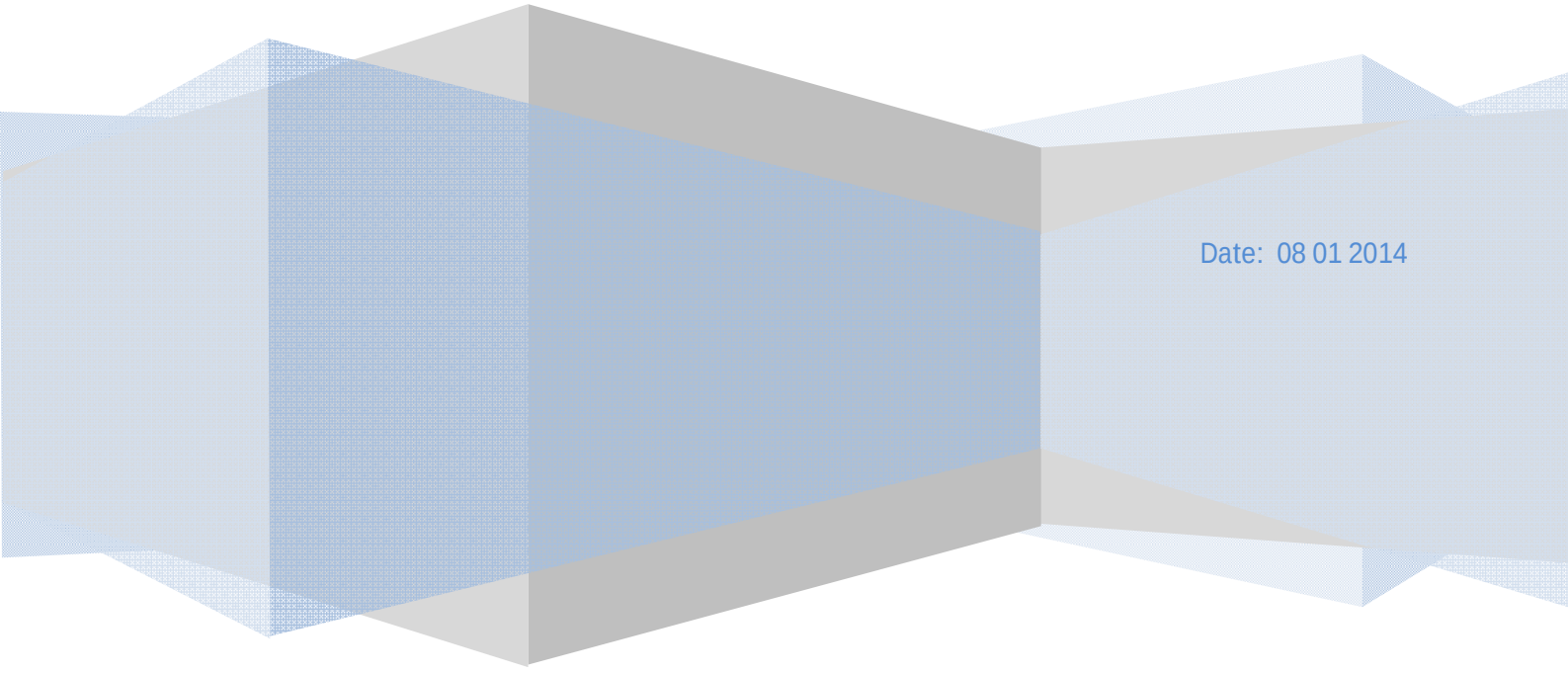
پێشکەشە بە یەکێتی ئەندازیارانی کوردستان

Precast Concrete

Brief Report about Precast Concrete Technology

Sirwan Hama Amen Qadir



Date: 08 01 2014

Table of Contents

General

Precast concrete products are a factory-made pieces manufactured with concrete and which, later, together with other pieces, will become part of a larger structure. Precast concrete elements are prepared, cast and hardened at specially equipped plants with a permanent location. Once a precast concrete product is produced and all the undertaken quality controls satisfactory, the unit is stored until delivery. It is then transported for use at another site.

Precast concrete is a highly versatile construction material that offers impressive design flexibility, energy efficiency, rapid installation and cost savings, among other notable benefits. New admixtures, concrete mixtures, fabrication techniques, and other innovations continue to change and expand the applications of the material and its benefits to owners, designers, engineers, contractors, and end users.

Buildings have been built in one place and reassembled in another throughout history. Ancient Roman builders made use of concrete and soon poured the material into moulds to build their complex network of aqueducts, culverts and tunnels. Modern uses for pre-cast technology include a variety of architectural and structural applications featuring parts of or an entire building system.

In the modern world precast paneled buildings were pioneered in Liverpool, England in 1905. A process was invented by city engineer John Alexander Brodie, whose inventive genius also had him inventing the football goal net. The tram stables at Walton in Liverpool followed in 1906. The idea was not taken up extensively in Britain, however was adopted all over the world, particularly in Eastern Europe.

Precast concrete offers an almost endless variety of products and design options for both above-ground and underground construction. From the largest infrastructure projects to the smallest architectural details, precast is one of the most versatile and sustainable building materials available for today’s fast-paced, environmentally conscious construction.

The production process for Precast Concrete is performed on ground level, which helps with safety throughout a project. There is a greater control of the quality of materials and workmanship in a precast plant rather than on a construction site. Financially, the forms used in a precast plant may be

reused hundreds to thousands of times before they have to be replaced, which allow cost of formwork per unit to be lower than for site-cast production. There are many different types of precast concrete forming systems for architectural applications, differing in size, function and cost. Precast architectural panels are also used to clad all or part of building facade free-standing walls used for landscaping, soundproofing and security walls and some can be prestressed concrete structural elements.

There are a few Reasons why precast concrete continues to grow in popularity among engineers, architects and specifies:

Strong and Growing Stronger

The strength of precast concrete gradually increases over time. Other materials can deteriorate, experience creep and stress relaxation, lose strength and deflect over time. The load-carrying capacity of precast concrete is derived from its own structural qualities and does not rely on the strength or quality of the surrounding backfill materials.

Easy Install

Although precast concrete is quite heavy, nearly all other competing materials require machinery for handling and installation as well. Speed of installation is more dependent on excavation than product handling and placement. Unlike other materials such as fiberglass, precast concrete does not require the use of special rigging (such as fabric slings) to avoid structural damage.

Lower Lifetime Costs

Precast's superior strength means that installation is often easier, quicker and less costly. It also requires less ongoing maintenance and a reduced likelihood of future problems. That means a lower total cost over the life cycle of a project.

Get the Job Done Fast

Precast concrete products arrive at the job site ready to install, which can save weeks over cast-in-place construction. Precast reduces the need for skilled labor on site and decreases the footprint. There is no need to order raw materials such as reinforcing steel and concrete, and no time wasted setting up forms, placing reinforcement, pouring concrete and waiting for concrete to cure.

Staying Power

Studies have shown that precast concrete products can provide a service life in excess of 100 years. For severe service conditions, additional design options are available which can extend the life of the precast concrete product.

This is extremely important when calculating life cycle costs for a project. Precast concrete also resists most substances. While no material is completely immune to attack from aggressive chemical agents, precast products can often be designed to resist corrosion in specific applications.

High Quality

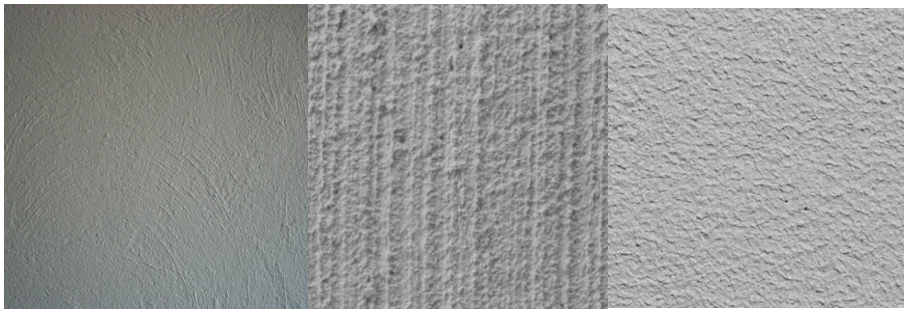
Because precast concrete products typically are produced in a controlled environment, they exhibit high quality and uniformity. Variables typically affecting quality on a job site – temperature, humidity, craftsmanship – are closely controlled in a plant environment.

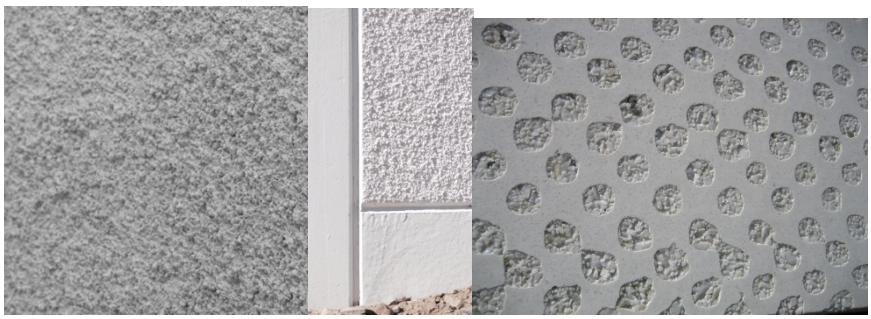
Water tightness Comes Standard

Precast concrete products manufactured in a quality-controlled environment and used with high-quality sealants offer a superior solution to water tightness requirements. Standard watertight sealants are specially formulated to adhere to precast concrete, making watertight multiple-seam precast concrete structures possible.

More than Good Looks

Precast concrete products are both functional and decorative. They can be shaped and molded into an endless array of sizes and configurations. Precast concrete can also be produced in virtually any color and a wide variety of finishes (acid-etched, sandblasted, smooth-as-cast, exposed-aggregate) to achieve the desired appearance for building and site applications. You are limited only by your imagination.





Precast concrete provides:

- **Design & aesthetic flexibility:**
  Long-span capabilities allow for greater open interiors. And precast concrete offers a variety of colors, textures and finishes, and can mimic masonry products like brick, granite, and limestone.
- **Durability:**
  Precast concrete is extremely impact and stress resistant, revealing minimal wear over time.
- **Rapid construction:**
  Superstructure components can be cast while foundation work is in progress.
- **Year-round installation:**
  Plant manufactured precast concrete components can be cast and erected year-round without delays caused by inclement weather.
- **Energy efficiency:**
  Precast concrete products have a high thermal mass, which can be further enhanced by the use of insulated foam core panels.
- **Safety:**
  This noncombustible material can meet fire-code provisions without additional design or spray-on fireproofing material. Precast concrete also maintains its structural integrity even when subjected to the intense heat of a fire.
- **Sustainable design:**
  Precast concrete naturally minimizes energy consumption and is a product certified by the U.S. Green Building Council (USGBC) as part of the Leadership in Energy & Environmental Design (LEED) program.

Some examples of precast products:

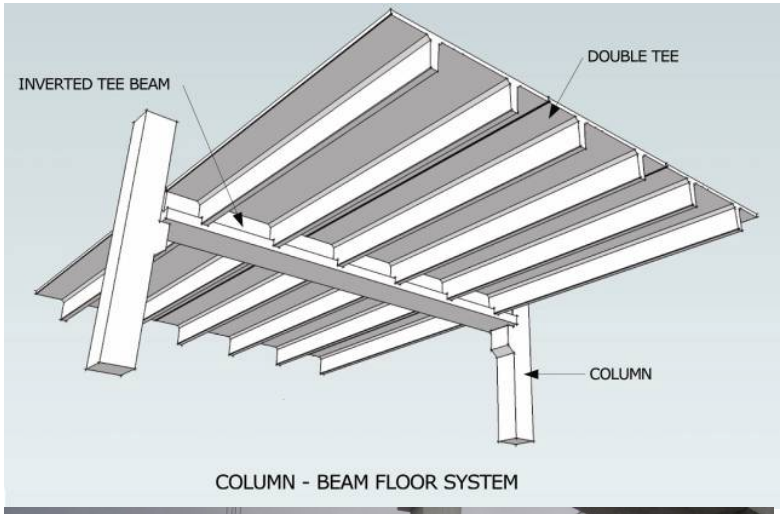
1. **Foundation-piles:**

There are many reasons a geotechnical engineer would recommend a deep foundation over a shallow foundation, but some of the common reasons are very large design loads, a poor soil at shallow depth.Deep foundations can be made out of timber, steel, prefabricated reinforced concrete and prefabricated prestressed concrete.Piles are generally driven into the ground in situ.

2. Beams & columns:

There is a variety of prefabricated structural beams and columns.Square or rectangular precast columns are commonly used to support beams, spandrels, and panels. Usually cast as multilevel components, precast columns can range in length from a single story to six or more levels.
Structural beams, including rectangular beams, L-beams, and inverted tee beams, are used to support horizontal deck components such as double tees and hollow-core slabs.

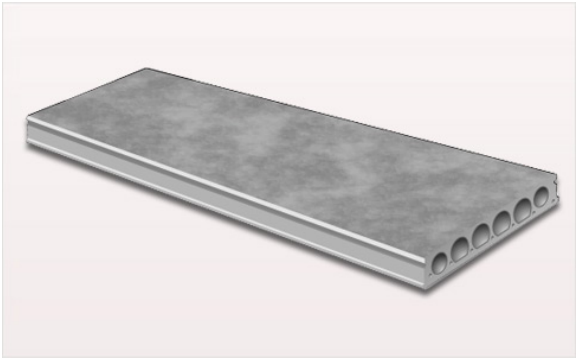
We can reinforce both beams and columns with either prestressing strand or conventional reinforcing bars for greater strength and support.

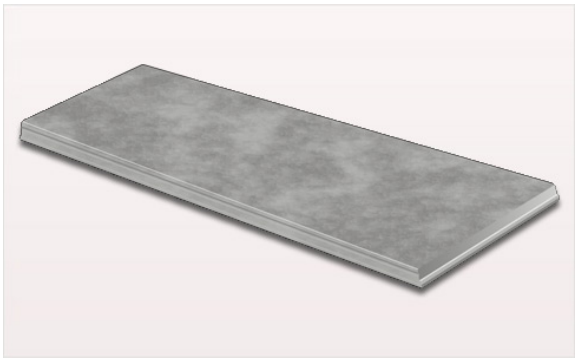


COLUMN - BEAM FLOOR SYSTEM

3. **Massive & hollow core floor slabs:**

Massive concrete plates and hollow core planks (or hollow core slabs) are typically used as floor/wall components in a wide range of building types. Long hollow cores, or voids, run the entire length of each piece and can be used to run mechanical and electrical equipment.With the benefit of prestressing and low self-weight longer spans can be achieved for the same loads or greater loads for the same depths.





4. **Wall-panels, solid or as a sandwich:**

Designed as load bearing or non-load bearing, precast concrete wall panels can be used as architectural, structural, or combination elements within a building's design. There are different types of panels such as solid wall panels, insulated wall panels, and acoustical sound walls.

5. **Roof-elements:**

6. **Balcony:**

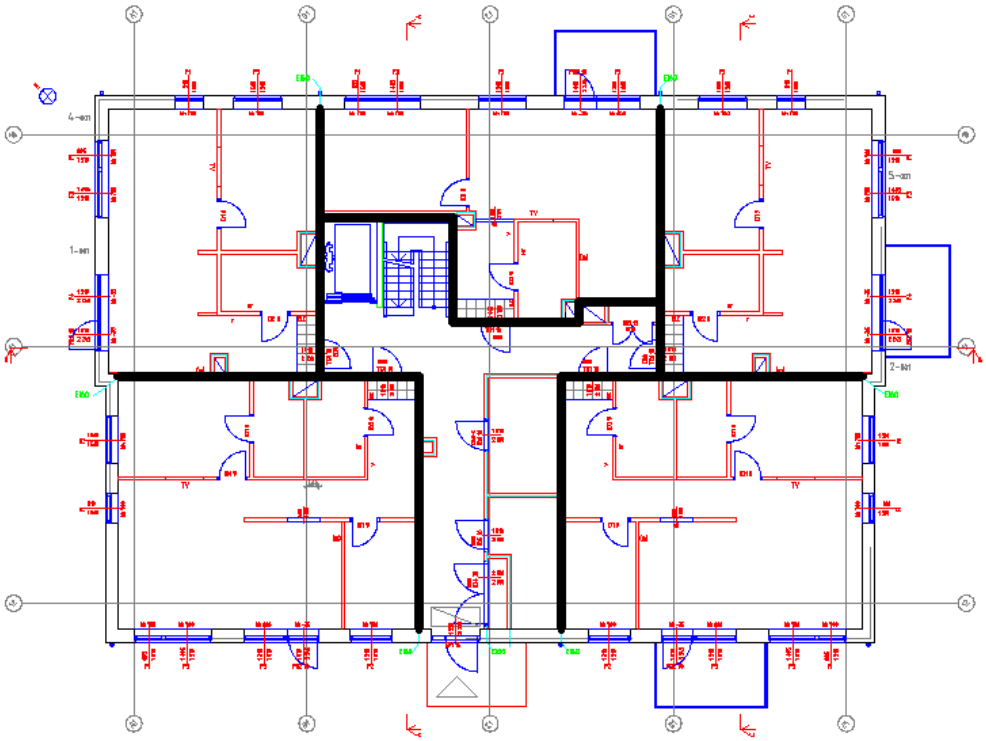
Having a well-designed balcony helps to change the face of how a building will look and it can be designed and carefully detailed in different types and sizes.

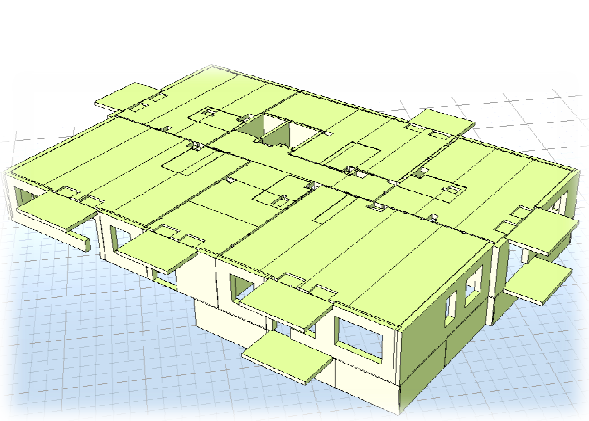
7. **Special products such as stare cases and foundation elements:**

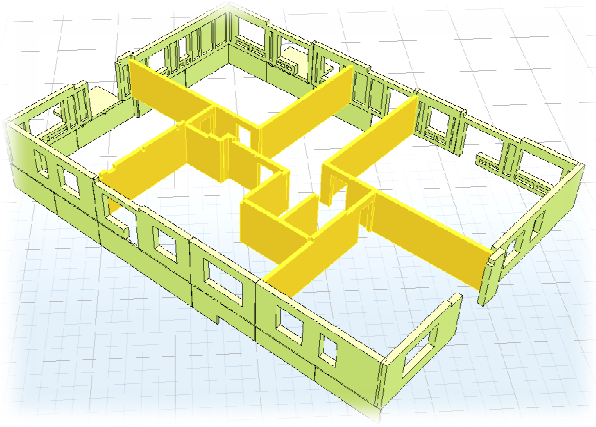
Building with precast, method for a simple house:

We will briefly describe the technology behind how we can build a house with prefab technology. Building with precast differs from site-built structures, we can simplify the method by comparing it when we are trying to build a toy by fitting the parts together and make sure that the structure is stable against external influences, for example, in our case, wind load and snow load.

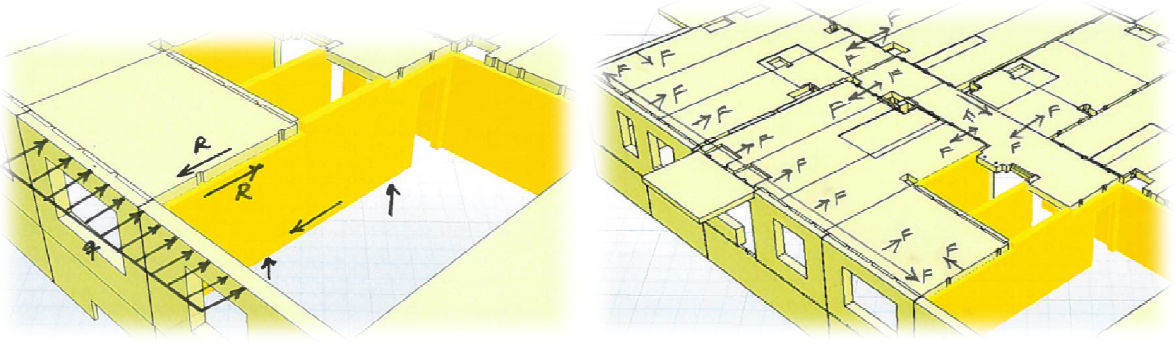
The first thing we start with when we build a house with prefab technology is the stability of the structure. We need to decide which elements in the building should stabilize the structure, it is very important to choose the right number of elements in the current directions and ensure that the links between these elements and the slab are done in such a way so that the loads can be transferred to the foundation.







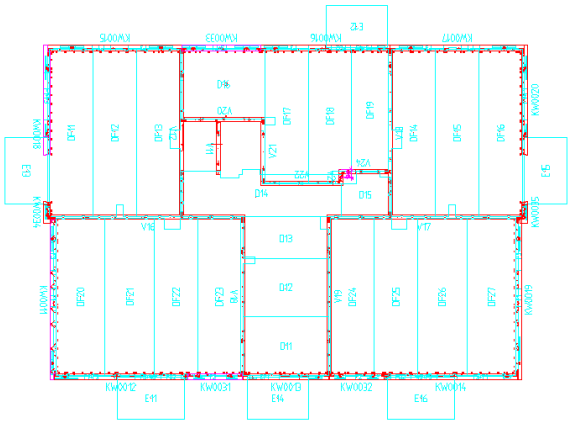
Horizontal forces such as wind loads will be transferred to the ground through the external wall panels and further to the slab in the current floor. The slab will transfer those shear forces to the internal wall panels and further to the ground.Joining forces must be created through connections between walls and floors.

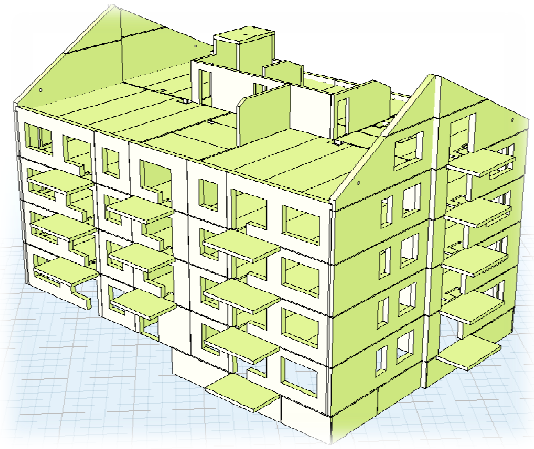


The slab elements have to be interconnected with each other by using reinforcement in the joints between them.

Next step is that we break down the structure, all the walls and the floors, to a number of elements and solve all the details and joints needed to tie these elements together again in order to get back the structure.

We have to choose suitable sizes for the elements which are possible for production, transport and assembly.





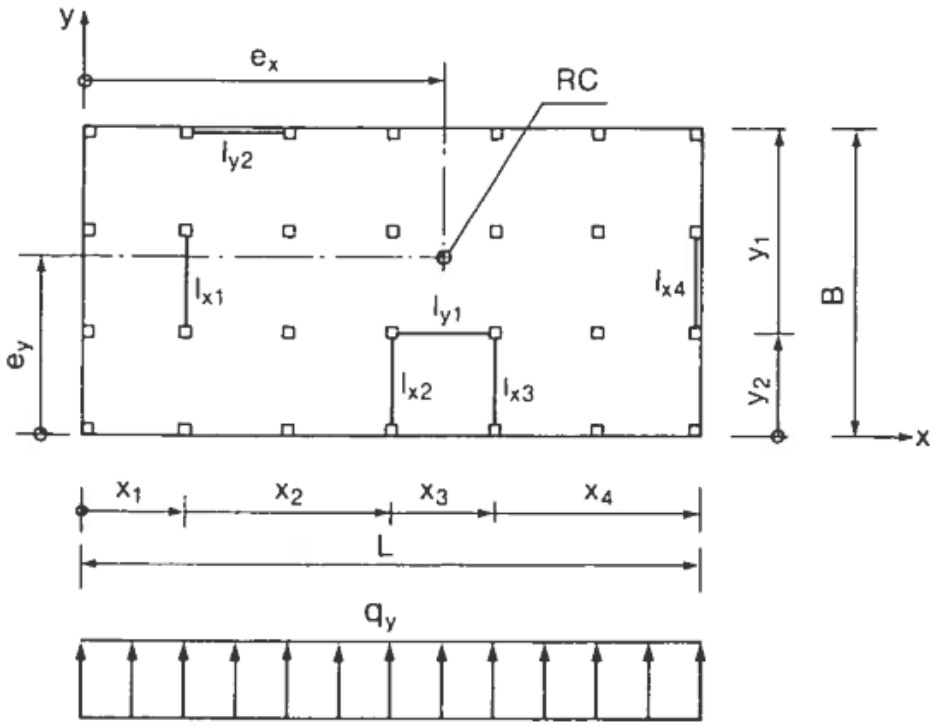
Location of the elements on plan drawing

3-D model

Stability

The stability and the distribution of horizontal forces can be calculated by using either structural calculation software/computer or hand calculation. For more complex and tall buildings the calculations should be made by computers in order to study the deformations and Eigen frequency more carefully and obviously with regard to earthquake in some countries.

For a simple structure as shown below, the load distribution for the horizontal forces can be calculated with the equations below:



$$Q_{xi} = q_y \, L \, (e_x - \frac{L}{2}) \frac{r_{xi} I_{yi}}{\sum r_i^2 I_i} \qquad r_{xi} = e_x - x_i$$

$$Q_{yi} = q_y \, L \, [\frac{I_{xi}}{\sum I_x} + (e_x - \frac{L}{2}) \frac{r_{yi} I_{xi}}{\sum r_i^2 I_i}] \qquad r_{yi} = e_y - y_i$$

$$\sum r_i^2 I_i = K$$

$$e_y = \frac{\sum y_i * I_{yi}}{\sum I_{yi}} \qquad e_x = \frac{\sum x_i * I_{xi}}{\sum I_{xi}}$$

$$\kappa = \sum (e_x - x_i)^2 * I_{xi} + \sum (e_y - y_i)^2 * I_{yi}$$

q_y =horizontal load / unit length [KN/m]

Q=horizontal load / stabilizing unit (each wall panel)

Control of stability for inernal wall panels for a single elevation:

f_{cc} = Concrete compression strength

For the stability of the wall following condition must be satisfied:

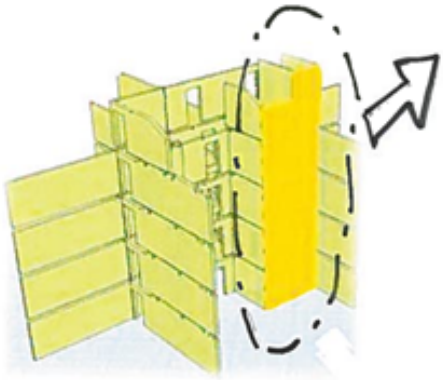
$$M_d \leq \frac{(l-x)}{2} * N_d$$

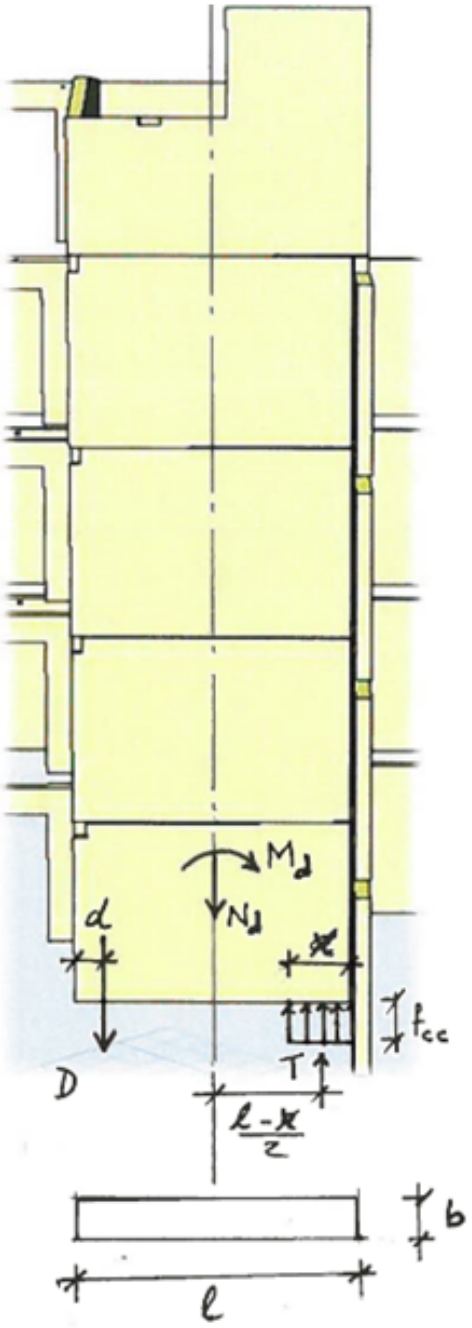
Otherwise we have to calculate tensile force D that has to be anchored to the foundation

$$M_{tot} = M_d + (\frac{l}{2} - d) * N_d$$

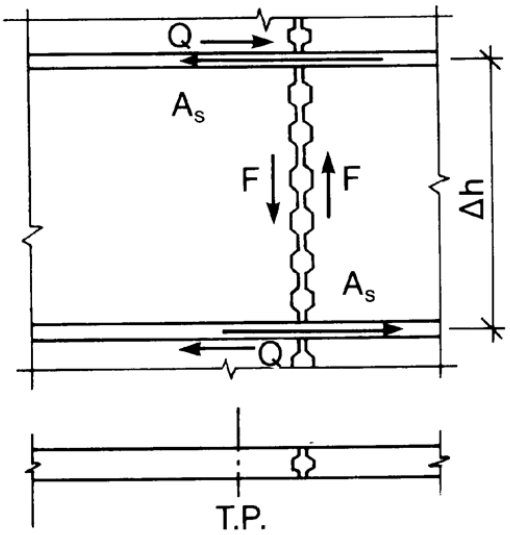
And further we ca calculate D as follows:

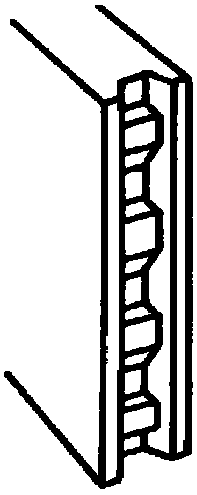
$$D = \frac{2Md - N_d(l-x)}{2(l-d)-x}$$

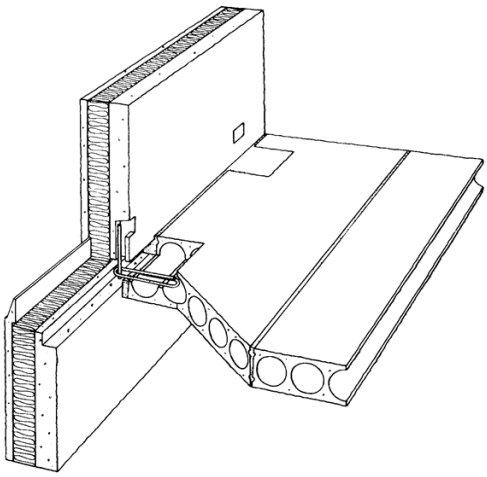


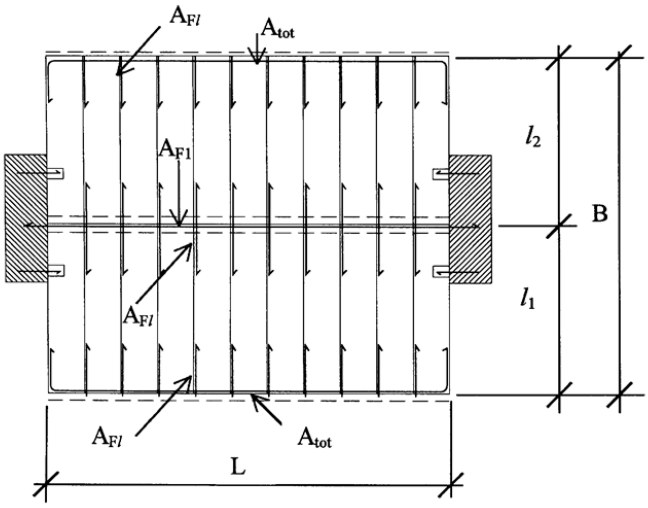


The wall sides must be provided with recess to be able to transmit shear forces and the same must be satisfied for the connections between slab elements and the wall panels as shown in the following figures.
The slab elements have to be interconnected with each other by using reinforcement in the joints between them.



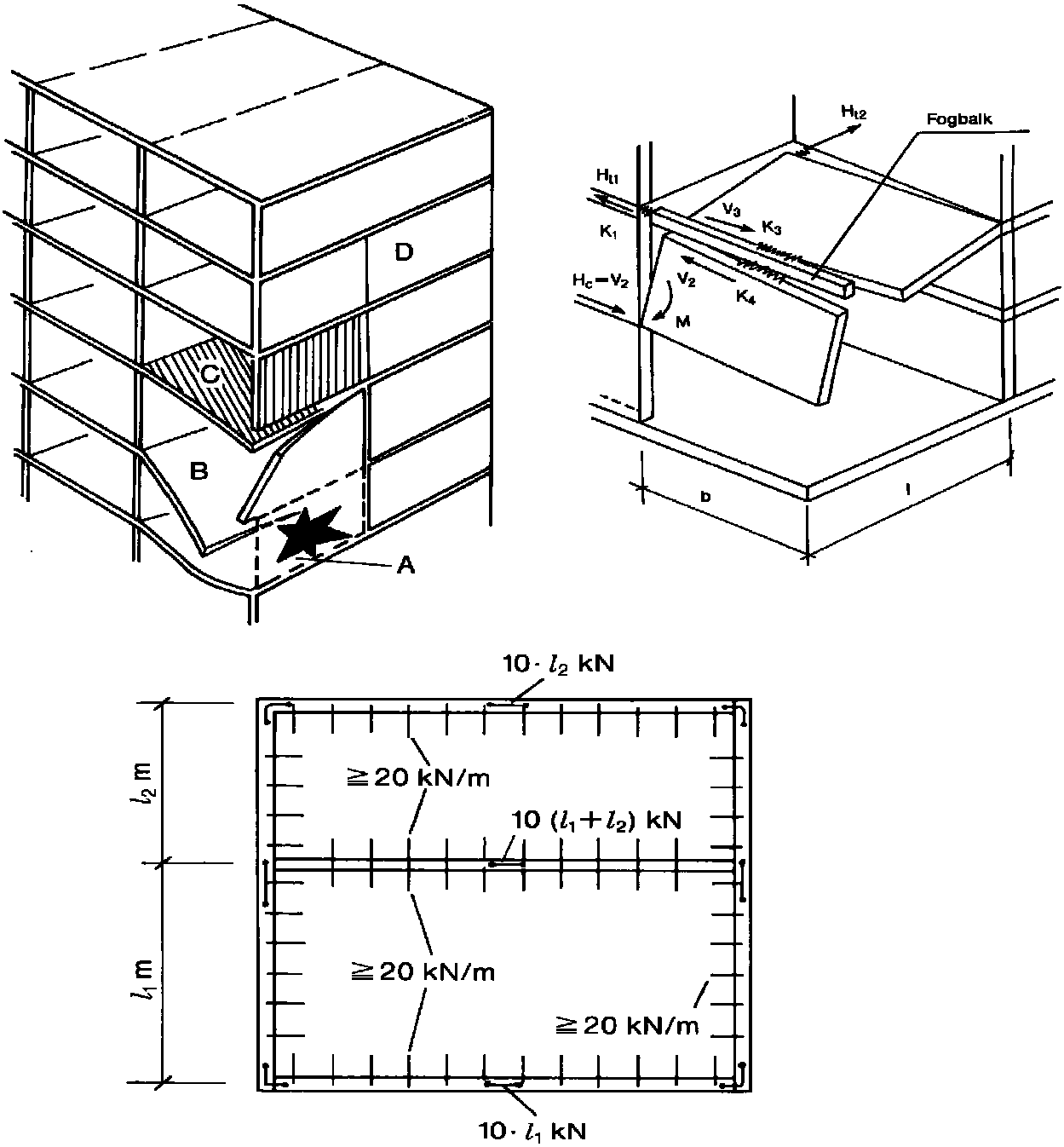




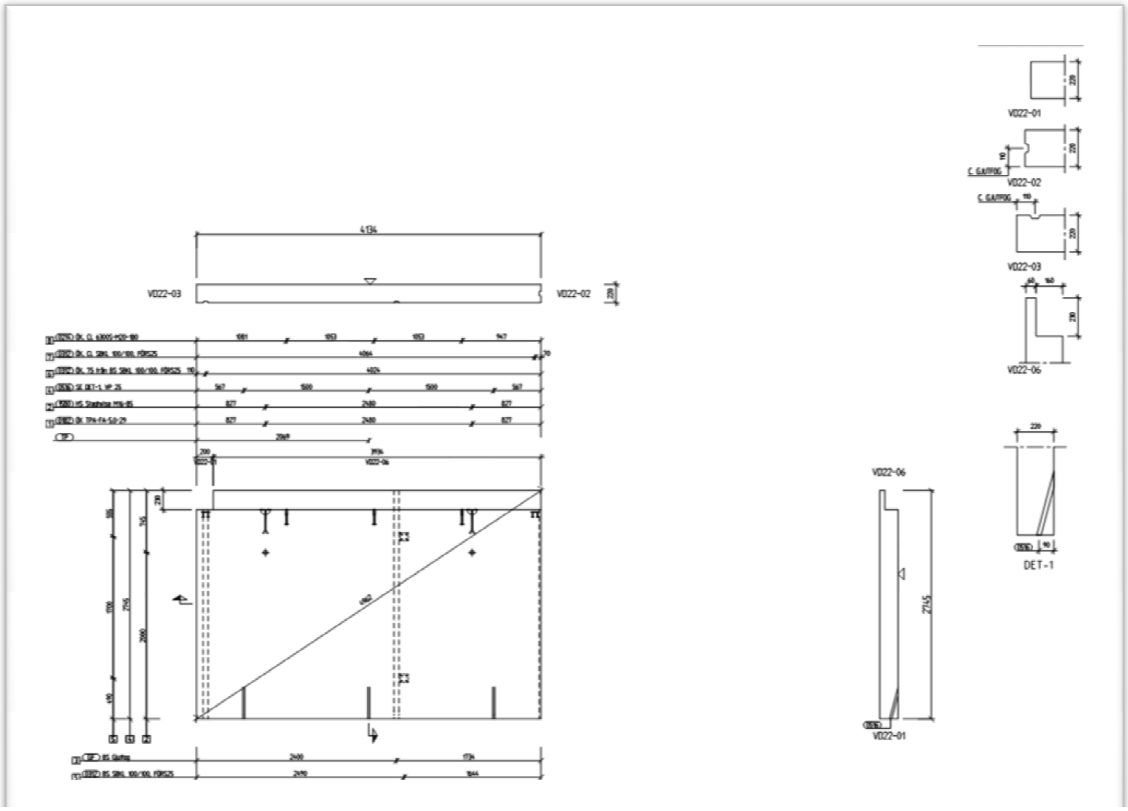


Transmission of shear forces

One a very important thing in precast structure context is that if an element is lost by any reason, it should not mean that the entire building collapses, all the elements have to be connected to each other in such a way that this phenomenon could not be possible to happen. There are recommendations for min. capacity between the connections as shown in following picture.

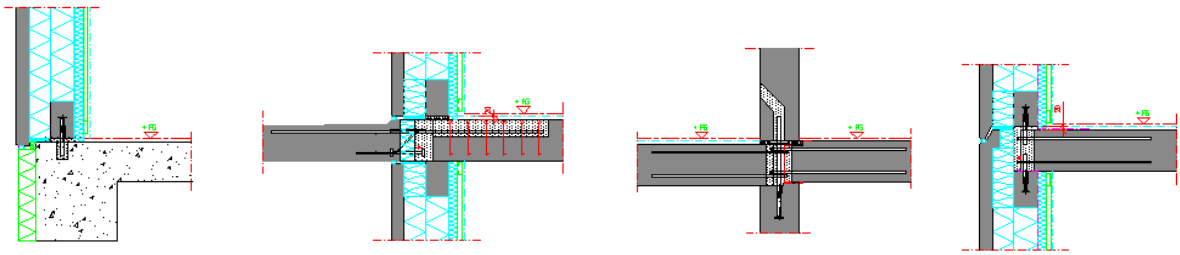


All elements must be designed and have their own drawing. The factory produces elements from these drawings, accuracy required in these drawings so that no errors will occur when we assemble the elements in place.



One typical exampel, drawing for an internal wall panel

We need also to produce drawings which need to be used for assembly. These drawings show how the structure should be assembled and in what sequence we can assemble.It is important to ensure stability during assembly as well, some of the elements need to be braced until the full interaction between the elements can be achieved.



Joints and details

Important things to remember about prefab construction:

1. There are different type of lift systems for different type of element such as columns, beams, walls and slab element. Lifting of each element is an important and critical moment throughout the process, external wall panels designed as sandwich elements are particularly complex to manage. The location of the lift is normally done so that the element will hang straight in the transportation and assembling.

2. Unfortunately accidents happen sometimes due to inaccuracies of the lift or handling of the element in a wrong way which, in the worst cases, can lead to fatal accident. Lift manufacturer specifies the liftcapacity, additional reinforcement and suitable location thereof. Then it's up to the designer to design the lift and reinforcement and then provide the suitable instructions and drawings to the factory. The factory shall ensure that the lift is cast in accordance with the instructions and proper lifting method is used. Every element has to be handled correctly even during transport and assembling.

   - Bracing of the elements may not be removed without permission from the designer or responsible person.

3. When the elements produced, various types of materials can also be cast in which simplifies some jobs such as electrical installations, plumbing and other installations. It requires careful coordination between all consultants who are involved in the project. The advantage of precast technology is that several things in the building process can be managed in the same time while enabling us to gain time in our building process.

4. Precast projects require good coordination between all involved partners. This can cause some difficulties some times when an individual consultant fails to deliver its part of the project on time, it provides a series effect and delays the assembly.

5. Planning at construction site before start means a lot of work and preparation e.g. crane placement, opportunities to transportations of the elements, storage and much more. It is important to study all the possible risks and difficulties that may affect the assembling of the building.

6. High safety and good procedures need to be considered in the construction site when it is about dealing with heavy elements.

7. It should never be allowed unauthorized persons areexisting in the construction site, the area should be provided with warning signs "Restricted Area".

8. Only educated people should be working with assembly, this also applies to the factory.

9. Make sure rather not work from a ladder when the risk of falls is quite large.

10. Covering over all openings in the slab during assembly and guardrail should be installed in the places with a risk of falling, warning labels should be used.

11. Tools and equipment in the workplace should be always removed after the day's work

Remember;

There are always many other things to remember, it is important to think right and logical.

Each project requires some specific things to adjust to.

The work environment must be properly adapted and is always decisive what kind of results you can get.

Please contact me in case of any inquiries about this subject through this E-mail:

Sirvan.amen@hotmail.com