries of the property	✓			
	Identification of existing buildings in the site	✓			
	Confirmation of present situation of neighbors	✓			
Positioning of building	Confirmation by roping	✓			
	Confirmation of a datum point	✓			
Working environment	Temporary bathroom	✓			✓

	Cleaning of the construction site				✓
Earthwork					
Sorts of works	Items to be inspected	Inspection methods			
		Inspections in accordance with the progress of work			Regular patrol for Inspection
		Ordinary Inspection	Assessment of performed-works	Public inspecting institution	
Boring and excavation		✓	✓		
Reduced level condition	Flatness and smoothness	✓			
	Level		✓		
	Soil condition	✓			
	Bearing capacity		✓		
Backfilling	Materials	✓			
Compaction	Rolling machine	✓			
Prevention of accident, disaster and pollution	Level of underground water				✓
	Countermeasures for rainy season				✓
	Influence to neighbor buildings				✓
Concrete Work					
Sorts of works	Items to be inspected	Inspection methods			
		Inspections in accordance with the progress of			Regular

		work			patrol for Inspection
		Ordinary Inspection	Assessment of performed-works	Public inspecting institution	
Materials Cement	Types of cement	✓		✓	
	Standard of Quality	✓✓		✓	
Materials for mixture	Sorts and the way of use	✓		✓	
Water	Quality of material			✓	
Aggregates	Size of aggregates			✓	
Trial mix	Strength of concrete and Determination of mix proportion			✓	
Inspection prior to casting concrete (Measurement of materials)	Slump	✓			
	Volume of air	✓			
	Concrete temperature	✓			
	Chloride	✓			
	Test of strength of compression			✓	
	Measuring equipment	✓			
Concrete casting	The time between mix and casting	✓			
	The check of the conditions of a casting concrete	✓			
	Cleaning and watering of formwork	✓✓			
Structure Reinforced concrete	Confirmation of performance	✓		✓	
	Diameter, number of bars, pitch	✓✓			
	Joint , fixing position, length	✓✓			

	Thickness of cover concrete and interval	✓✓			
Formwork	Materials of concrete shuttering board	✓✓			
	Cleaning of casting joint surface	✓✓			
	Order of casting	✓			
	Confirmation of dimensions	✓			
	Fixings to be placed	✓			
Curing of structure	Avoidance of direct rays	✓			✓
	Moisture curing	✓			✓
Removal of formwork	Time between casting and removal of form	✓			
Safekeeping of materials	Safekeeping of cement and reinforcing bars	✓			✓

Brick Work

Sorts of works	Items to be inspected	Inspection methods			
		Inspections in accordance with the progress of work			Regular patrol for Inspection
		Ordinary Inspection	Assessment of performed-works	Public inspecting institution	
Common work	Distribution, reinforcement layout, wooden brick				✓
Materials	Vertical and level of brick		✓		✓✓
	Sorting of bricks	✓			✓✓
	Quality of brick	✓			✓✓
	Strength of brick			✓	

	Reinforcement , cement and materials for frames				✓✓
Mortar	Mixture of mortar				✓✓
	The time required for using after mixture				✓
Iron reinforcement	Joint treatment and fixation				✓
Brick work	Laying leveling string				✓✓
	Height of brick piling				✓✓
	Bond width				✓✓
Supportive fittings Installation of plumbing inside block	Plumbing				✓✓

Retrofitting work

Sorts of works	Items to be inspected	Inspection methods			
		Inspections in accordance with the progress of work			Regular patrol for Inspection
		Ordinary Inspection	Assessment of performed-works	Public inspecting institution	
Materials	Sorts, Quality, Strength	✓			✓
Inspection during the work schedule	Confirmation progress works	✓			✓
Inspection at the completion of work	Completeness and accuracy of works	✓✓			✓

Finishing Work

Sorts of works	Items to be inspected	Inspection methods			
		Inspections in accordance with the progress of work			Regular patrol for Inspection
		Ordinary Inspection	Assessment of performed-works	Public inspecting institution	
Materials	Sorts, Quality, Strength	✓			✓
Inspection during the work	Confirm the substrate				✓

schedule					
Inspection at the completion of work	Completeness and accuracy of works	✓			✓

7.4 COMPLETION INSPECTION (AT THE TIME OF COMPLETION OF THE CONSTRUCTION)

7.4.1 Purposes

Completion Inspection is to check if the building and equipment are completed and delivered according to the drawings and specifications. This shall be implemented through performance check, appearance check and work-performed check.

7.4.2 Timing

Completion inspection is to be carried out after the completion and before handover.

7.4.3 Methods

After a self-check by the contractor, the construction supervisor shall check the building against the drawings and specifications.

7.4.4 Items to be checked

a. Items to be corrected
b. Performed-work check on invisible parts (check by the construction progress pictures)
c. External appearance

7.5 KEEPING THE CONSTRUCTION PROGRESS RECORD

Concerning the following items, pictures, correspondences, as-built drawings to indicate the quality and performed-work must be kept for more than 5 years.

a. Parts that required particular attention during the construction period
b. Parts where design and/or construction method were changed
c. Hidden parts and parts that may be a problem in the future.

7.6 REPORT

The construction supervisor shall regularly report the inspection result to the appointed person of the implementation agency, namely the Public Works Department (PWD).

Appendix I

- Quality control table
- Check List for work performed

Table Appx I-1 Quality control table

QUALITY CONTROL TABLE								
WORK		CHECK ITEM		CHECK METHOD	STANDARD	FREQUENCY OF CHECKING	CONTRACTTOR'S RESPONSIBILITY	REMARKS
	CONCRETE							
A	Material							
	1 Cement	1)	Classification of Cement	Printing of the cement bag	**i) OPC: BDS-EN-197-1:1993 CEM-I, 52.5 N**	Occasionally at Plant's Store prior to mixing design	**Approval to be taken before mixing**	
		2)	Match to the Standard	Printing of the cement bag				
	2 Admixture	1)	Type, Suitability	Manufacturer's Specification	**BDS EN-934-1 / Manufacturers Standard**	Prior to Mixing Design	**Manufacturer's specification and previous test record to be submitted before mixing for approval**	
	3 Coarse Aggregates	1)	Grading Range	Visual Inspection	**BDS 243 (1963)**	Once when source or kind of aggregates are changed	**Approval to be taken from the Engineer in charge before mixing**	
	4 Fine aggregates	1)	Grading Range	Visual Inspection				
B	Mixing	1)	Mixing ratio	visual inspection for mixing ratio with standard bucket	As standard set by the contractor for the required strength	Once at the time of Commencement with each strength and whenever mixing design is changed	**Setting of standard and get approval from the engineer in charge**	
		2	Water content	Water content to be measured using standard bucket				
C	**Test**	1)	Slump Test	Field test using standard device	**Guideline From BNBC, PWD book of Specification or manufacturers** specification	Every time when placing concrete	**Test shall be done in presence of the engineer in charge and record to be submitted**	
	At the time of taking samples	2)	Compressive Strength Test	Cylinder test in the laboratory	**BDS ISO 1920-4(2008)**		***Cylinder shall be taken in presence of the engineer in charge, submit laboratory test report**	
D	**Structural Work**							
	1 Reinforcement Work		Specification of Re-Bars (Strength)	Tensile Test, Frog Mark			**Submit Test Report before use**	
	2 Post - Installed anchor	1)	Chemical Anchor	Manufacturers certification	Manufacturers specification	Every lot deliveried on site	**Submit Manufacturers specification, sample and calcualtion before actual use**	
		2)	Mechanical Anchor					
	3 Steel Work	1)	Specification of Plates (strength)	tensile strength test			**Submit Test Report before fabrication work**	
	4 Grouting	1)	Consistency test	Flow value	ASTM 939-10 or equivalent		**Submit Test Report**	
	Non-shrinkage Mortar	2)	Compressive strength test	Manufacturers certificate			**Submit Manufacturers certificate**	
	5 Carbon Fiber wraping	1)	Carbon fiber sheets				**Submit Manufacturers certificate and test report**	

Table Appx I-2 Check list for work performed

CHECK LIST FOR THE PERFORMED WORK								
WORK		MEASUREMENT ITEM	METHOD	FREQUENCY OF MEASUREMENT	UNIT	TREATMENT OF RESULTS	ALLOWABLE TOLLERANCE	REMARKS
A	Earthwork				mm			
	1 Excavation	Bottom Level	1	・4 corner and 1 center for square trench	10	Survey Record	±30 mm	Photo record shall be attached
				・every 5m at center of trench				
				・every 5m in length and breadth for overall excavation				
	2 Backfilling	Top Level	1	・every 5m in length and breadth	10	Survey Record	±30 mm	Photo record shall be attached
B	Foundation Work							
	1 Gravel / Crushed S	Top Level	1	・4 corner and 1 center for square trench	10	Survey Record	±30 mm	Photo record shall be attached
				・every 5m at center of trench				
				・every 5m in length and breadth for overall excavation				
		Width	2	Every 5m	10	Survey Record	±50 mm	Photo record shall be attached
C	Concrete Work							
	1 Footing	Top Level	1	Random	1	Survey Record	±20 mm	Photo record shall be attached
	Underground Beam	Cross Section	2	Random	1	Survey Record	+50 ～ −10 mm	Photo record shall be attached
		Dimensions						
	2 Slab on Grade	Top Level	1	Random	1	Survey Record	Steel Trowel Finish: ±10 mm	Photo record shall be attached
	3 Column	Cross Section	2	Random	1	Survey Record	+20 ～ −5 mm	Photo record shall be attached
		Dimensions						
		Deviation from Plumb	2	Random	1	Survey Record	±20 mm	Photo record shall be attached
		Line						
	4 Girder, Beam	Cross Section	2	Random	1	Survey Record	+20 ～ −5 mm	Photo record shall be attached
		Dimensions						
		Bottom Level	1	Random	1	Survey Record	±20 mm	Photo record shall be attached
	5 Slab	Top Level	1	Random	1	Survey Record	Steel Trowel Finish: ±10 mm	Photo record shall be attached
		Bottom Level	1	Random	1	Survey Record	±20 mm	Photo record shall be attached

WORK			METHOD	FREQUENCY OF MEASUREMENT	NIT m	TREATMENT OF RESULTS	ALLOWABLE TOLERANCE	REMARKS
D	Structural Work							
	1 Reinforcement Work	Diameter, number and space	As per Design Drawings	When completed assembling re-bars.		Inspection Record		Photo record shall be attached
		Length and location of splice joints, Anchor length	As per Design Drawings	When completed assembling re-bars.				
		Concrete coverage, Additional bar	As per Design Drawings and Specifications	When completed assembling re-bars.				Photo record shall be attached
								Photo record shall be attached
	2 Post-Installed anchor							
	3 Steel Work							
	4 Formwork	Size	As per the Design Drawings and Shop Drawings	When location is marked and before placing concrete		Inspection Record		Photo record shall be attached
								Photo record shall be attached
		Level and perpendicular accuracy	As per Specification	Before placing concrete				Photo record shall be attached
		Embedded metal (conduit)	As per the Design Drawings and Shop Drawings	Before placing concrete				Photo record shall be attach
		Concrete Placing Plan	Check Plan and location of construction joint etc	Before concrete work				
		Time to remove forms and props	As per Specification	At the time of striking form				
								Photo record shall be attached
	5 Concrete Work (Placing)	Consumed time from mixing to the end of placing	Within allowable time (within 90 minutes at ≧25℃, within 120 minutes at <25℃)	During placing concrete, as much as necessary		Concrete Placing Record		Photo record shall be attached
		Cleaning of form and construction joint	No rubbish and waste (by viewing)	Before placing concrete		Inspection Record		Photo record shall be attached
		Consolidation	Number and use situation of vibration machine (by viewing)	During placing concrete, as much as necessary		Concrete Placing Record		
	6 Non-Shrink Grout Work							
	7 Carbon Fibre Work							
	Method of measure	Level Machine etc				Measurement: surveyed from Benchmark and Reference Line		
		Measuring Tape						

Appendix Ⅱ

- Daily report
- Weekly report
- Overall progress report

Table Appx II-1 Daily report

Contractor Header

DAILY REPORT

Project Name:_____ Temperature at 8:00 am:_____

Date:_____ Temperature at 2:00 pm:_____

A. Administrative & Technical Staff:

Item #	Name			Position	Item #	Name			Position
1-				Site Engineer	5-				Professional Surveyor
2-				Foreman	6-				Quantity Surveyor
3-				Office Boy	7-				Electrical Engineer
4-				Project Guard	8-				Mechanical Engineer

B. Labors:

Item #	Labor Category	No.	hr	Item #	Labor Category	No.	hr	Item #	Labor Category	No.	hr
1-	Form Workers			9-	Masonary			17-	Carpentry workers		
2-	Form Workers Helpers			10-	Tilers			18-	Lab. Technicians		
3-	Rebar Fixers			11-	Tiler Assistants			19-	Machine Operators		
4-	Rebar Fixers Assistants			12-	Plasters			20-	Metal Fixers		
5-	Skilled Labors			13-	Painters			21-	Aluminium Fixers		
6-	Semi Skilled Labors			14-	Plumbers			22-			
7-	Unskilled Labors			15-	Plumbers Assistants			23-			
8-	Technicians			16-	Electricians			24-			

C. Equipment:

Item #	Labor Category	No.	hr	Item #	Labor Category	No.	hr	Item #	Labor Category	No.	hr
1-	Excavators			9-	Electrical Mixers			17-	Graders		
2-	JCB			10-	Bar Bending Machines			18-	Pickups		
3-	Loaders			11-	Bar Cutting Machines			19-	Vehicles		
4-	Dump Trucks			12-	Mechanical Troweling			20-	Piles Drilling Machine		
5-	Compactors			13-	Jack Hammers			21-			
6-	Vibrators			14-	Compressors			22-			
7-	Transit Mixers			15-	Scaffold System			23-			
8-	Concrete Pumbs			16-	Asphalt Finishers			24-			

D. Works in Progress:

Item #	Description	Location
1-		
2-		
3-		
4-		
5-		
6-		
7-		

D. Request for Inspection:

Result for Inspection

E. Materials Delivered to Site:

Item #	Material	Unit	Quantity		hr	Name		Party
1-					1-			
2-					2-			
3-					3-			
4-					4-			

Contractor's Comments

Name:_____ Signature:_____

Resident Site Engineer's Comments:

Name:_____ Signature:_____

Table Appx II-2 Weekly report

Concepts Engineers & Associates								
WEEKLY REPORT								
Date:							15-Mar-15	
Last week Work Contents	Work progress at zone G-c	Sampling for pull-out test done at 14/03/15.						
	Work progress at zone G1	Earth excavation & CC casting completed for foundation. Rebar binding is in progress.						
	Rebar test	Rebar has been sent in BUET for test						
	Concrete Cylinder Test	To check the compressive strength of concrete, cylinder has been prepared at 1:1.5:3 with water-cement ratio of 0.40, 0.45 and 0.50						
	Approval of steel plate & bolt	Buet test report found on 12/03/15. As the yield strength found lower than required strength, so some modified section of steel channel has been proposed by Inoue san.						
Issues to be solved	Zone G1	At the combined footing section, an existing column intersect our footing area. Need to check and approval of rebar placement.						
	Samples of Chemical materials	Non-shrinkage grouting need to arrange for test & approval, delivery date of these materials to the site was at 03/03/15, but not reached at site yet.						
	Revise Drawing	Revise drawing needed showing every detailing.						
	Revise schedule	Master schedule need to revise synchronizing with the task that was not performed at previous week.						
	Project profile signboard	Need a guideline for the content of project profile signboard.						
This week Work Contents	The weekly meeting	5th weekly meeting will be held on 15th Mar 2015.						
	Weekly schedule	Contractor will give the weekly schedule.						
	Zone G-c	Pull-out test will be done. Repairing work of beam & column will start.						
	Zone G1	Foundation casting will be done and will be progress for superstructure.						
	Electrical drawing	preparation and modification of electrical drawing .						
Daily Work of last week Check	Name of Work	8-Mar Sun.	9-Mar Mon.	10-Mar Tue.	11-Mar Wed.	12-Mar Thur.	13-Mar Fri.	14-Mar Sat.
	CIVIL WORKS							
	Ground Floor							
	Testing & Approval of materials							
	Zone G-c							
	sampling for pull-out test							
	Zone G1							
	Earth excavation							
	CC casting							
	Shore protection							
	Rebar binding							
Contractor's signature		Date:						

Table Appx II-3 OVERALL PROGRESS REPORT

(The Name of the Project)

Period of Report	*(Month, Year)*
Client	*(Name)*
Contractor	*(Name)*
Supervisor	*(Name)*
Location	
Commencement of Construction	*(DD/MM/YY)*
Scheduled Completion Date	*(DD/MM/YY)*
Actual Progress	*(**% at the end of Month)*
Picture *(Whole view of the site)*	

WORK DESCRIPTION

date	day	Major Activity	16		
1		*Performed Main Work*	17		
2			18		
3			19		
4			20		
5			21		
6			22		
7			23		
8			24		
9			25		
10			26		
11			27		
12			28		
13			29		
14			30		
15			31		

REMARKS

(Special Event, Etc.)

1. Summary of Progress

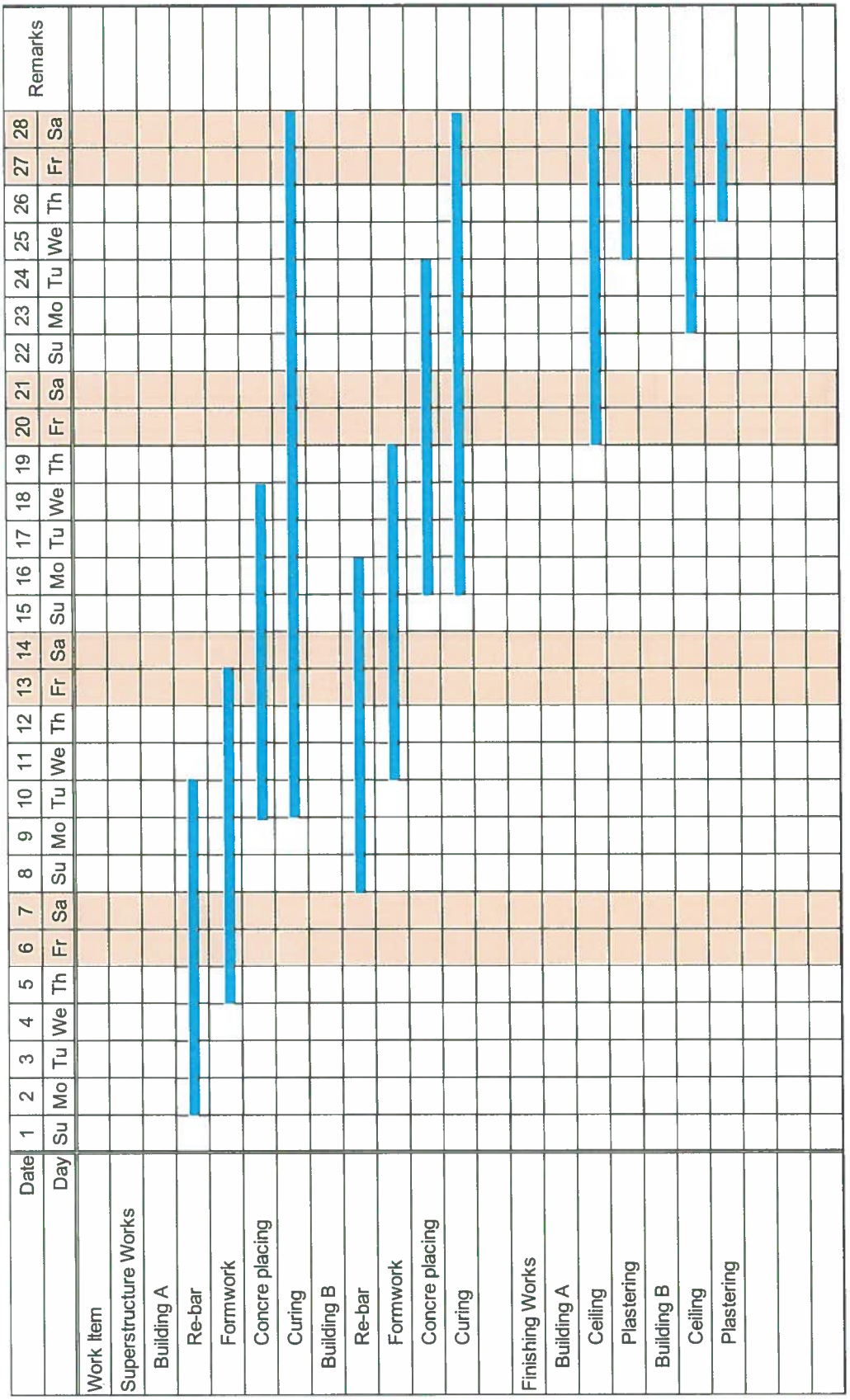
(1) Monthly Progress

Summary of performed construction work for last one month, using the table below.

Table: Work Items

Work Item Contents	Target volume (in last month)	Actual volume (in last month)	Total Volume	Total Progress (%)
Re-bar work	**** Ton	**** Ton	**** Ton	**** %
Concrete work	**** CUM	**** CUM	**** CUM	**** %

Table: Monthly Schedule (Bar Chart, Scheduled work)

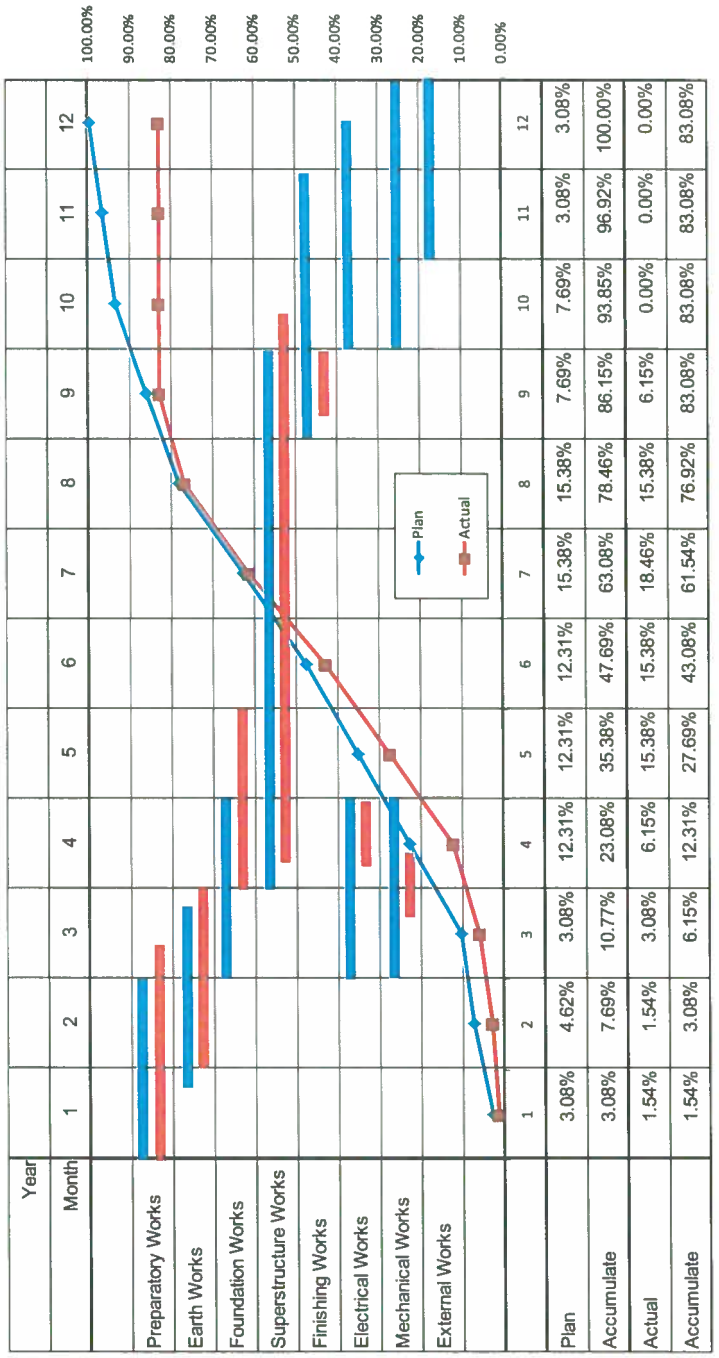


(2) Overall Progress

Comments concerning scheduled completion date upon a consideration of overall actual progress.

In case of that the progress is behind target schedule, necessary action to catch up.

Table: Comparison of result between schedule and actual progress



	1	2	3	4	5	6	7	8	9	10	11	12
Plan	3.08%	4.62%	3.08%	12.31%	12.31%	12.31%	15.38%	15.38%	7.69%	7.69%	3.08%	3.08%
Accumulate	3.08%	7.69%	10.77%	23.08%	35.38%	47.69%	63.08%	78.46%	86.15%	93.85%	96.92%	100.00%
Actual	1.54%	1.54%	3.08%	6.15%	15.38%	15.38%	18.46%	15.38%	6.15%	0.00%	0.00%	0.00%
Accumulate	1.54%	3.08%	6.15%	12.31%	27.69%	43.08%	61.54%	76.92%	83.08%	83.08%	83.08%	83.08%

2. Construction Supervision

*Summary of construction supervision such as "approval of shop drawings for ***", "Inspection of ****"and/or "meeting with ****".*

3. Instruction to the Constructor

All of instruction to the Constructor to secure the quality of construction work.

4. Safety Control

All of supervising works and/or instructions to secure safety during construction work, such as safety patrol, tool box meeting by the Constructor.

Photographs showing construction work.

	
Safety drill during construction work	Worker with full safety gears
Photographs showing construction work.	*Photographs showing construction work.*
Comments (DD/MM/YY)	*Comments (DD/MM/YY)*
Photographs showing construction work.	*Photographs showing construction work.*
Comments (DD/MM/YY)	*Comments (DD/MM/YY)*

5. Others (Hartal, Blockade, etc.)

Appendix Ⅲ

- Material submission form
- Request for inspection
- Inspection and Testing record

Table Appx III-1Material submission form

Header					
Project:					
Tender No:					
MATERIAL SUBMISSION FORM					
Date:			No:		
No.	Description	No. in (B.O.Q)	Source	Place of	Remarks
I hereby certify that the submitted sample is according to the contract, and if any discrepancy appear I will be responsible and the approval of the mentioned samples will not cause financial payments.					
Contractors Representative:					
Signature:					
☐ Approved					
☐ Approved as Noted					
☐ Not Approved					
☐ Resident Site Engineers Comments:					
Resident Site Engineers:			Signature:		
			Date:		

Table Appx III-2 Request for inspection

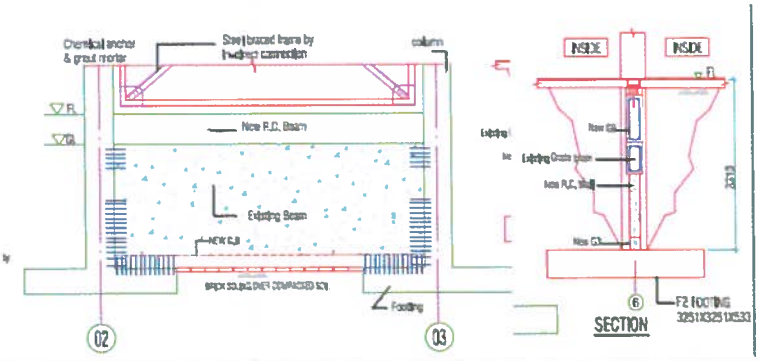
Header	
Project:	
Tender No:	
REQUEST FOR INSPECTION	
Date:_____	No:_____
Location	
Time	
Contractors Representative	
Signature	
First Inspection	
Resident Site Engineers Comments:	
Date:_____	Time:_____
☐ Approved	
☐ Not Approved	Resident Site Engineer Signature:_____
Contractor Signature:_____	
Second Inspection	
Resident Site Engineers Comments:	
Date:_____	Time:_____
☐ Approved	
☐ Not Approved	Resident Site Engineer Signature:_____
Copy received to proceed accordingly	
Contractor Signature:_____	

Table Appx III-3 Inspection and Testing Record

[Inspection and Testing Record]

Project Name:	RMG SECTOR SAFE ENVIROMENT PROGRAM RETROFITTING WORKS FOR XY KNITWEAR LTD

[Type]	[Acceptance Inspection/Testing] /Testing]		[In-process
[Date]	2015 / /		
[Item]	Re-bar, Form work		
[Content]	Footing		
[Accompanying Doc ments/Dra ing]	Shop drawing / Specification		
[Detail]	[Criterion]	[Results]	[Remarks]
Line 6, 02-03 Footing F2 form work	1500*1500	Pass	
Line 6, 02-03 Footing F2 re-bar work	12φ @100 C/C 12φ @100 C/C		Correct Bar arrangement
[Indication items and Remarks detail]			
[Passed] / **[Failed]**			
[Permission by Supervisor]			Signature
[Inspection Passed] : [Permission to next process]			END
[Inspection Failed] : [Re-inspection or other measures]			



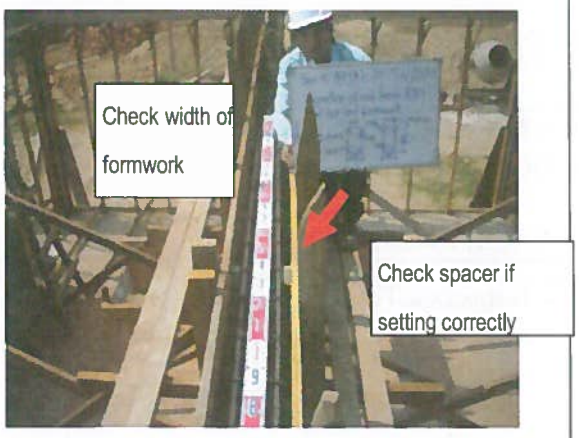


PHOTO 1: Check rebar size, formwork size, spacer, overlap

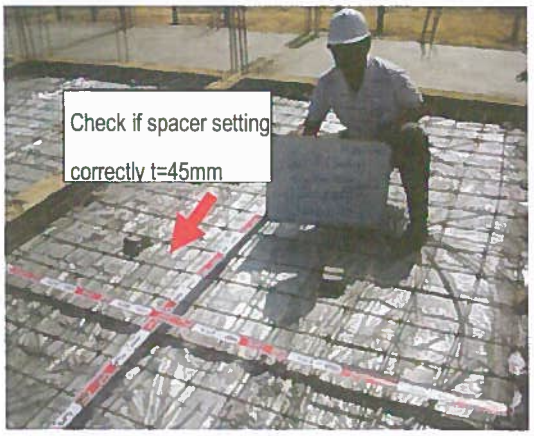


PHOTO 2:Check size of bar D6, pitches @ 200mm, overlap 270 mm

PHOTO 3: Check number of bar, size, pitches, tied each bar Setting correctly in the center a line

PHOTO 4: Checking verticality of formwork by plumbing

Appendix IV

- Photographic monitoring in construction work

Photographic monitoring in construction work.

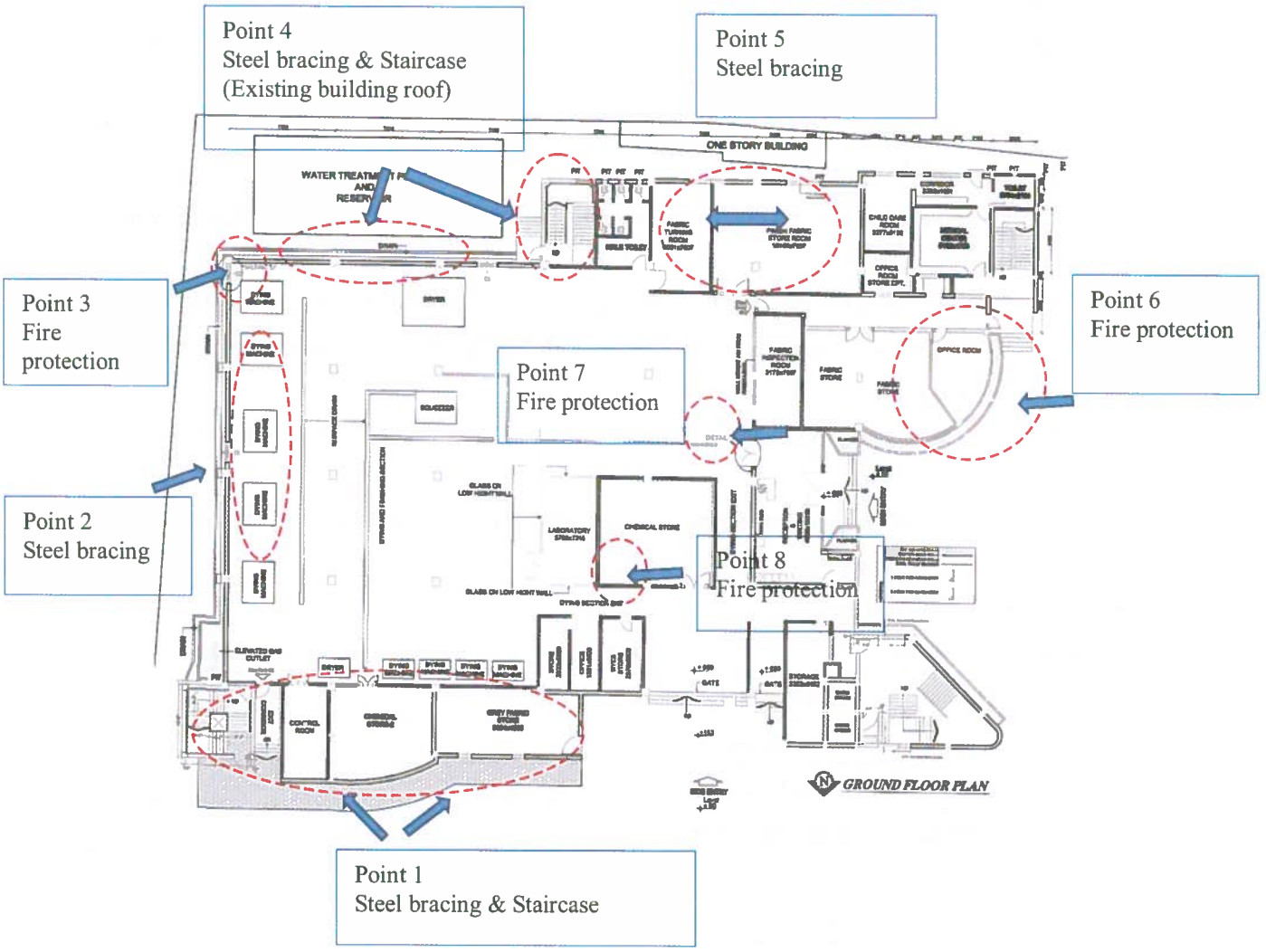
Purpose: To monitor the Retrofitting construction works from the start of construction to the end.

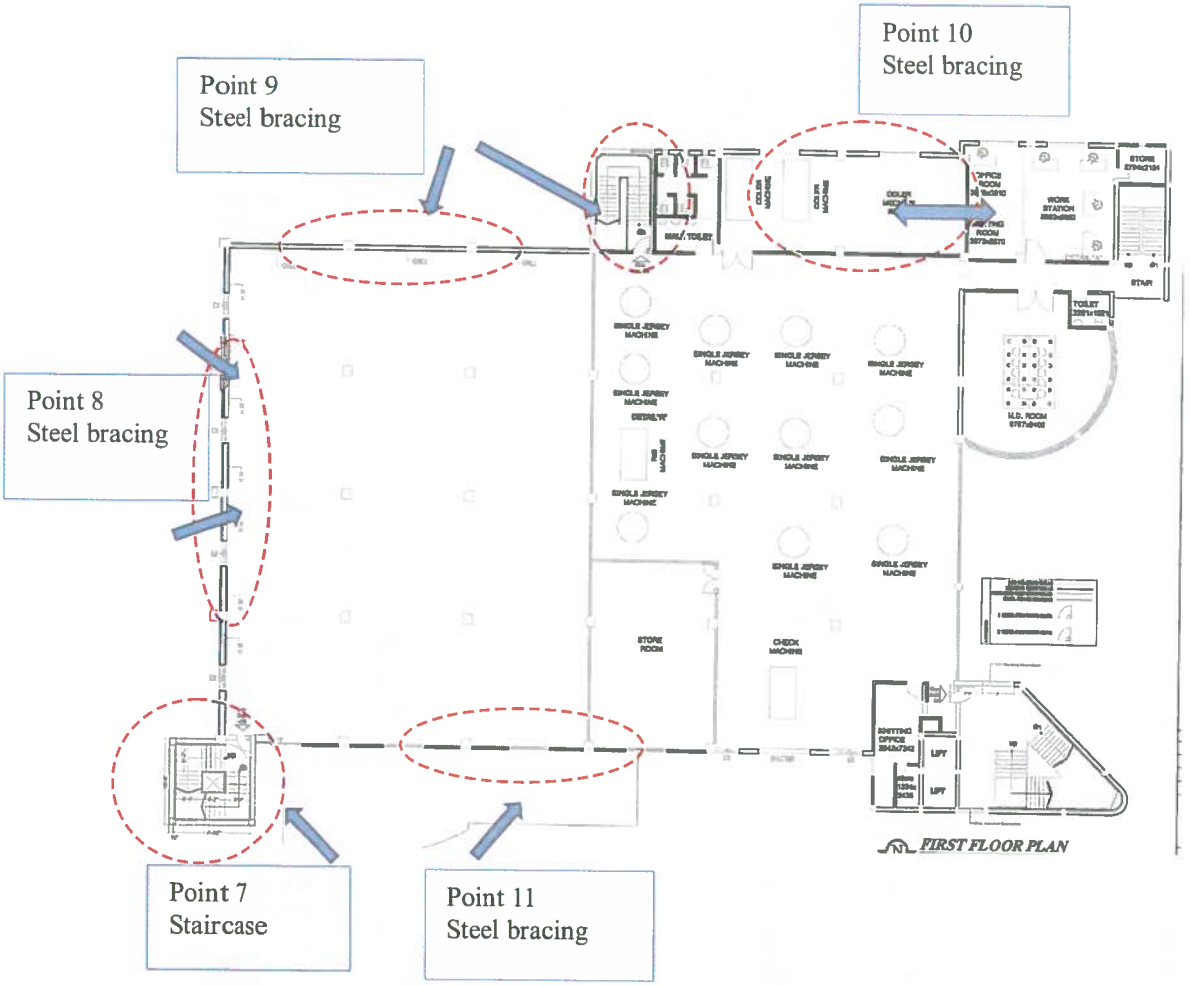
Points to be considered during photography

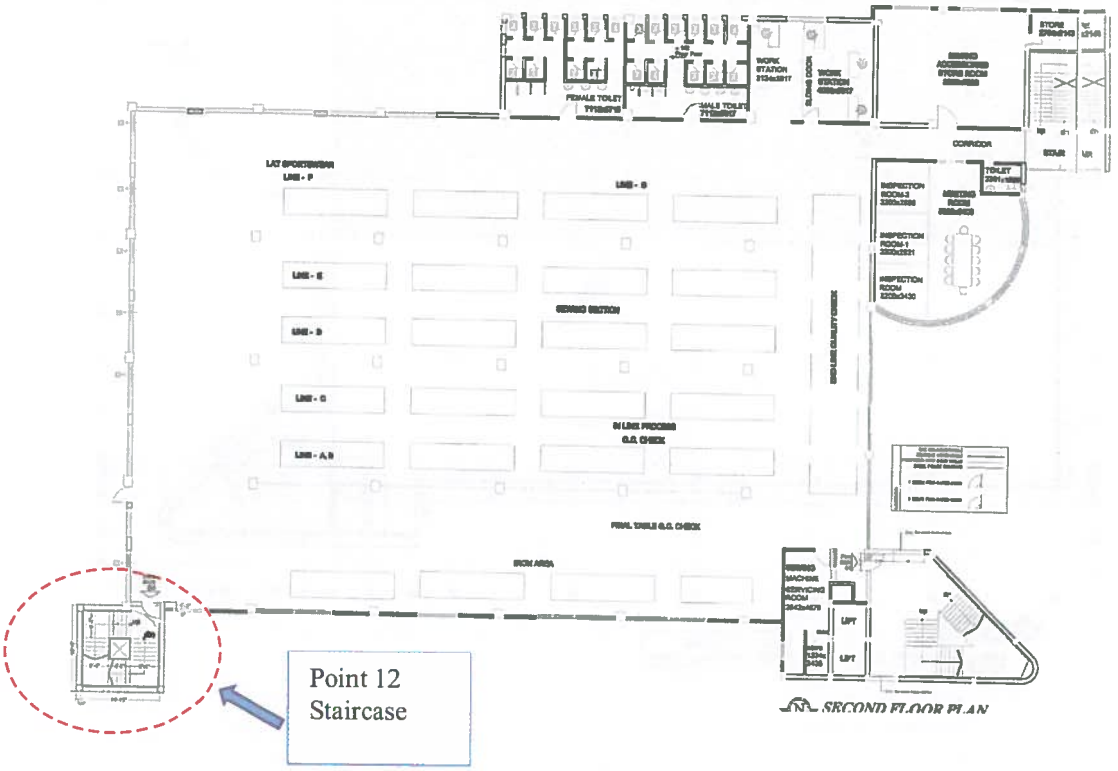
1. Photographing pre-constructing, constructing and post-constructing according to construction part number (by same point, same angle, same level as much as possible).
2. Timing of photography: perform together with an engineer at the time of a weekly regular meeting.
3. At least two photos for each point are necessary. They are photographing construction part by panoramic view to be specific (distant view) and detail part to show reinforcing specification (near view).
4. Attaching drawings to show construction part number and photo location to photographic record.
5. Filling date and time, point number, construction type and point number, content collection and other necessary items in photo mount.

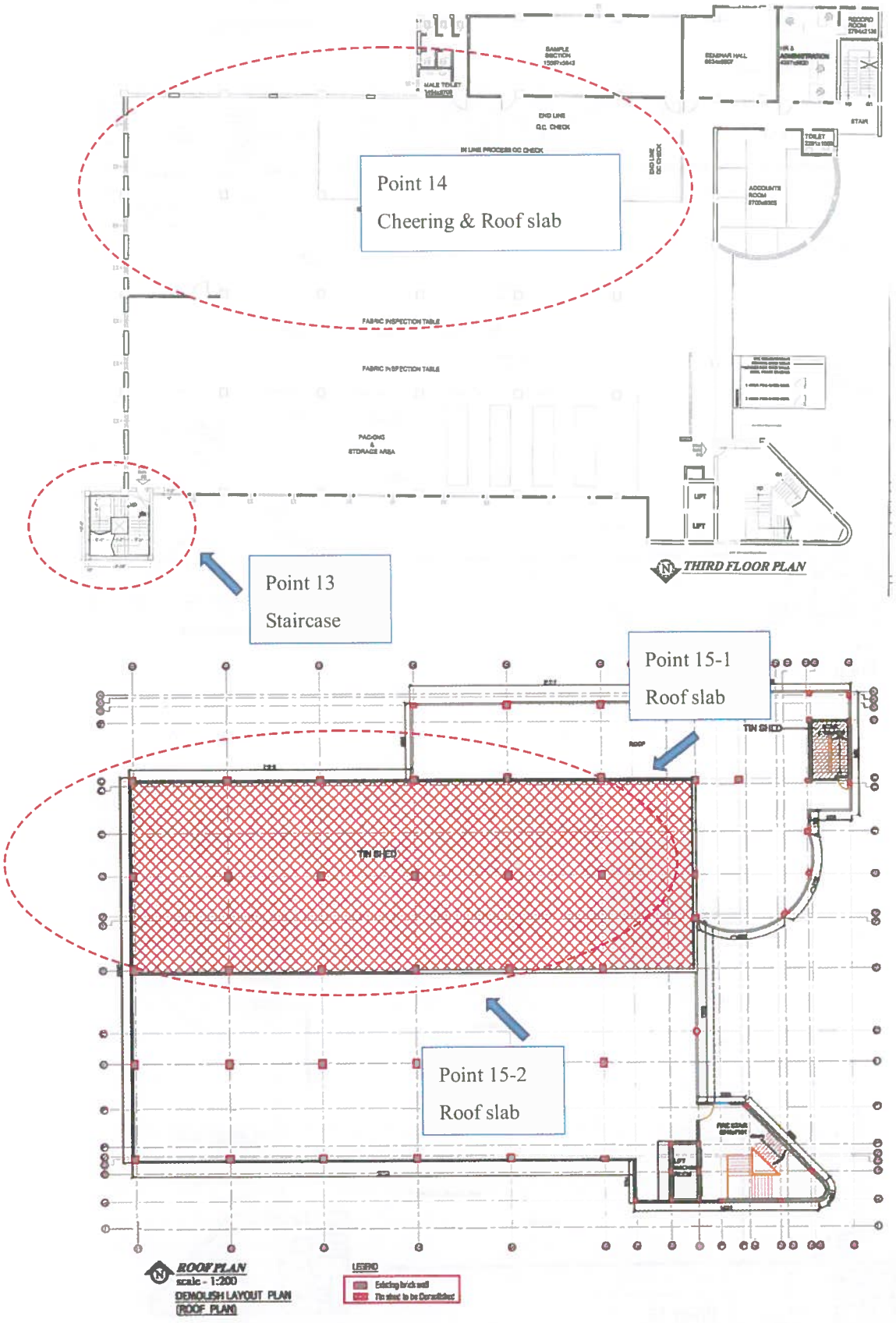
■ Target point list (Sample)

Floor	Point	Target	Remarks
Ground Floor	Point 1	Steel bracing	
		& Staircase	
	Point 2	Steel bracing	
	Point 3	Fire protection	
	Point 4	Steel bracing	
		& Staircase	
	Point 5	Steel bracing (right)	
		& Steel bracing (left)	
	Point 6	Fire protection	
1st floor	Point 7	Staircase	
	Point 8	Steel bracing	
	Point 9	Steel bracing (right)	
		& Steel bracing (left)	
	Point 10	Steel bracing (right)	
		& Steel bracing (left)	
	Point 11	Steel bracing	
2nd Floor	Point 12	Staircase	
	Point 13	Staircase	
	Point 14	Ceiling & Roof slab	
Roof Floor	Point 15	Roof slab	


Point 4
Steel bracing & Staircase
(Existing building roof)
Point 5
Steel bracing
Point 3
Fire
protection
Point 6
Fire protection
Point 7
Fire protection
Point 2
Steel bracing
Point 8
Fire protection
Point 1
Steel bracing & Staircase
ONE STORY BUILDING
GROUND FLOOR PLAN


Point 9
Steel bracing
Point 10
Steel bracing
Point 8
Steel bracing
Point 7
Staircase
Point 11
Steel bracing
FIRST FLOOR PLAN


Point 12
Staircase
SECOND FLOOR PLAN


Point 14
Cheering & Roof slab
THIRD FLOOR PLAN
Point 13
Staircase
Point 15-1
Roof slab
Point 15-2
Roof slab
TIN SHED
ROOF PLAN
scale - 1:200
DEMOLISH LAYOUT PLAN
(ROOF PLAN)
LEGEND

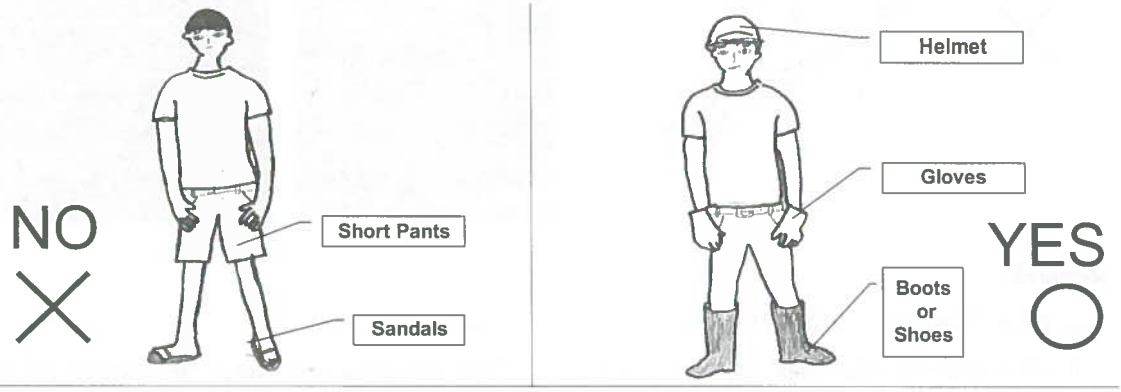
Appendix V

- Minimum requirements for quality control

(Illustration by MOHRI, ARCHITECT & ASSOCIATES, INC.)

Minimum requirements for quality control

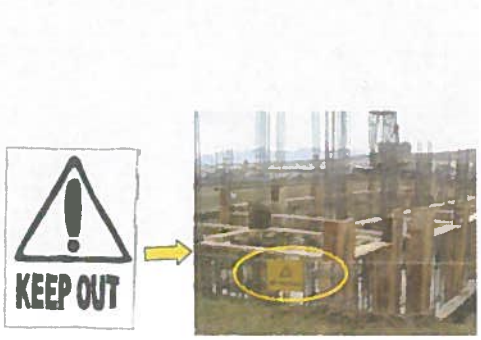
1. Safety Requirements



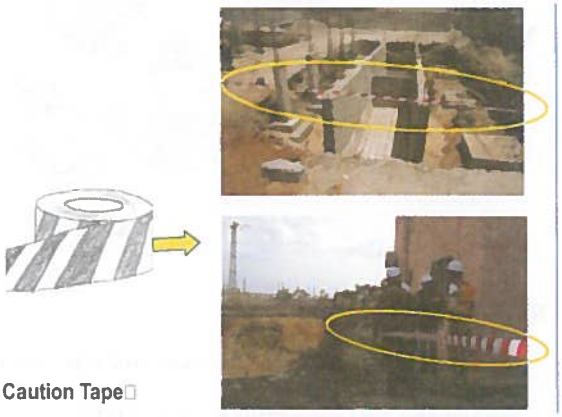
Remarks

a. Wear a helmet, gloves and shoes or boots in a construction site

b. Cover your skin as much as possible.



Caution Sign

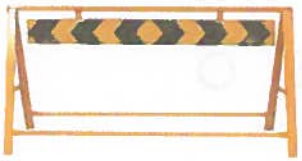


Caution Tape

Remarks

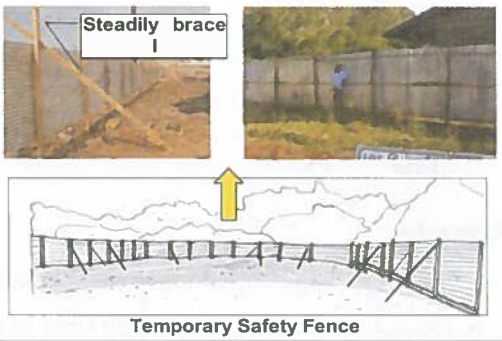
a. Place caution tape in front of dangerous areas.

b. Display a caution sign where it is easy to see.



Caution Barricade

Sign with Stand



Temporary Safety Fence

Remarks

a. Place a caution barricade or caution sign so workers do not enter dangerous areas.

2. Site Condition

NO ×

Remarks

a. Keep construction sites clean for site safety and work efficiency

b. 30-minutes weekly clean-up should done to collect and dispose garbage and rubbish off the site.

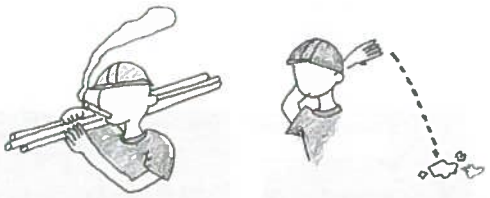
YES ○

Remarks

a. Keep construction sites clean for site safety and work efficiency

b. Always, pay attention to site safety.

c. Provide dustbins in the site for proper garbage disposal and empty them regularly



NO ×

YES ○

Remarks

a. Set up garbage collection areas. Do not litter.

b. Do not smoke during working time in the construction sites.

c. Allow smoking only in designated areas and only during lunch and break times.

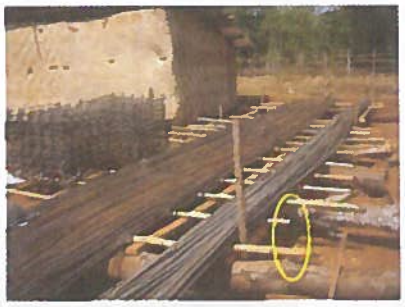
3. Stockyard condition

Wooden Materials **Aggregate & Sand stockyard**

Remarks

a. Protect Aggregate & Sand from rain with vinyl (plastic) sheets.

b. Timber stockpile should be provided with pallets and raised from the ground to avoid moisture and condensation.



Reinforcing bars

Remarks

a. Store reinforcing bars off the ground, like on a pallet or wooden bars and raised 300mm (minimum) from the ground.

b. Protect reinforcing bars from rain and moisture with vinyl (plastic) sheets to avoid rust.

Cement bags

Remarks

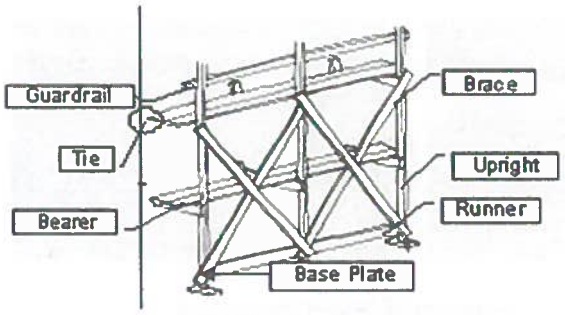
a. Construct a temporary shed in the site.

b. Cement bags shall be put on the pallet and raised at least 300mm from the ground.

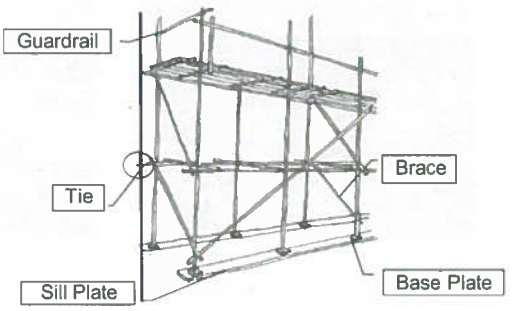
c. Cement bags shall be stacked no more than10 packages.

d. Protect the bags of cement from rain with vinyl (plastic) sheets

4. Temporary Works



Wooden Scaffolding



Tubular Scaffolding

Remarks

a. Make sure material is strong enough to sustain the loads like workers' weight and material loads.

b. Check if the scaffolding is steady or not when working and walking on it.

c. Prepare an emergency plan for accidents, such as scaffolding collapse or people falling.

d. Always, provide handrails for all platforms.

Remarks

a. The scaffolding is not fixed to a stable structure.

b. There is no handrail.

YES ○

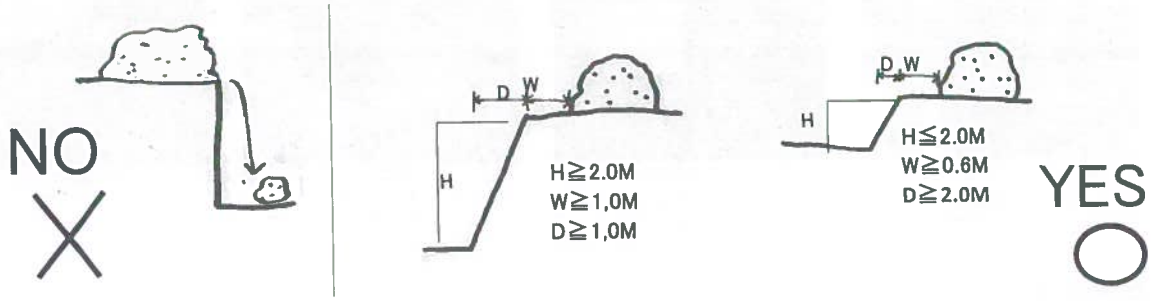
Remarks

a. The scaffolding is fixed to stable structure and secured.

b. Handrail is in place and other required bracings and supports.

c. Working platform is clean and free from clutter.

5. Excavation Work



Remarks

a. Do not excavate straight down.

Excavate at an angle so soil does not fall back in the excavated pit.

b. Handrail is in place and other required bracings and supports.

c. Keep excavated soil at a certain distance from the edge of excavated areas.

YES

Remarks

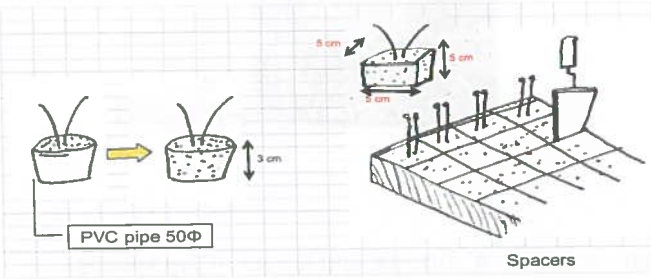
a. There is enough distance between the edge of excavation and batter boards.

b. The site is excavated at an angle.

c. Discard or moved excess excavated soil from site if it is too loose to avoid soil corrosion back to excavated areas.

6. Concrete Work

(1) Requirements

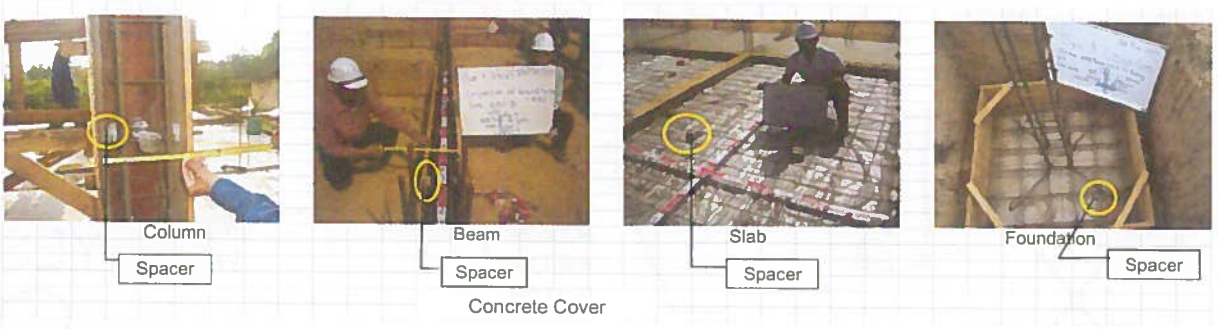


Remarks

a. Make sure there is enough concrete thickness before making spacers.

b. Spacer should be prepared before the structural formwork.

c. Always, place spacers to keep reinforcing bars in place.

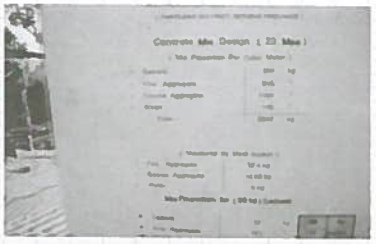


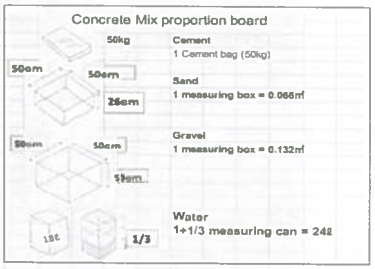
Remarks

a. Make sure that enough spacers are placed in right places.

- Slab: Upper side steel bar, 1～2piece/m^2, Below side steel bar, 1～2piece/m^2
- Column: Each side 2m/piece (@=2m)
- Beam: Bottom, Both side 2m/piece (@=2m)
- Wall: Vertical @= 2m/piece, Horizontal @=1.5m/piece

b. Check locations and sizes of spacers before casting concrete.


Concrete Mix proportion board

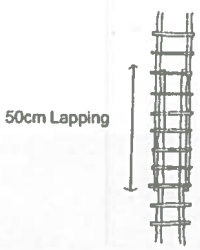


Remarks

a. Concrete mix proportion should be written on the board and installed near the mixing place.

b. Mortar mix proportion should be written on the board and installed near the mixing place.

(2) Steel Reinforcement

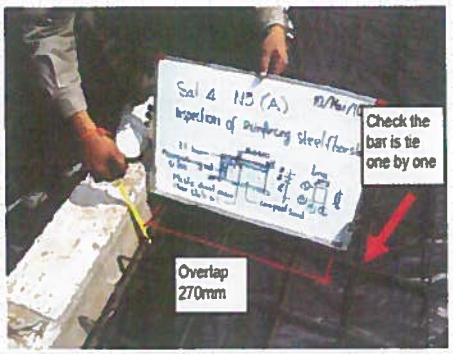


Remarks

a. Make sure that the sizes of reinforcing bars, spacing of stirrups, and length of lap splices conforms to the specification.

b. Always check and prepare rebar cutting list and bending schedule prior to start of work.

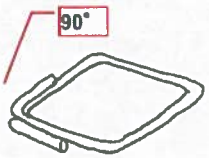
c. All fabricated re-bars should be kept elevated from ground to minimize accumulation of rust.



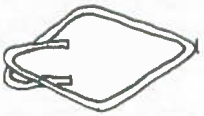
Remarks

a. Make sure that the sizes of reinforcing bars, spacing of stirrups, and length of overlap splices match the specification.

b. Fabrication of reinforcement shall be accurately done to the dimension shown on the drawings.



No



Yes

Remarks

a. Make sure that the sizes of reinforcing bars, spacing of stirrups, and length of lap splices conforms to the specification.

b. The bending of hooks shall be checked in the construction site. Samples of hoops and stirrups should be submitted to the Consultant.

(3) Formwork

Remarks

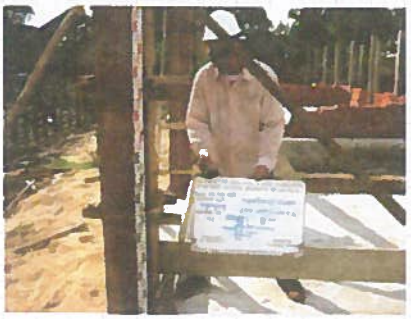
a. The supports of formwork shall be checked in the construction site.

b. Fabrication of formwork shall be accurately done to the dimension shown on the drawings.

Remarks

a. Fabrication of formwork shall be accurately done to the dimension shown on the drawings

b. Re-use of formwork shall be subject to the approval of the Site Engineer.



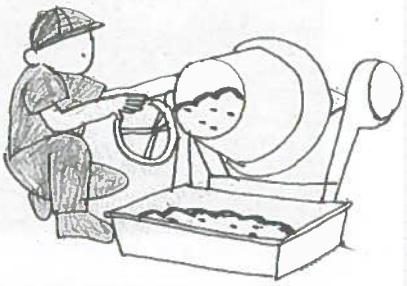
Remarks

a. The verticality of column's formwork shall be check in the construction site.

b. Use Plumb Bob and level bar to check that the column are true to line and grid.

c. Sufficient bracings and supports on the column formworks should be provided to minimize movement and shaking during concrete.

(4) Concrete mixture



Remarks

a. Measure the ingredient correctly for each batch.

b. Manufacturing of concrete shall be accurately done to meet the trial mix test result.

Remarks

a. Form shall be cleaned immediately before placing concrete.

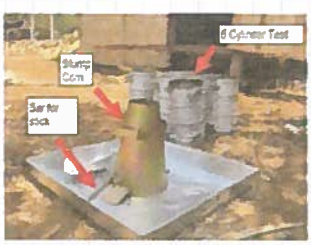
b. Secure formwork for columns and beams with bracing or pegs so that the form can stand the pressure during casting of concrete.

c. Casting concrete release point shall be done within 1.5m.

d. When casting concrete, poke the concrete with a steel rod.

e. During casting concrete, strike the formwork for concrete with a rubber or wooden hammer.

f. Concrete shall be cured for at least four days and 3 times/day and as required by Engineer.



Concrete test requirements

Concrete slump test

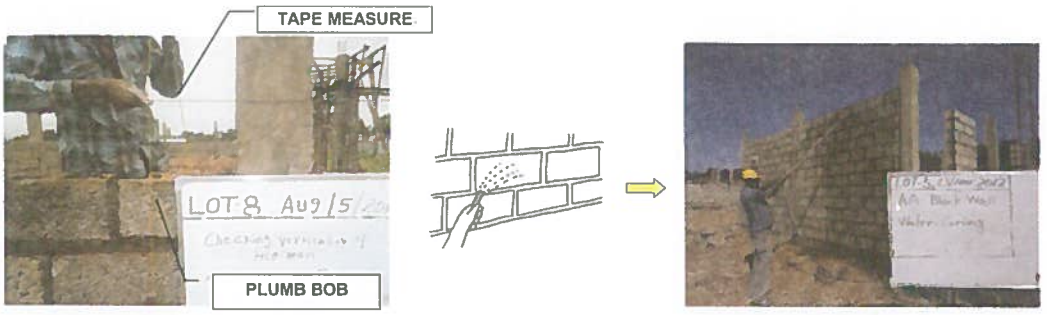
Concrete temperrature check

Remarks

a. Concrete testing equipment shall be kept clean to get accurate test results

b. The casting concrete temperature shall be at 35 ℃ or less.

(5) Block Work



Remarks

a. The verticality of brick wall shall be checked in the construction site.

b. Block should be kept wet before the block laying works start to ensure good bonding with the mortar.

c. Block wall shall be cured for at least 2～3 days and as required by Engineer.

Appendix VI

- List of BDS and other Adopted Standards

Table: Appx VI-1: Important BDS and Adopted Standards List

Date: 28.07.2013 (Note: Many standards are revised and approved but SRO has not done yet)

BDS 208 : 2009 (3rd revision) Specification for Common Building clay bricks Specifies the dimensions, quality & strength of common burnt clay bricks, methods of sampling, testing etc.
BDS 281 : 1963 Organic impurities in sands for concrete The test covers the determination of the presence of injurious organic compounds in natural sands.
BDS 286 : 1963 Description and classification of mineral aggregates Describes the aggregates of granite, limestone etc.
BDS 385 : 1964 Beam impact test V-notch for steel.
BDS 386 Steel Wire, Method for Simple Torsion Testing of
BDS 426 : 1964 Wrapping test for steel Describes the wrapping test of wire.
* BDS 558 Asbestos Cement Pipes, Joints and Fitting for Sewerage and Drainage.
* BDS 559 Cast Iron Sanitary Pipes and Fittings for Waste Water and Ventilation
* BDS 613 Asbestos cement products, sampling and inspection of.
* BDS 636 Galvanized steel barbed wire
* BDS 680 Steel nails for building purposes
BDS 868 : 1978 Galvanized corrugated sheet for roof & wall coverings It deals with the use of galvanized corrugated steel sheets for roofing & cladding in building, Suggestions are given on design & materials, construction & maintenance along with information of weather tightness, durability, thermal insulation, etc.
BDS 1031 : 2006 (1st revision) Mild steel tubes, tubular and other wrought steel fitting, MS tubes. It covers the requirements for butt welded and seamless screwed and socketed and plain M.S. tubes, designation, manufacture, chemical composition, tolerances, test workmanship, etc.

BDS 1249 : 1989 Acid resistant bricks It specifies the requirements for acid-resistant bricks, dimensions, tolerances, test etc.
BDS 1250 : 1990 Burnt clay facing bricks It specifies the dimensions, quality & strength of burnt clay facing bricks used in building & other structure, physical requirements etc.
BDS 1263 : 1990 Burnt Clay hollow bricks for walls & partitions It covers the dimensions, quality & strength for hollow bricks made from burnt clay & having perforations through & at right angle to the bearing surface tests.
BDS 1265 : 1990 Industrial safety helmet It specifies the requirements regarding material, construction workmanship & finish & performance requirements of helmets intended to provide protection against falling objects & other hazards.
BDS 1266 : 1990 Non metal Helmet for firemen & civil defense personnel It lays down the requirements regarding materials, construction, workmanship & finish, weight & performance of helmets, for the firemen & civil defense personnel.
BDS 1301 : 1990 Glazed earthenware tiles It covers the requirements for glazed earthenware tile & associated fittings, generally used for finishing the surfaces of walls & floors of water closets, bathrooms, kitchen, hospitals & similar places.
BDS 1303 : 1990 Chemical resistant mortars It covers the requirements for silicate type, sulphur type & resin type chemical resistant mortars for bonding chemical resistant masonry units.
BDS 1304 : 1990 Methods of test for chemical resistant mortars It covers the methods for carrying out the following tests on silicate type, sulphur type & resin type chemical resistant mortars. Method of test. i) Working time, ii) Tensile strength, iii)Flexural strength, iv) Compressive strength, v) Bond strength etc.
BDS 1314 : (P-1) 1990 Fire detection & alarm system, general & definition It specifies the components of fire detection & alarm systems, requirements for their interconnection & installation & the performance, testing & servicing of parts or of complete system. Fire detection & alarm systems for buildings.

BDS 1315 : 1990 Fire protection safety sign It specifies : i) means of giving warning of fire & manual controls. ii) means of escape from fire. iii) means of fire fighting. iv) means of preventing fire spreading. v) areas or materials of special fire risks.
BDS 1316 : 1990 Life jacket It specifies the performance & safety requirements for life jackets & internal life jacket/safety hamesses, life jackets covered. i) Inherently buoyant life jacket-buoyancy produced by materials higher than water buoyant life jacket. ii) Partially inherently-buoyancy produced by materials lighter than water & partly by inflation. ii) Inflammable life jacket-buoyancy produced solely by inflation.
BDS 1355 : 1992 Dimensions and properties for hot rolled steel column channel and angle sections This standard covers the nominal dimensions, mass and sectional properties of hot rolled sloping flange beam and column section.
BDS 1357 : 1992 Washers for use with fittings for water services This standard covers requirements of washer for water services suitable for use in bib taps, slops valves, self closing taps, flush valves, pillar taps and Ferrules.
BDS 1358 : 1992 Protective filters for welding cutting and similar operations This standard covers requirements of the filters.
BDS 1359 : 1992 Industrial safety belts and harnesses This standard covers the requirements for safety belts and harnesses and their components.
BDS1360 : 1992 Equipment for eye and face protection during welding This standard covers the requirements of goggles; hand shield helmet intended to protect an operator above the shoulder.
BDS 1432 : 1993 Burnt clay perforated building bricks Specifies the requirements in regard to dimensions, perforations, quality, strength and also for quality of surface in case of special grade for facing bricks of perforated burnt clay building bricks for use in walls and partitions.

BDS 1459 : 1994 White Portland cement Includes requirements of chemical and physical properties of white Portland cement.
BDS 1495 : 1994 High aluminium refractory bricks Specifies the dimension, characteristics and classification of high alumina refractory bricks.
BDS 1575 : 1997 Cast iron manhole cover and frames Lays down basic and performance requirements for Manhole covers and frames in cast iron, intended for use in drainage and water works.
BDS 1576 : 1997 Method for tensile testing of steel tubes Prescribes the method of conducting tensile testing of steel tubes.
BDS 1577 : 1997 Carbon steel Billets for the manufacturing of reinforcing Bars and Wire rods Specifies requirements for carbon steel billets for manufacturing of wire drawing rods and reinforcing bars of the different 5 (five) types and grades.
BDS 1626 : 1999 Concrete pipes (with and without) reinforcement Covers the requirements and test for reinforced and unreinforced cement concrete pipes of both pressure and non- pressure varieties used for water mains, sewers, culverts and irrigation works.
BDS 1688 : 2001 # ISO 5223 : 1999 Specification for test sieves for cereals. Specifies requirements for test sieves to be used for the laboratory determination of undesirable substances in a sample of cereals and which pass through test sieves of the following nominal sizes.
BDS 1803 : 2008 Specification for Hollow Clay Bricks and Blocks

Adopted Standards List:

BDS EN 196- 1 : 2012 (1st revision) Methods of testing Cement Part-1 Determination of strength This Bangladesh Standard describes a method of determining the compressive and flexural strengths of cement mortar.
BDS EN 196-2 : 2012 (1st revision) Methods of testing Cement Part-2 Chemical analysis of cement This Bangladesh Standard describes the procedures for the chemical analysis of cement.
BDS EN 196-3 : 2012 (1st revision) Methods of testing Cement Part-3 Determination of setting time and soundness This Bangladesh Standard describes the methods for determining setting time and soundness of cements.
BDS EN 196-5 : 2012 (1st revision) Methods of testing Cement Part-5 Pozzolonacity test for pozzolanic cement This Bangladesh Standard describes the method of measuring the pozzolanicity of pozzolanic cements.
BDS EN 196-6 : 2012 (1st revision) Methods of testing Cement Part-6 : Determination of fineness This Bangladesh Standard describes the method for determining the fineness of cement
BDS EN 196-7 : 2012 (1st revision) Methods of testing Cement Part-7 :Methods of taking and preparing, samples of cement This Bangladesh Standard describes only the equipment to be used, the methods to be followed and the provisions to be complied with for testing to assess the quality of products prior to, during or after delivery
BDS EN 196-21:2003 Methods of testing Cement Part-21: Determination of the chloride and alkali content of cement. This Bangladesh Standard specifies methods of determining the chloride, carbon dioxide and alkali content of cement.
BDS EN 197-1: 2003 (Reaffirmed 2010 Including Amendment 1) Cement Part-1 Composition, specifications and conformity criteria for common cements. BDS EN 197-1 defines and gives the specifications of 27 distinct common cement products and their constituents
BDS EN 197-2: 2003 Cement Part-2: Conformity Cement evaluation EN 197-2 specifies the scheme for the evaluation of conformity of cements to their corresponding product

specification standards, including certification of conformity by a certification body.
BDS EN 451-1: 2003 Methods of testing fly ash V (Part 1): Determination of free calcium oxide content This Bangladesh Standard describes the procedure for the determination of free calcium oxide content in fly ash.
BDS ISO 6935 (Part-1): 2012 (2nd Revision) Steel for the reinforcement of concrete - Part-1: Plain bars Specifies technical requirements for plain bars designed for reinforcement in ordinary concrete structures and for non-prestressed reinforcement in prestressed concrete structures.
BDS ISO 6935 (Part-2): 2012 (2nd Revision) Steel for the reinforcement of concrete - Part-2: Ribbed bars Specifies technical requirements for ribbed bars designed for reinforcement in ordinary concrete structures and for non-pre stressed reinforcement in prestressed concrete structures.
BDS ISO 6935 (Part-3): 2006 Steel for the reinforcement of concrete - Part-3: Welded Fabric. Specifies technical requirements for factory made sheets or rolls welded fabric manufacture from steel wires or bars with diameters from 4 mm to 16 mm and designed for reinforcement in ordinary concrete structured and for non-prestressed reinforcement in prestressed concrete structures.
BDS ISO 10065: 2006 Steel bars for the reinforcement of concrete– Bend and Rebend tests Specifies procedures for bend and rebend testing of reinforcing steel bars. The purpose of the rebend test is to determine the ageing properties of bars exposed to plastic deformation.(Superseded by BDS ISO 15630 series)
BDS ISO 10144 : 2006 Certification scheme for steel bars and wires for the reinforcement of concrete structures. Specifies rules for a certification scheme for continuous production of steel bars and wires for ordinary reinforcement of concrete structures in order to verify the conformity with requirements specified in product standards such as ISO 6935-1 and ISO 6935-2.
BDS ISO 10545 -1 : 2006 Ceramic tiles — Sampling and basis for acceptance. Specifies rules for batching, sampling, inspection and acceptance/rejection of ceramic tiles.
BDS ISO 10545 -3 : 2006 Ceramic tiles — Determination of water absorption, apparent porosity, apparent relative density and bulk density. Specifies methods for determining water absorption, apparent porosity, apparent relative density and bulk density of ceramic tiles.
BDS ISO 10545 -4 : 2013 (1st Revision) Ceramic tiles — Determination of modulus of rupture and breaking strength

Defines a test method for determining the modulus of rupture and breaking strength of all ceramic tiles.
BDS ISO 10545 -5 : 2005 Ceramic tiles — Determination of impact resistance by measurement of coefficient of restitution Specifies methods for determining the impact resistance of ceramic tiles by measuring the coefficient of restitution.
BDS ISO 10545 -6 : 2013 (1st Revision) Ceramic tiles — Determination of resistance to deep abrasion for unglazed tiles. Specifies test methods for determining the resistance to deep abrasion of all unglazed ceramic tiles used for floor coverings.
BDS ISO 10545 -7 : 2006 Ceramic tiles — Determination of resistance to surface abrasion for glazed tiles. Specifies a method for determining the resistance to surface abrasion of all glazed ceramic tiles used for floor covering.
BDS ISO 10545 -8 : 2006 Ceramic tiles — Determination of linear thermal expansion Defines a test method for determining the coefficient of linear thermal expansion of ceramic tiles.
BDS ISO 10545 -10 : 2006 Ceramic tiles — Determination of moisture expansion. Specifies a method for determining the moisture expansion of all ceramic tiles.
BDS ISO 10545 -12 : 2006 Ceramic tiles — Determination of frost resistance. Specifies a method for determining the frost resistance of all ceramic tiles intended for use in freezing conditions in the presence of water.
BDS ISO 10545 -13 : 2006 Ceramic tiles — Determination of chemical resistance. Specifies a test method for determining the chemical resistance of all ceramic tiles at room temperature. The method is applicable to all types of ceramic tiles.
BDS ISO 10545 -14 : 2006 Ceramic tiles — Determination of resistance to stains. Specifies a method for determining the resistance to stains of the proper surface of ceramic tiles.
BDS ISO 4995: 2006 Hot-rolled steel sheet of structural quality This standard applies to hot rolled steel sheet of structural quality usually without the use of micro alloying elements. The product is intended for structural purposes where particular mechanical properties are required.
BDS ISO 7801 : 2008 Metallic materials – Wire – Reverse bend test
BDS ISO 2531: 2008 Ductile iron pipes, fittings, accessories and their joints for water or gas applications.

BDS ISO 4179 : 2008 Ductile iron pipes for pressure pipelines – Centrifugal cement mortar lining – General requirements
BDS ISO 4633: 2008 Rubber seals – Joint rings for water supply, drainage and sewerage pipelines – Specification for materials.
BDS ISO 8179 - 2: 2008 Ductile iron pipes – External coating – Part 2: Zinc rich paint with finishing layer
BDS ISO 2591-1 : 2008 Test sieving -Part 1: Methods using test sieves of woven wire cloth and perforated metal plate
BDS ISO 3310-1 : 2008 Test sieves — Technical requirements and testing — Part 1: Test sieves of metal wire cloth
BDS ISO 3310-2 : 2008 Test sieves — Technical requirements and testing — Part 2: Test sieves of perforated metal plate
BDS ISO 3310-3 : 2008 Test sieves - Technical requirements and testing — Part 3: Test sieves of electroformed sheets
BDS ISO 1920-1 : 2008 Testing of concrete — Part 1: Sampling of fresh concrete
BDS ISO 1920-2 : 2008 Testing of concrete — Part 2: Properties of fresh concrete
BDS ISO 1920-3 : 2008 Testing of concrete — Part 3: Making and curing test specimens
BDS ISO 1920-4 : 2008 Testing of concrete — Part 4: Strength of hardened concrete
BDS ISO 1920-5 : 2008 Testing of concrete —Part 5: Properties of hardened concrete other than strength
BDS ISO 1920-6 : 2008 Testing of concrete —Part 6: Sampling, preparing and testing of concrete cores
BDS ISO 1920-7 : 2008 Testing of concrete — Part 7: Non-destructive tests on hardened concrete
BDS ISO 4103 : 2008 Concrete - Classification of consistency
BDS ISO 6274 : 2008 Concrete - Sieve analysis of aggregates
BDS ISO 6783 : 2008 Coarse aggregates for concrete - Determination of particle density and water absorption – Hydrostatic balance method
BDS ISO 7033 : 2008 Fine and coarse aggregates for concrete - Determination of the particle mass-per-volume and water absorption - Pyknometer method

BDS ISO 4951-1 : 2008 High yield strength steel bars and sections — Part 1: General delivery requirements
BDS ISO 4951-2 : 2008 High yield strength steel bars and sections — Part 2: Delivery conditions for normalized, normalized rolled and as-rolled steels
BDS ISO 4951-3 : 2008 High yield strength steel bars and sections — Part 3: Delivery conditions for thermomechanically-rolled steels
BDS ISO 15630-1 : 2012 (2nd Revision) Steel for the reinforcement and prestressing of concrete — Test methods — Part 1: Reinforcing bars, wire rod and wire
BDS ISO 15630-2 : 2012 (2nd Revision) Steel for the reinforcement and prestressing of concrete — Test methods — Part 2: Welded fabric
BDS ISO 15630-3 : 2012 (2nd Revision) Steel for the reinforcement and prestressing of concrete — Test methods — Part 3: Prestressing steel
BDS ISO 148-3: 2008 Metallic materials — Charpy pendulum impact test — Part 3: Preparation and characterization of Charpy V reference test pieces for verification of test machines
BDS ISO 377: 2008 Steel and steel products — Location and preparation of samples and test pieces for mechanical testing
BDS ISO 463: 2008 Geometrical Product Specifications (GPS) — Dimensional measuring equipment — Design and metrological characteristics of mechanical dial gauges
BDS ISO 471: 2008 Rubber — Temperatures, humidity's and times for conditioning and testing.
BDS ISO 580: 2008 Plastics piping and ducting systems — Injection-moulded thermoplastics fittings — Methods for visually assessing the effects of heating
BDS ISO 6507-1: 2008 Metallic materials — Vickers hardness test — Part 1: Test method
BDS ISO 6507-2: 2008 Metallic materials — Vickers hardness test — Part 2: Verification and calibration of testing machines
BDS ISO 6508-1: 2008 Metallic materials — Rockwell hardness test — Part 1: Test method (scales A, B, C, D, E, F, G, H, K, N, T)
BDS ISO 6508-2: 2008 Metallic materials — Rockwell hardness test — Part 2: Verification and calibration of testing machines (scales A, B, C, D, E, F, G, H, K, N, T)
BDS ISO 6508-3: 2008

Metallic materials — Rockwell hardness test — Part 3: Calibration of reference blocks (scales A, B, C, D, E, F, G, H, K, N, T)
BDS ISO 8659: 2008 Thermoplastics valves – Fatigue strength – Test method
BDS ISO 9034: 2008 Hot-rolled structural steel wide flats – Tolerances on dimensions and shape
BDS ISO 9513: 2008 Metallic materials — Calibration of extensometers used in uniaxial testing
BDS ISO 9853: 2008 Injection-moulded unplasticized poly(vinyl chloride)(PVC-U) fittings for pressure pipe systems–Crushing test
BDS ISO 10474: 2008 Steel and steel products — Inspection documents
BDS ISO 12092: 2008 Fittings, valves and other piping system components made of unplasticized poly(vinyl chloride) (PVC-U), chlorinated poly(vinyl chloride) (PVC-C), acrylonitrilebutadiene- styrene (ABS) and acrylonitrilestyrene-acrylester (ASA) for pipes under pressure — Resistance to internal pressure — Test method
BDS ISO 14284: 2008 Steel and iron — Sampling and preparation of samples for the determination of chemical composition
BDS EN 12390-4: 2008 Testing Hardened Concrete — Part 4: Compressive Strength — Specification for Testing Machines
BDS ISO 3545-3: 2008 Steel tubes and fittings – Symbols for use in specifications – Part 3: Tubular fittings with circular cross-section
BDS ISO 4145: 2008 Non-alloy steel fittings threaded to ISO 7-1
BDS ISO 5256: 2008 Steel pipes and fittings for buried or submerged pipelines – External and internal coating by bitumen or coal tar derived materials
BDS EN 490: 2008 Concrete roofing tiles and fittings for roof covering and all cladding — Product specifications
BDS EN 491: 2008 Concrete roofing tiles and fittings for roof covering and wall cladding — Test methods
BDS EN 538: 2008 Clay roofing tiles for discontinuous laying — Flexural strength test
BDS EN 539-l: 2008 Clay roofing tiles for discontinuous laying Determination of physical characteristics — Part 1:

Impermeability test
BDS EN 1024: 2008 Clay roofing tiles for discontinuous laying — Determination of geometric characteristics
BDS EN 14437: 2008 Determination of the uplift resistance of installed clay or concrete tiles for roofing — Roof system test method
BDS EN 14891: 2008 Liquid applied water impermeable products for use beneath ceramic tiling bonded with adhesives — Requirements, test methods, evaluation of conformity, classification and designation
BDS ISO 22965-1: 2008 Concrete — Part 1: Methods of specifying and guidance for the specifier
BDS ISO 22965-2: 2008 Concrete — Part 2: Specification of constituent materials, production of concrete and compliance of concrete
BDS ISO 23996: 2008 Resilient floor coverings — Determination of density
BDS ISO 24342: 2008 Resilient and textile floor coverings – Determination of side length, edge straightness and squareness of tiles
BDS ISO 24346: 2008 Resilient floor coverings — Determination of overall thickness
BDS ISO 11602-1: 2008 Fire protection — Portable and wheeled fire extinguishers — Part 1: Selection and installation
BDS ISO 11602-2: 2008 Fire protection — Portable and wheeled fire extinguishers- Part 2: Inspection and maintenance
BDS ISO 3419: 2008 Non – alloy and alloy steel butt–welding fittings
BDS ISO 5251: 2008 Stainless steel butt–welding fittings
BDS ISO 6761: 2008 Steel tubes – Preparation of ends of tubes and fittings for welding
BDS EN 934-1: 2008 Admixtures for concrete, mortar and grout — Part 1: Common requirements
BDS EN 934-2: 2008 Admixtures for concrete, mortar and grout — Part 2: Concrete admixtures — Definitions, requirements, conformity, marking and labeling
BDS ISO 3893: 2008 Concrete — Classification by compressive strength
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