BAR BENDING AND CONCRETING

Level-II

Learning Guide -38

Unit of Competence:-Erect Pre-cast Concrete Structural & Cladding Units

Module Title: - Erecting Pre-cast Concrete Structural & Cladding Units

LG Code: EIS BBC2 M11 LO2-LG-38

TTLM Code: EIS BBC2 TTLM 1019v1

LO 2: Erect precast concrete structural units

Instruction Sheet	Learning Guide #38

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics –

- Positioning structural units
- Fixing structural units
- Erecting temporary propping
- Erecting pre-cast structural units as to contract specifications

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, **you will be able to –**

- Position structural units
- Fix structural units
- Erect temporary propping
- Pre-cast structural units erected to contract specifications

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 6.
3. Read the information written in the information “Sheet 1, Sheet 2, Sheet 3 and Sheet 4” **in page 3, 9, 16 and 19** respectively.
4. Accomplish the “Self-check 1, Self-check t 2, Self-check 3 and Self-check 4” **in page 8, 15, 18 and 27** respectively
5. If you earned a satisfactory evaluation from the “Self-check” proceed to “Operation Sheet 1, Operation Sheet 2 and Operation Sheet 3 ” **in page 28** and Operation Sheet 4 **in page 29**
6. Do the “LAP test” **in page 29**

Information Sheet-1	Positioning structural units

1.1 The main features of this construction process are as follows:

- The division and specialization of the human workforce
- The use of tools, machinery, and other equipment, usually automated, in the production of standard, interchangeable parts and products
- Compared to site-cast concrete, precast concrete erection is faster and less affected by adverse weather conditions.
- Plant casting allows increased efficiency, high quality control and greater control on finishes..

This type of construction requires a restructuring of entire conventional construction process to enable interaction between design phase and production planning in order to improve and speed up construction.

1.2 Precast Concrete Construction Considerations

- **Erection Sequence**

Precast concrete members shall be erected according to preplanned sequence. The erection plan is commonly prepared drawings If it is important for structural stability and for access to connections at specific location. The erection sequence shall avoid multiple handling of elements. Finally, a trial erection operation should be considered to identify any unforeseen erection difficulties.

- **Erection Safety**

Safety during the handling and erection of precast concrete elements is substantially important. Therefore, all machines and equipment employed precast concrete element handling and erection need to be maintained to a high standard, load tested, and be suited to the intended utilization.

- **Erection Tolerances**

Generally, the precast unit should be erected in accordance with the tolerances provided by applicable codes, unless other tolerances are used in the design and specifications.

- **Rigging**

A rigging system for handling and erecting precast elements requires careful and thorough preplanning. It may be necessary to equalize loads between lifting points on certain precast elements, such as beams or flat slabs.

Lifting accessories may be in the form of slings/cables, hooks or shackles. The selection of such components should take into consideration the forces due to all operations involved in the handling and erection of the precast units.

Headroom availability and maneuverability during erection may also have an impact on the type of rigging system selected.

- **Temporary bracing**

Precast concrete elements must be adequately braced and supported during all phases of erection to ensure proper alignment and structural integrity until permanent structural connections are completed.

- **Leveling shims**

Leveling shims should be formed from a suitably durable material and should have adequate strength to carry the full imposed loads. Leveling shims carry the full construction load of the precast element and must provide adequate support to prevent movement until the element is incorporated in the main structure.

- **Propping**

All temporary propping requirements must be shown on the erection drawings. The design of temporary propping systems should be in accordance applicable codes. Temporary propping should provide full support for all construction loads.

1.3 Precast Concrete Construction Procedure

- After the completion of construction preparations, the layout of the structure is set.
- Then, the foundation of the columns are constructed (Fig. 1)

Fig. 1.1: Foundation for Precast Concrete Columns

- After that, the columns are placed using suitable machines (Fig. 2), and continuously checked by surveyor for alignment (Fig. 3). In the case of Frame system and slab-column system with shear wall. Alternatively, precast panels are installed in the case of large panel system (Fig. 4).

Fig. 1.2: Final Adjustment and Installation of Columns

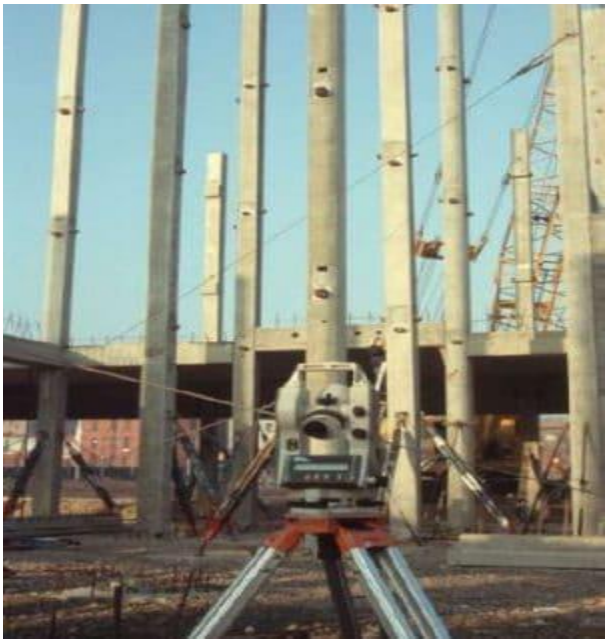

Fig. 1.3: Install Precast Concrete Columns

Fig. 1.4: Large Panel Precast Concrete System Construction

- Beams for precast frames (Fig. 5), and precast floors in the case of large panel systems (Fig. 6) and column-slab systems are placed.

Fig. 1.5: Precast Beam Erection

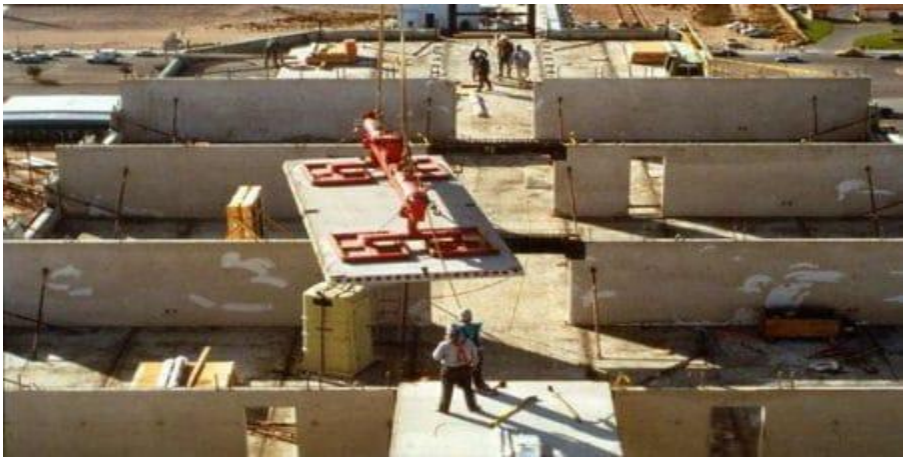

Fig. 1.6: Placement of Hollow Core Precast Concrete Slab on Walls

- For precast frames, after the installation of precast concrete beams, precast concrete floors are erected.

Fig. 1.7: Precast Concrete Slab Placement

- The above steps are followed until the construction is finalized. For each system of precast concrete construction, certain type of connections are used.

Self-Check -1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Safety during the handling and erection of precast concrete element is substantially importance.

A. True

B. False

2. Which of the following consideration of precast concrete construction.

A. Erection sequence

B. Temporary bracing

C. Erection safety

D. All

3. Which one is the first step of precast concrete construction procedure

A. Columns are placed

B. Preparation

C. Layout of the structure is set

D. All

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Short Answer Questions

2.1 Elements in Precast Concrete Building Systems

Precast concrete members are manufactured in factory under controlled conditions to keep standard dimensions and tolerances. Structural elements used in the construction of precast concrete buildings include:

1. Precast concrete wall (Panels), Fig.1
2. Precast Slabs, Fig. 2 and 3
3. Precast Beam and Girders, Fig.4
4. Precast Columns, Fig. 5
5. Precast Stairs, Fig. 6

Fig. 2.1: Precast Concrete Panel

Fig. 2.2: Hollow Precast Concrete Floor

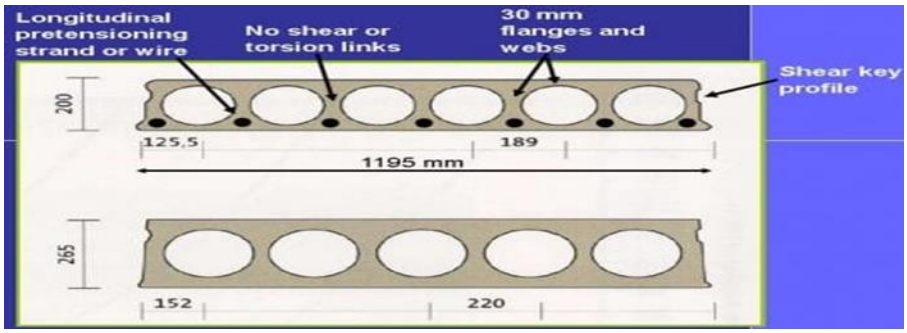

Fig. 2.3: Details of Hollow Precast Concrete Floor

Fig. 2.4: Precast Concrete Beam

Fig. 2.5: Precast Concrete Columns

Fig. 2.6: Precast Concrete Stairs

2.2 Types of Connections

1. Beam to Column Connections (Fig. 7, 8, and 9)

2. Column to floor connection (Fig. 10)

3. Panel to Panel Connections (Fig. 11 and 12)

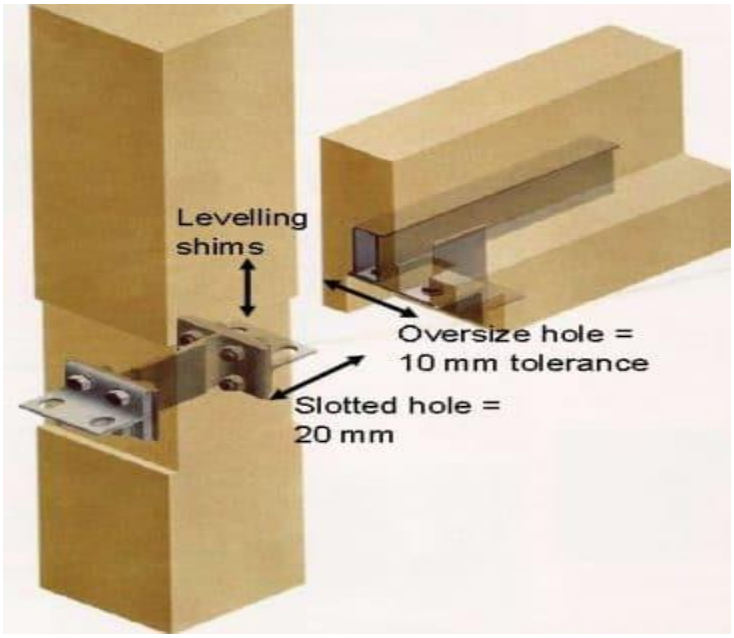

Fig. 2.7: Expensive but Safe Cleated Connector

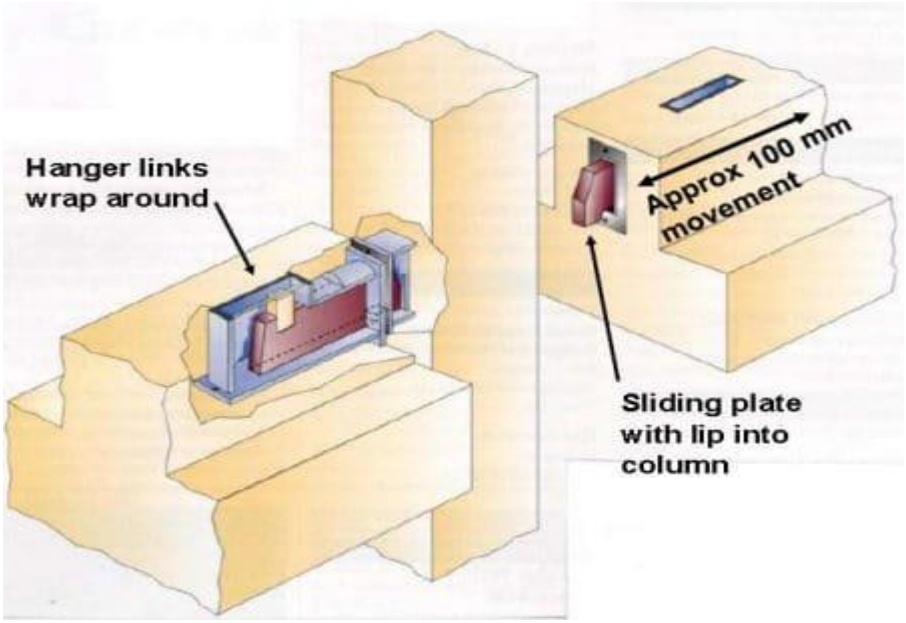

Fig. 2.8: Sliding Plate Connections

Fig. 2.9: Beam to Column Seated Connection

Fig. 2.10: Seated Connection

Fig. 2.11: Deep Nib Connection Between Walls Provide Large Complimentary Shear Stiffness and Strength

Fig. 2.12: Vertical Joint Using Deep Nib

Structural Stability

The stability of precast concrete structural systems are provided through bracing. There are number of techniques through which structures are braced, as illustrated in the following figure.

Fig. 2.13: Bracing Techniques

Self-Check -2	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Which one of the following is not types of connections
   A. Beam to column connection
   B. Column to floor connection
   C. Panel to panel connection
   D. None
2. Which is the element of structural unit?
   A. Precast slab
   B. Precast concrete wall
   C. Precast column
   D. All
3. Precast concrete members are manufactured in factor under controlled conditions is to not keep standard dimensions and tolerances.
   A. True
   B. False

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Short Answer Questions

Information Sheet-3	Erecting temporary propping

3.1 Propping and Support Details

Props are required for a variety of reasons to:

- Reduce the self-weight deflection of precast flooring systems while the cast-in-place topping concrete is placed and cured;
- Provide temporary gravity load support during construction. For example, where seating lengths are less than the specified minimum, or where the connection requires cast-in-place concrete or welding to provide permanent support;
- Resist wind loads and accidental side loads during erection;
- Prevent tensional instability or rotation of beams loaded along one edge;
- Provide fine adjustment of the precast element to the correct level while freeing the crane quickly for the next lift; and
- Support temporary construction loads that exceed the design capacity of any part of the structure.

Where the element requires propping, that requirement should be noted on the shop drawings.

Support details for precast elements include temporary shims, rubber or plastic bearing pads, leveling bolts or mortar pads.

Direct concrete to concrete, or concrete to steel bearing should be avoided unless some edge spelling and cracking is acceptable.

Precast floors exposed to the sun (for example the top levels of car parking buildings) require special consideration as the long term effects of thermally induced movements can cause severe spalling at the support.

Permanent grouting or mortar packing of precast concrete support points requires care and supervision to ensure that the requirements for strength and durability are met.

3.2 Temporary bracing

- Wherever possible bracing should be fixed to the element before lifting.
- When it is necessary to attach the braces after the element has been positioned, the element should be held safely by the crane whilst the braces are installed on the upper face by the use of a ladder or alternative access system.
- Generally, a minimum of two braces should be used for all elements.

Where elements can be effectively coupled together one central brace to resist rotation or toppling may be sufficient subject to design by a registered engineer.

- Braces shall be attached to a flat surface which is capable of withstanding the applied load.
- Bracing bolts should be checked at regular intervals and immediately after any occurrence such as an earthquake or storm.

Note: All equipment used in conjunction with the handling, transportation and erection of a precast element must be maintained to a high standard and be suitable for its intended use.

Fig. 3.1: Propping *Techniques*

Self-Check -3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. The purpose of temporary propping at erecting precast concrete structure unit.

A. Reduce the self-weight deflection

B. Provide temporary gravity load

C. Resist wind load

D. All

2. Temporary bracing should be fixed to the element before lifting

A. True

B. False

3. Which one is the following material is used to prepare the temporary propping.

A. Steel

B. Wooden

C. None

D. A&B

Note: **Satisfactory rating - 5 points** **Unsatisfactory - below 5 points**

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Short Answer Questions

Information Sheet-4	Pre-cast structural units erected to contract specifications

4.1 Erect pre-cast concrete unit

As true information before erection of precast

Precast concrete is a concrete w/c is cast in one place for use elsewhere and is a mobile material.

-Precast concrete units are erected by using the joints.

- **Erection**
  - ✓ Work to be performed by a Qualified Erector.
  - ✓ Install in accordance with shop drawings and manufacturer's recommended installation procedures.
  - ✓ All precast work until permanent connections and/or adjoining cast-in-place concrete work or masonry has been completed and the framework is stable.
- **Grouting**
  - ✓ After precast units have been placed and secured, grout open spaces at connections and joints between platforms and stairs, and between platforms and floor plank.
  - ✓ Place grout in a manner to finish smooth, plumb, and level with adjacent concrete surfaces.
- **Installation**
  - ✓ The manufacturer shall perform a field pre-erection survey prior to erection of precast Members. Any discrepancies shall be reported to the contractor as soon as they are discovered for correction prior to start of precast erection.
  - ✓ Work shall be executed by workmen skilled in this trade, set work plumb, true and Square with joints parallel and uniform, all in accordance with the approved erection drawings.
  - ✓ Components shall be anchored in final position by bolting and/or welding as shown on drawings.

- ✓ Clean up at the completion of the work, and at other such times directed by the Engineer, all rejected and surplus materials, rubbish and apparatus shall be removed from the project site.

4.2 Support and Anchorage Systems

Precast concrete panel connections are an important component of the envelope system. Precast manufacturers use numerous different types of anchors, which are often characterized as gravity and lateral connections.

The primary purpose of the connection is to transfer load to the supporting structure and to provide stability.

The criteria used to design precast connections include but is not limited to:

- Strength
- Ductility
- Volume change accommodations
- Durability
- Fire resistance
- Constructability

4.3 Types of Connections

- Hardware design for connections should take into account the tolerances for both the precast concrete components and the structure.
- These considerations may require clip angles and plates with slots or oversize holes to compensate for dimensional variations, field welding or sufficient shim spaces to allow for variations in elevation.
- Sufficient minimum clearance between precast units and structure should be provided to allow for product, interface and erection tolerances.
- Hardware should be designed to compensate for additional stress at maximum anticipated clearance.

✓ Bolted Connections

Bolted connections simplify and speed-up the erection operation, because the connection is positive immediately. Final alignment and adjustment can be made later without tying up crane time. Bolting should be in accordance with the erection drawings, using material specified by the designer.

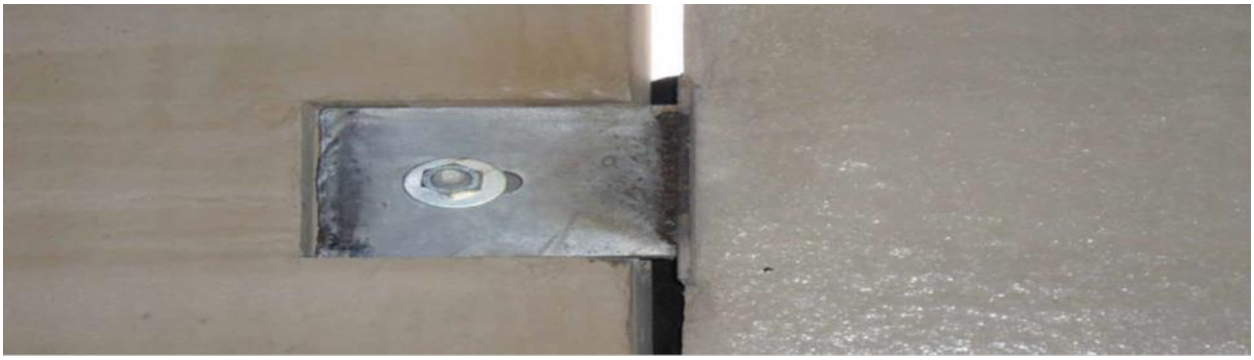

Fig. 4.1: Bolted Connections

- ✓ Welded Connections

Welded connections are the most common and typical connection used in the erection of precast concrete. These connections are structurally efficient and adjust easily to varying field conditions. The connections are usually made by placing a loose plate between two structural steel plates that are embedded both in the cast-in-place or the precast concrete panel and welded together. Some connections are designed to bend and yield in one direction while remaining rigid in all other directions. Welded connections should be installed exactly as shown on the erection drawings and details.

- ✓ Dowel/Anchor Bolt Connections

In a dowel connection, the strength of dowels in tension or shear depends on dowel diameter, embedded length and the bond developed. Good practice is to provide sufficient embedment to develop the full dowel strength. Threaded anchor bolts and rebar anchor dowels that protrude from the foundation are the critical first connection to precast members. Usually, this work is performed by a subcontractor not responsible to the erector. It is important that these items be placed accurately in both plan and vertical alignment.

4.4 From the element the structural unit part of the precast concrete is partially seen

1. **Column*:*** is very use full and essential vertical structure unit of the precast concrete. In precast concrete column to estimate the size of a precast column added up to the total roof & floor area supported by the column.

Where; 250mm thickness column can be supported up to the 185m^2

300mm thickness column can be supported up to the 240m^2

400mm thickness column can be supported up to the 370m^2

600mm thickness column can be supported up to the 740m^2

The value may be interpolated column in 50cm increments of size column are usually square.

- **Shape of stirrup in vertical precast concrete column**

In Ethiopian standard practical works Column are placed at d/c position of structure

- ✓ At corner
- ✓ At center (intermediate)
- ✓ At c cross center
- ✓ At end (not corner) in Ethiopian standard the groove teeth should be at least 60mm depth inside to the column and the groove width of column also 60mm.

2. Slab (floor): types slab floors commonly used

- **Precast solid slab floor**: a concrete slab with out ribs or voids that span b/n beam or bearing wall
- **Precast hollow core slab**: that has internal longitudinal cavities to reduce its weight
- **Single tee:** a precast slab element whose profile resembled the letter T
- **Double tee:** a precast slab element that resembled the letter TT in cross section

- ✓ *In Precast solid slab floor***:** depth is 1/40of its span of slab may minimum from 90mm-200mm
- ✓ *In Precast hollow core slab floor*: span is in 250mm thick slab up to 7.6m-8m
  300 mm thick slab up to 9.8m-10m
  350mm thick slab up to 12m

Example: of solid slab floor &hollow core slab floor are below the picture

3. Beam: same information of beam is currently used is

Depth of beam 1/12 their span is fore carry heavy load

Depth of beam 1/15 their span is fore carry light weight load

The width of beam is usually about ½ it depth it depth means up to 150mm-300mm deep

In Ethiopian standard currently used see you below the following pictuThey are d/c

types of beams their by size, strength & popular in Ethiopia & other worlds.

From those types of beams based of shapes is partially.

4. Precast wall: is used as a building block unit or used as masonry units.

Precast solid slab are common used as a load bearing wall panels in many types of low rise and high rise buildings.

Precast wall is used at opening & enclosed area

The size of precast wall at door & windows

length1250mm

Width 300mm

Depth 50mm is commonly used in Ethiopia

The size of precast at whole direction of enclosed area

Length 1300mm

Width 300mm

Depth 50mm is commonly used in Ethiopia

Precast wall is jointed with column but the load type is not distribution load as a masonry unit b/c the load is transfer one to the other next course vertically down this is called **concentration load.**

NB the thickness of wall must be inter locked with the column joint based on specification and designer.

5. Stair case: ideally the delivery precast stair should be arranged to that they can be lifted , positioned & fixed direct from the delivery vehicle thus avoiding double handling precast in stair case **a**re usually designed for two condition.

- For lifting & handling
- Final fixed condition

6. Bridge beam: production precast prestresed beam is a factory provide a guarantee of high quality production, durable, high standard dimension accuracy as well as saving false work.

Products for use in bridge span are **12-40metrs**. Includes beam a variety of design (arrangement) for either close or open soffit bridge for medium & long span major road span.

***"M" Beam Bridge*:** provides deck or floor pseudo box for medium & long span road bridge construction.

***"Y" Beam*:** series provides an opens soffit solution for medium & long span major road bridge construction.

***"supper Y" Beam*:** provide for the longest span major motor way schemes providing an economical solution for up to 40m span.

***"T" Beam*:** are available for use in short & medium span. Bridge, car park, jetties and heavily loaded structure.

It is rapidly erected alternative to a wholly or totally or completely in situ slab.

Beam: w/c by forming strong box section in combination with the in situ slab provides for torsion force in skew bridge construction.

"Edge beam" is used commonly is an standard beam, single beam, double tee beam used for foot bridge. Example: foot bridge construction.

Floor & roof for building & car parks

Seating elements & rams in guarantee& staid

Connections with in the structure are made by welding plates at the bearing position and at adjoining flanges.

7. <u>Sea defense unit</u>: is may be constructed at sea and ocean. From these type

- **Dolls unit**: These concrete elements covered by patent are of the form of a ***"twisted H"*** one leg of the **"H"** is set at 90^0 to the other. The element cast with each legs of the horizontal & the bar of the ***"*H *"***vertical.
- **Shed unit**: these proprietary sea defense elements take the form of cube with a hollow concrete. Each faces is pierced so than when set in to place in element stifle the face of waves on a shore. The elements are cast in steel mould the side of w/c carry profiles to form the piercing in the face. The central voids is formed by all inflatable former w/c can be simply deflated for stripping purpose.
- **walling unit:** sea wall elements provides a smooth wave breaking protection for the shore line, contracts generally requires large no of elements & they are cast from steel or concrete mould either cast on edge or reversed to accommodate the geometry. Precast face down ensures a dense wall compacted durable surface.
- **Piles:** pestered piles are cast on long line beds, shoes & capes. Acting distribution plates locate the wire or strand (as a fiber string).

In case of major civil engineering work such as power station contracts have set up site

casting facilitate employing concrete mould b/n gravity abutment.

Ready mixed concrete has been used to good advantage the delivery vehicles discharging directly into the mould.

Where reinforcement concrete piles are cast in concrete moulds, rings, comprising pump, & hydraulic jacks have been used in pairs at the lifting points to to jack the pile sufficiently to break the bond at the concrete / mould inter face/

These types of pile are in a yard, cured & then driven in to the ground. Generally precast concrete pile is of square, section with chamfered corners, octagonal section or round section. While driving these piles in to hard soil cast iron or mild steel shoes are provided at the lower end.

The concrete mix is may be up to 1:2:4.

The size of pile may be 25-60mm

The length may be from 3-30m they are cast with out taper with the point lower end never more than 2cm per length of the pile

The diameter vertical reinforcement steel bars 20mm

The diameter lateral reinforcement steel bars5-10mm

The center of spacing to lateral tie about 10cm -30cm

A concrete cover pile is 50mm & the form works are removed after 3 days.

For convenient handling of piles some special devices are used. Cast iron bolts fixed in to plate are cast in the pile at the point of lifting

Advantages of precast concrete pile

- The reinforcement is maintained in the correct position
- Driving of such piles is easer in soft or wet soil the driving of adjacent piles does not produce any additional stresses in the pile.
- This pile can be driven under water also.
- Defect of casting may be examined & repaired before driving the pile.
- Such types of piles have high resistance to biological& chemical action of the ground.

Disadvantages of precast concrete pile

- This piles are very heave & difficult to transport
- A weaker joint is formed in case of lapping additional length. On the other hand material wasted if along pile is to be cut to size.
- The shocks & vibrator render them weaker.

8. Railway sleepers: same sleepers manufactured in other countries in individual moulds implying post tensioning techniques but all manufactures in the UK is in gang formation 6 or 8 elements wide on heated line. Quantities of concrete cast in each shift are high and placement & compaction are carried out by a casting machine.

9. Box culvert: is usually used b/c of progress of construction work in the ground depending to a great deal on resolution of problem of support drainage & contingencies.

Example in situ constructer has first to excavate & level the base then place hard core , blind concrete then installed membrane , if specified prior to side forms reinforcement & stop end member pierced by continuities steel & all this work carry out in the prevailing weather condition. So use of precast elements provides solution to these problems.

Using Box culvert with hard base prepared installation proceeds, element being placed by crane from the delivery vehicle then lined & leveled. Final jointing is archived

by winching units to close the joints; jacking techniques are employed in constructing under passes & culverts. The element being driven as the ground is excavated as in tunneling with a shield.

Box culverts are usually cast on and around a central collapsible form to facilities concrete placement.

External vibration is applied as the concrete is distribution evenly around the four sides of the unit. The whole mould is covered down for curing purpose. After stripping the element are turned in to the service potion for delivery.

10. Retaining wall unit: Steel moulds are used in production the element being cast in edge for ease of placement & compaction. To facilitate handling at site. Holes are formed the upright limb of the element.

11. Tunnel segment: is cast to extremely demanding level of accuracy b/c in service the physical form of the element grantees the final geometry to the tunnel.

Self-Check -4	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Pre-cast concrete unite are erected by using the joints

A. True

B. False

2. ---------- is after pre-cast units have been placed and secured, fill open spaces at connection and joints.

A. Erection

B. Grouting

C. Installation

D. Cladding

3. Which one are the criteria used to design pre-cast connections.

A. Strength

B. Ductility

C. Fire resistance

D. All

Note: **Satisfactory rating - 5 points** **Unsatisfactory - below 5 points**

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Short Answer Questions

Operation Sheet 1	Positioning structural units

Procedures for positioning structural units

Step 1- wear PPE.

Step 2- set the layout of the structure

Steps 3- construct the foundation of the column

Step 4- place column by using appropriate machine

Step 5- continuously check the alignment

Step 6 – position pre-cast structure unit

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Operation Sheet 2	Fixing structural units

Methods for fixing structural units

Step 1- wear PPE.

Step 2- select methods of fixing

Step 3- check alignment

Step 4- fixe the positioned pre-cast structure unit

Operation Sheet-3	Erecting temporary propping

Techniques for erecting temporary propping

Step 1- wear PPE.

Step 2- select required materials

Step 3- select required tools and equipment

Step 4- installs temporary propping

.

Operation Sheet-4	Erecting pre-cast structural units as to contract specifications

Techniques for Erecting pre-cast structural units as to contract specifications

Step 1- wear PPE.

Step 2- select required materials

Step 3- select required tools and equipment

Step 4- check alignment

Step 5- select types of connection

Step 6- erect pre-cast structural units

LAP Test	Practical Demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within --- hour.

Task 1. Position structural units

Task 2. Fix structural units

Task 3. Erect temporary propping

Task 4. Erect pre-cast structural units as to contract specifications

Reference

- Different website like the contractor civil engineering .com
- Internet
- Christian Meuli Karl Wehrle Heini Müller Heini Pfiffner Volume 3

Name trainers who prepared the material

N0	Name	Qualification	Region	E.mail
1	Tesfaye Assegidew	MSC in CoTM	SNNPR	tesfayeassegidew@gmail.com
2	Habtamu wendmagegn	Bsc in Civil Eng	Dire Dawa	Joniyitna9@gmail.com
3	Yazachew Geneti	Msc in CoTM	BGRS	0917858176
4	Gebresilasie Jemal	Bsc	Addis Abeba	Gebrajemal@gmail.com
5	Getachew Mohammed	MSC in CoTM	Amhara	Gerimom07@gmail.com
6	Kibryisfaw Tulema	Bsc in	Somalie	kibrutulema@gmail.com