Question 1. (15p)

1.1 Explain the role of compaction in the production of concrete structures. Which are consequences if the compaction is a) inadequate and b) too effective? Which factors are affecting the required compaction time?

1.2 Your task is to investigate the quality of hardened concrete structure. What are the factors affecting the estimated strength of hardened concrete in structure?

1.3 You are responsible for casting of massive foundation structure (10 * 10 * 3 m^3) in July in Finland. Present your choices to keep the concrete temperature during hydration below +60 °C.

Answer question 1 here and use the same numbering

1.1 Compaction

- Compaction of concrete is one of the important site operations that enable the fresh concrete to reach its potential design strength, density and low permeability
- Expelling the entrapped air from the concrete
- 1% air in the concrete approximately reduces the strength by 5%.
- If we don't expel the entrapped air, it will result into honeycombing and reduced strength

- **Over-vibration** – may cause problems when grossly oversized equipment is operated for an excessive length of time, but is more likely to cause problems with poorly proportioned mixes or those to which excessive amounts of water have been added.
- **Under-vibration** – is far more common than over-vibration and, when it occurs, can cause serious defects. Invariably, the concrete is incompletely compacted which reduces its strength, its durability and possibly adversely affects its surface finish.

- factors are affecting the required compaction time:
    - vibration equipment
    - workability of concrete (Slump and flow table classes)
    - Air entraining of concrete

1.2 Quality control

- Production at concrete plant (quality of material) - raw materials, mix design (w/c-ratio, …), equipment (scales,…), production control (mixing time, calibration of consistency, …), hauling of concrete
- Excecution of concreting works at the site
    - Adjustments of fresh concrete properties at site

  - Casting (thickness of layers, free-fall height, …)
  - Delayes while casting
  - Compaction
  - Curing (humidity, temperature)
  - Maturity of concrete
- Quality control and testing
  - Test method (rebound hammer, compressive strength test etc.)
  - Sampling and equipment, Sampling rate, locations, Preparation, handling and storing of the samples
  - Analyse of results

1.3 Massive structures – choices to keep the concrete temperature during hydration below +60 °C

- **Suitable materials for mass concrete**
  - Cement with low C3S and low C3A and less amount of cement
  - Fly ash and slag can reduce the heat of hydration
  - Aggregate with low coefficient of thermal expansion
  - Replace part of water with ice and use liquid nitrogen
- **Placement Techniques**
  - (Using of Insulating forms) affects mainly on temp. differences
  - Cast concrete at night / early morning
  - Pre-cooling aggregate and cement
  - Casting in thin layers (~ 450 mm)
  - Providing joints (for expansion and movement)
- **Post-Placement Techniques**
  - Post cooling – embedded pipes

Question 2. (15p)

2.1 What are the major advantages and also disadvantages of pre-cast concrete elements compared to cast-in-situ structures?

2.2 When building an apartment building in Finland, for which structures you would select pre-cast elements and which structures you would produce cast-in-situ? Justify shortly your choices.

2.3 Explain (*shortly*) the manufacturing process of hollow core slab elements. Also explain a solution for bathroom areas when hollow core slabs are used.

Answer question 2 here and use the same numbering

2.1 Pre-cast vs. in-situ

- **Pre-cast concrete.**

advantages	disadvantages
• Entire building can be precast-walls, floors, beams etc. • High quality. • Flexibility in use. • More durable • Optimum use of materials • Protection of environment.	• Very heavy members. • Connections between elements may be difficult. • Somewhat limited building design. • Joints between elements are often expensive and complicated. • Cranes are required to lift elements.

- **Cast in site concrete.**

advantages	disadvantages
• Limitless flexibility of shape and size. • Wide variety of surface and textures can be achieved. • Homogeneous connections.	• Needs high labour and plant on site. • Formwork is time consuming. • Quality control is difficult.

2.2 Apartment building in Finland

- pre-cast elements
  - External walls
  - Floors
  - Internal load bearing walls
  - Balconies

  - Stairs and lifts
  - Internal non-load bearing walls
  - Columns and beams
- cast-in-situ
  - Foundation

2.3 manufacturing process of hollow core slab

- Production cycle 6-14h
  - Cleaning beds
    - Casting beds are cleaned from old concrete
    - Mould oil to surface of the bed
  - Pulling strands
    - Several strands pulled to about 1000 MPa (about 50 cm pulling with 100m strand length)
  - Extruding hollow core or slip forming techniques
    - Semi dry concrete low water/cement ratio to reach C50/60 or higher strengths
    - Automated concrete transport
    - Water to smoothen bottom surface (with mould oil)
    - Machine operator draws according plans
    - No additional side supports needed for the slab
    - Openings are drilled manually to wet concrete
  - Solution for bathroom areas
    - Hollow cores can be also stamped for suitable platform to bathroom piping etc.
    - Very used in residential markets
  - Sawing
    - After designed curing time hollow core slabs are cut to the preferred length
    - Also, diagonal cuttings are possible
  - Lifting
    - Sawed hollow core slabs are lifted from moulds to drilling station
    - Every slab gets drilled holes to remove excess water to prevent freezing and other moisture problems
    - Ready elements are lifted to predesigned loads
  - Storing
    - Elements are lifted to legs or under crane waiting for construction site delivery
    - Leg-system benefit is that truck can drive under loads without any other lifting

Question 3. (15p)

1. wet or dry shotcreting method

- Wet shotcreting process:
  - Step 1: All ingredients, including water, are thoroughly mixed and introduced into the shotcrete equipment.
  - Step 2: Wet material is pumped to the nozzle where compressed air is introduced
  - Step 3: Mostly wet-process shotcreting is done with premixed mortar or small aggregate concrete.
- Dry shotcreting process:
  - Step1: Pre blended, dry or semi-dampened materials are placed into shotcrete equipment and metered into a hose.
  - Step2: Compressed air conveys materials at high velocity to the nozzle where the water is added.
  - Step3: Then the material is consolidated on receiving surface by high impact velocity.

2. the most common methods of under water concreting?

- Placing in dewatered caissons or cofferdams (normal in-the-dry practice)
- Tremie method (the use of tremie pipes is convenient for casting large amount of high flowable concrete)
- Grouted aggregate method (includes placing aggregate in the forms then injecting concrete into the bottom and filled the forms to the top)
- Bucket placing – skips method (suitable for cases where small amount of concrete is needed for different locations)
- Placing in bags
- Pumping technique

3. typical work phases of slip form construction

- Prefabricating a slipform or utilizing existing forms
- Installation of the slipforms
- Actual slip casting phase (24 hours per day)
  - ➢ Reinforcement
  - ➢ Installation of openings, steel plates and other embedded items
  - ➢ Concrete casting
  - ➢ Finishing of concrete surface and after care treatment
  - ➢ Slipform raising (raising speed typically 3 – 7 m/24 hours according to application)
- Raising the slipform up and support it on the casted wall
- Removing of lifting rods and filling of holes if needed
- Slipform removal

Question 4. (15p)

Select the right statement and justify your answer
(Notice: points are given for the right selection and justifying the answer)

4.1 Statistical quality control of concrete helps

a) in narrowing down the tolerance limits of variability
b) in taking into account the actual variability of concrete (Notice the word STATISTICAL which investigates the variability of concrete)
c) to ascertain the range of value that can be expected under existing conditions
d) All of the above

4.2 The mixing time of concrete:

a) is the time required to produce uniform concrete
b) is counted from the instant when all the solid materials have been put in the mixer (Min. mixing time = 1 min for 1m³ + 15 sec for each additional 1 m³ from adding the dry materials to the mixer)
c) is independent of the number of revolutions
d) may be ignored in favor of number of revolutions
e) All of the above.

4.3 Identify incorrect statement(s):

a) The formwork may be defined as moulds of timber or some other material into which the freshly mixed concrete is poured at the site and which hold the concrete till it sets.
b) The formwork includes the total system of support of freshly placed concrete, i.e., form lining and sheathing plus all necessary supporting members, bracings, hardware and fasteners.
c) The main objective of formwork is the smooth and esthetically attractive external surface of concrete (wrong objective for formworks).
d) In addition to forms being of right size, a good formwork should be strong, stiff, smooth and leak proof.

4.4 While using vibrators for compacting concrete mixes:

a) vibrators are used for spreading concrete in the form
b) vibrators reduce entrapped air from concrete (The objective of compaction is the expelling the entrapped air from the concrete. 1% air in the concrete approximately reduces the strength by 5%. If we don't expel the entrapped air, it will result into honeycombing and reduced strength)
c) vibrators cause smaller and lighter constituents to rise to the surface and give better finish
d) prolonged vibration reduces chances of segregation
e) all of the above

4.5 In cold weather concreting it is recommended to:

a) heat the water for mixing
b) use insulating formwork and delay its removal
c) use additional quantity of cement
d) use air-entraining agents
e) All of the above (heating water will increase the initial concrete temperature, form insulation will protect the concrete against freezing, addition cement will increase the hydration heat and AEA is recommended to protest the young concrete against freezing after ending of the heating) – Notice that AEA is compulsory for XF exposure class, but recommended during cold weather casting.