Precast Concrete in Brazilian Arenas for the 2015 World Cup. General Concepts and example: Corinthians Itaquera. SP

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SUMMARY

The construction of the Stadiums for the next World Cup is presently progressing at a very fast rate. For each Stadium the financial system used is specific and tries to attend to very different conditions. The projects of these infrastructures were developed to fulfill strict requirements imposed by FIFA and, at the same time, to be able to offer different and valuable uses after the event, trying to avoid possible white elephants at the end of the competition. This important commitment has given rise to multiuse buildings which can be used as football arenas during the World Cup and as sport or cultural installations, or, in certain cases, as Shopping Malls, after the event.

Additionally, there are several other demanding conditions: the construction schedule is very tight, FIFA has imposed the green certificate for all the projects and very strict cost control conditions have been imposed due to the crisis, financial management and the Brazilian what goes here???. Under these conditions many of the arenas have been designed using prefabrication. In some cases only the slabs were prefabricated, using hollow core slabs. In other cases more than 90 % of the construction was prefabricated.

In this paper the example of Corinthians' Arena, in Itaquera Sao Paulo, is described. Piles, slabs, columns, beams, grandstands and grandstand beams have been prefabricated. Some elements were prefabricated in factories and others, the majority, were prefabricated on site. In fact, the prefabricator installed a prefabrication plant on site. Additionally, some areas, with an irregular geometry or with special structural requirements, such as the shear walls, were cast in-place.

Corinthians Arena in Sao Paulo

The Corinthians Arena, located in the east part of the city of Sao Paulo in Itaquera, will have a seating capacity of 48000 spectators. For the opening ceremony the Stadium has to increase its current seating capacity by 20000. This increase in seating capacity will be provisional and shall be removed once the World Cup has finished. The project will cover an area of approximately 200000 m2 and will have more than 3500 parking places. Additionally, it is foreseen that the Stadium will have installations able to receive the 32 Head of States who shall be representing the countries which participate and will allow the housing of more than 5000 journalists.

The stadium will make an old dream come true for the Sport Club Corinthians Paulista. The project is being built through a private contract between Corinthians and Odebrecht. The works began on 30th May 2011.

The Arena was design by Anibal Coutinho from CDCA Architects. One of the key points of the architectural design is its adaptation to the ground area so taking advantage of the differences in level and therefore minimizing earthworks.

The project is defined according to the sustainable criteria employing rain water recycling systems and generation of energy employing Photovoltaic panels on the facade, for example.

The football pitch is set in a north-south direction. The grandstands are set in the east and west wings. Practically all the necessary services for the Stadium are located in these areas. The highest point of the stadium is to be found on the west wing. At the north and south ends, stands can be found at ground level.

Figure 1. Virtual image of Corinthians Stadium in Sao Paulo.

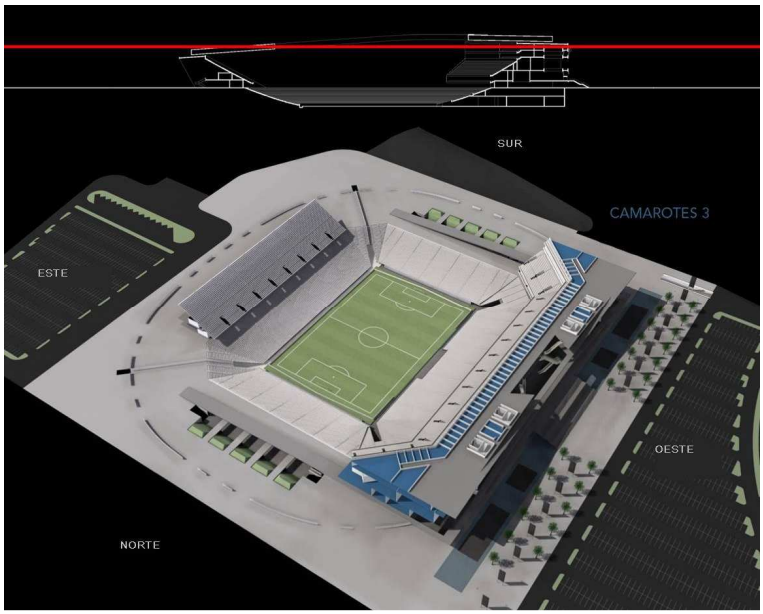

Figure 2. View below roof level

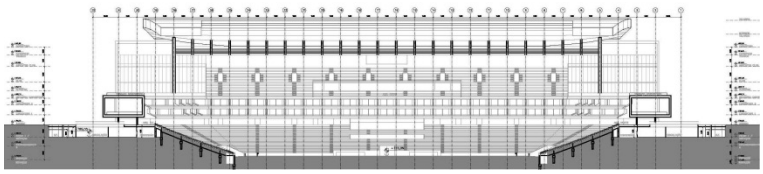

Figure 3. North-South cross section

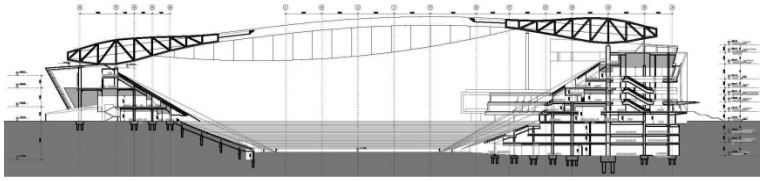

Figure 4. East-west cross section

The structure below roof level is made of structural concrete. Practically 80 % of this structure is pre-cast, the remaining is in-situ or composite, with steel girders and top concrete slabs. Composite construction has only been used when construction conditions have impeded a concrete solution.

Due to the amount of prefabricated elements necessary CPI, the prefabricator, installed a 7500 m2 prefabrication plant on-site. This company employs 45 people, during the day, and 15 at night. This

factory will produce around 3500 elements and will employ up to 150 people in peak periods. Columns, beams, grandstands and grandstand beams shall be manufactured here.

Figure 5. Assembly of precast grandstands prefabricated beams on site.

Additionally, there are other precast elements which are supplied by local prefabricators, such as piles and hollow core slabs.

The structural solution is composed of frames, in the eastwest direction, made of precast columns and beams. The frames are separated every 7,50 m, except at the edges in which they are set at 10,50 m. in the north-south directions the structure is composed of hollow core precast slabs of 20+6 cm, for the normal spans of 7,0 m, and 25+6 for the larger spans.

In specific areas, where the structural behavior demands a more monolithic solution, such as close to the cores, or where due to specific constraints, it was not possible to use precast slabs, in situ concrete slabs or composite solutions were employed.

To resist horizontal forces, due to wind for example, to improve the dynamic behavior of the entire structure and to stabilize the steel roof, which covers the four stands of the Arena, cast insitu cores were implemented.

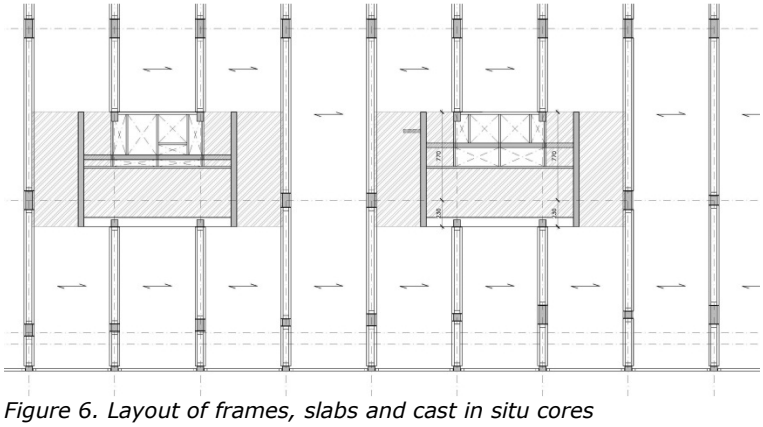

Figure 6. Layout of frames, slabs and cast in situ cores

Due to the geotechnical conditions the foundation was solved using driven precast piles. 50 and 70 cm diameter piles were employed. Although in the foundation of the cores inclined piles were placed to resist horizontal forces.

Figure 7. Pile driving

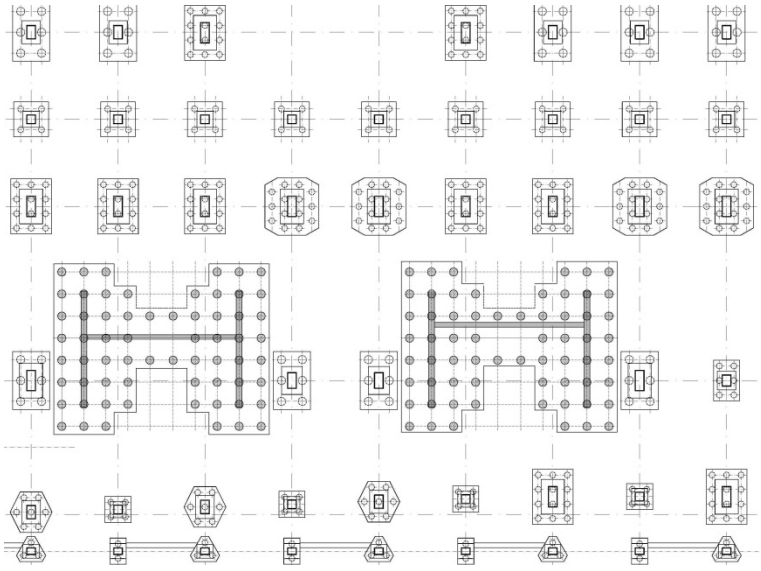

Figure 8. Layout of core piles

Figure 9. The cup piles were cast in situ.

The tie beams between the cap piles of one or two piles were cast in situ.

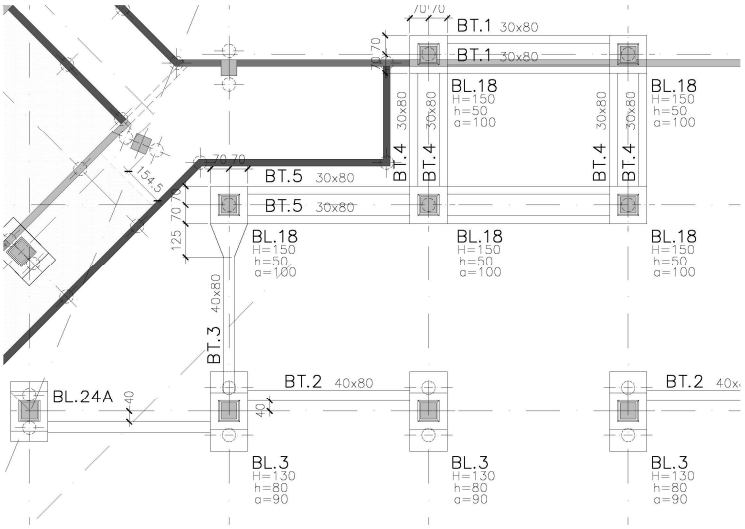

Figure 10. Tie-beam layout.

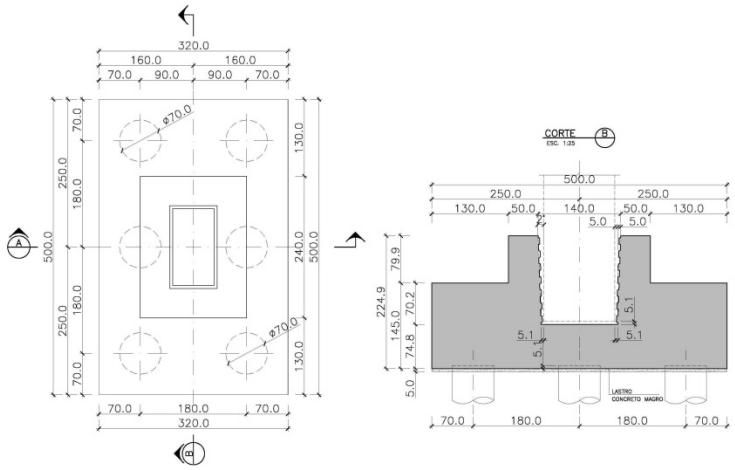

Figure 11 Plan view and cross section of cap pile of six piles.

Figure 12 Execution of pile caps.

Due to the especially bad soil conditions in certain zones in the west wing, it was necessary to substitute the grade slab for a slab supported directly on the cap piles.

The cores were executed using jump formwork. The connection between the core and the slabs, at the different levels, was solved using special reinforced details.

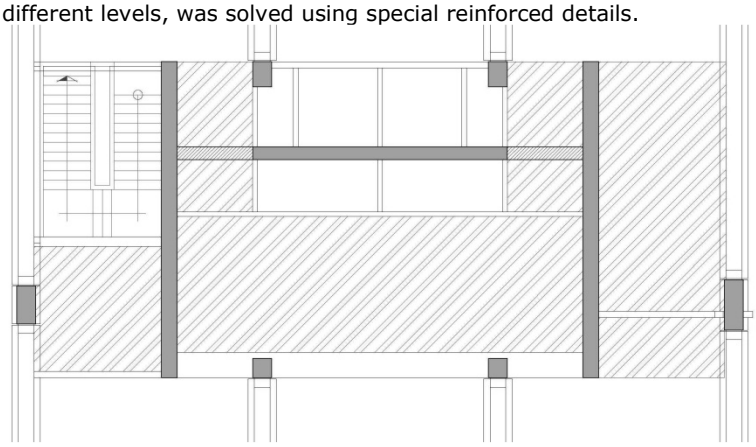

Figure 13. Geometrical plan definition of the cores zones.

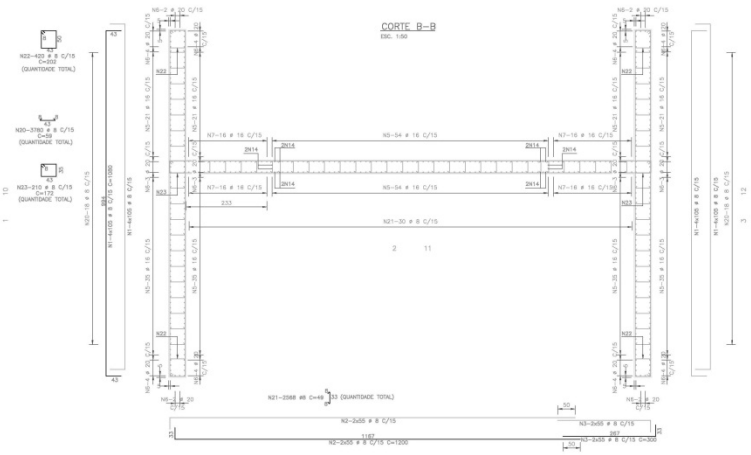

Figure 14. Reinforcement layout of the cores.

In the East wing, where the height was not so great , single precast columns were employed. In the highest areas of the west wing the columns were split into two elements which were assembled using couplers to offer continuity to the main vertical reinforcement.

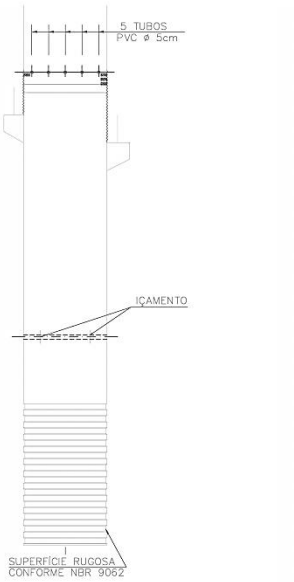

Figure 15. Precast column of the east wing.

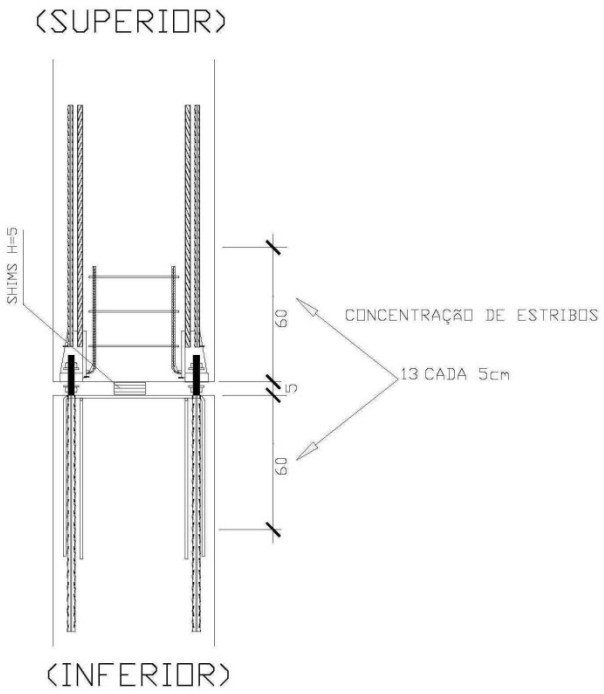

Figure 16. Joint detail between two prefab column segments, in the west wing.

The nodes of the frames are monolithic. To materialize this monolithism, the beams are supported by corbels situated at different levels on the precast columns. After the installation of the precast beams the small space between the back face of the beam and the front face of the column is grouted. The continuity to the upper reinforcement of the beam, through the column, is guaranteed using coupled reinforcement, cast with the precast column, which is then continued, after the installation of the beam.

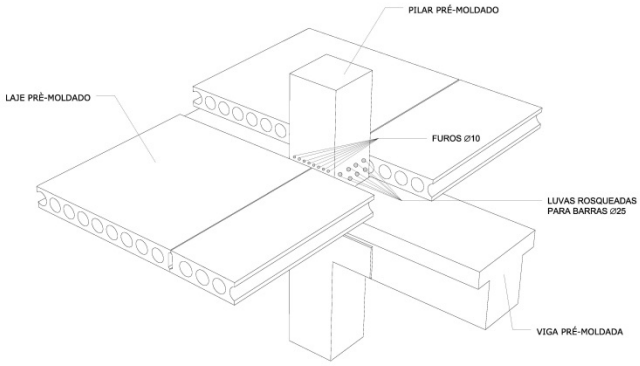

Figure 17 Typical columns beam and slab node detail.

In some zones, due to the strict clearance height restrictions, it is has been deemed necessary to substitute the precast concrete beams for slender composite beams.

In some other zones, such us between level 2 and 3 in the west wing, where some columns were eliminated to allow an auditorium to be placed, cast insitu post tensioned girders were proposed.

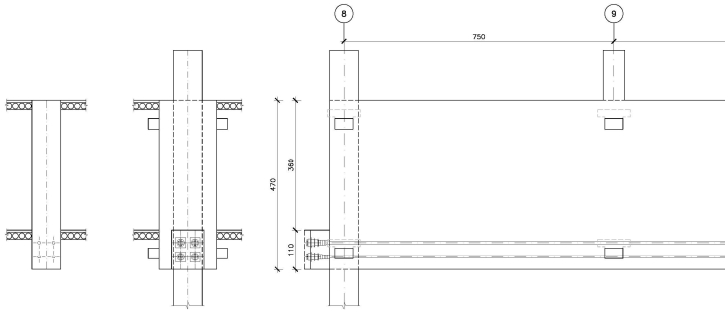

Figure 18. Geometrical definition and details of the post tensioned in-situ concrete beams for auditorium area in west zone.

The Corinthians Arena is a challenge in all respects. It is a project which has many important, demanding economic, time and contextual restrictions which have demanded the imposition of ideal structural solutions.

CDCA Anibal Coutinhio. Architects
EGT Engenharia + Fhecor Ingenieros Consultores Structural Engineers for concrete structure and foundations
Werner Sobek Structural Engineers for the steel roof