

REPORT NO.

ITR-IEBH-108-4 v1.0

TITLE

ITER Engineering Basis Handbook

Vol. 1: Genesis, Design and Evolution

Chapter 8 - Managing the Design and Construction of ITER

Section 4 - Construction Achievements and Milestones to Date

CHIEF EDITOR

Dr. Gianfranco Federici

CHIEF EDITOR'S EMAIL

gianfranco.federici@euro-fusion.org

September 15th, 2026

About the ITER Basis Engineering Handbook

This handbook consists of two volumes which describe the ITER design from its inception up to the design, construction and assembly in 2025.

The handbook is not designed to be read as a continuous sequence of chapters. Instead, it is composed of focused, self-contained sections that address specific topics. Each chapter can be read and understood independently, allowing readers to engage with the material most relevant to their needs without requiring familiarity with preceding chapters. As a result, the reader will find certain overlapping content in chapters.

It is to be noted that at the time of writing, the design for some systems is still on-going. Therefore, the reader should consider that whilst there is significant value of this important point-in-time study, an update would be required as the Project progresses.

A broad Project overview is given in the first volume, to provide the reader with background information necessary to understand the context in the subsequent more-detailed chapters of the second volume, dedicated to the individual systems composing ITER.

For the overall table of contents of the Handbook and to access each one of the chapters, please refer to <https://www.iter.org/scientists/iter-technical-reports>.

Authors and Contributors of this Chapter

This chapter is authored by Robert Arnoux.

Volume 1
GENESIS, DESIGN AND EVOLUTION

Chapter 8
MANAGING THE DESIGN AND CONSTRUCTION of
ITER

Section 4

CONSTRUCTION ACHIEVEMENTS AND MILESTONES TO DATE

Table of Contents

8.4 Construction Achievements and Milestones 1

8.4.1 Achievements and Milestones to Date 1

Chapter 8

MANAGING THE DESIGN AND CONSTRUCTION OF ITER

8.4 Construction Achievements and Milestones

8.4.1 Achievements and Milestones to Date

In January 2007, preparatory works began on the vast tract of national forest that France had conceded to the ITER Organization. Adjacent to France's Cadarache nuclear research centre, some 75 kilometres north of Marseille, this new "international territory" (ITER is a site on French territory operating under an international legal regime of privileges and immunities) covered an area of 180 hectares—a footprint four times as large as the Vatican City but slightly smaller than the Principality of Monaco—approximately half of which would be used and the other half left untouched (see Figure 8.4-1).



Fig. 8.4-1: ITER construction site, Cadarache- view toward Vinon-sur-Verdon.

As part of its commitment to ITER, France was to deliver a perfectly level, 42-hectare platform for the main buildings of the scientific installation as well as cleared areas to accommodate buildings, industrial facilities, storage areas, storm basins, roads and parking spaces. Over a period of less than two years, more than 2.5 million cubic metres of rock and soil were removed—a volume equivalent to that of the Cheops Pyramid—and by the summer of 2010 construction could begin in earnest (see Figure 8.4-2).



Fig. 8.4-2 : the platform that will house the ITER scientific buildings is ready for construction to begin. 1,000 metres long, 400 me wide.

Geological studies had determined that the most suitable location for the ITER machine and the massive structure that would house it was a cretaceous limestone outcrop at the northern edge of the platform. In the first week of August 2010, under the responsibility of the European Domestic Agency *Fusion for Energy*, bulldozers, scrapers and power shovels began excavating the 17-metre deep, 90 x 130 metre seismic pit that would house the foundations of the 320,000-tonne Tokamak Complex (see Figure 8.4-3).



Fig. 8.4-3 : Panoramic photo, taken in September 2010, showing the ITER site as the digging begins for the Tokamak Complex.

As construction machinery dug deeper and explosives blasted the rock at an average rate of 4,000m³ per day (see Figure 8.4-4 and Figure 8.4-5), a more conventional operation was ongoing a few hundred metres away.



Fig. 8.4-4: Aerial view of the construction site while blasting, September 2010.



Fig. 8.4-5: Aerial view of the construction site, September 2010.

The official name of the building didn't do justice to the full scope of its future activities: in the Poloidal Field Coils Winding Facility, the four largest of the tokamak's ring-shaped magnet coils would be manufactured. Measuring 17 to 24 metres in diameter, the poloidal field coils would not only be wound in this space, but also assembled, insulated, equipped and cold-tested before being handed over to the ITER Organization (see Figure 8.4-6 to Figure 8.4-9).



Fig. 8.4-6: The Poloidal Field Coil Winding Facility under construction, lateral view.



Fig. 8.4-7: The Poloidal Field Coil Winding Facility under construction, view from above.

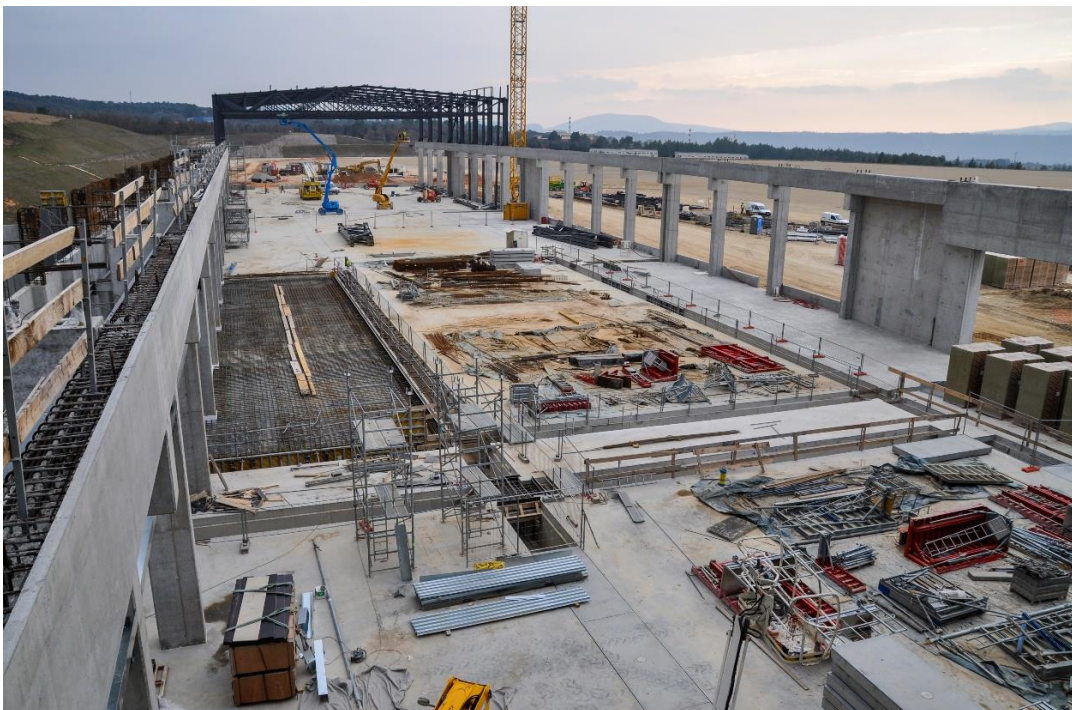


Fig. 8.4-8: The Poloidal Field Coil Winding Facility under construction, view from the building.



Fig. 8.4-9: The Poloidal Field Coil Winding Facility under construction, exterior work nearly completed.

Of the 39 buildings that would eventually rise on the platform, this six-storey-tall factory was the first to be completed. On the day it was inaugurated, in February 2012, representatives of the construction consortium, the European Domestic Agency and the ITER Organization were dwarfed by the dimensions of the facility (see Figure 8.4-10). Standing under the circular spreader beam suspended over their heads, they resembled passengers in a deserted spaceport waiting to board a ship bound for some distant planet.



Fig. 8.4-10: PF Winding Facility completed.

In the tokamak seismic pit, the creation of the Tokamak Complex foundations provoked a similar feeling of wonderment (see Figure 8.4-11 and Figure 8.4-12). In the 8 months—from August 2011 to April 2012—the construction teams created a ground-level basemat, retaining walls and 493 columns with anti-seismic pads designed to filter and absorb accelerations linked to earthquake-induced ground motion (see Figure 8.4-13 to Figure 8.4-17). On top of these pads the “B2 slab” was created—the heavily reinforced, 1.5-metre-thick concrete basemat designed to support the full weight of the Tokamak Complex plus machinery and equipment. Work was completed in nine months, in August 2014.



Fig. 8.4-11:: excavation of the Tokamak Seismic Isolation Pit, December 2010.



Fig. 8.4-12: The Tokamak Seismic Isolation Pit, seventeen metres below the surface of the ITER platform, May 2011.

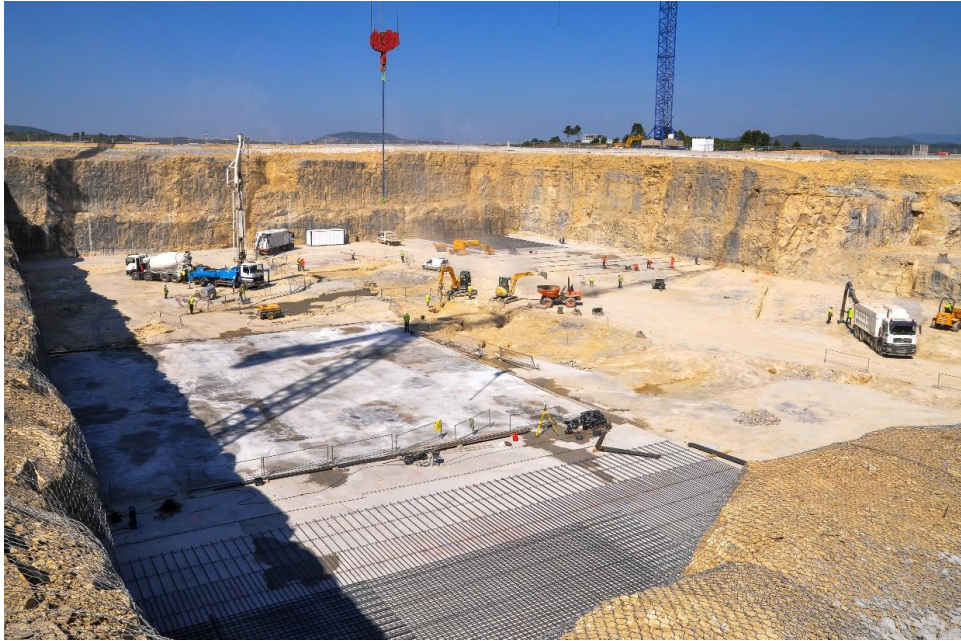


Fig. 8.4-13: Reinforcement work begins for the basemat of the Tokamak Complex Seismic Pit, September 2011.



Fig. 8.4-14: Reinforcement work for the basemat of the Tokamak Complex Seismic Pit, October 2011.



Fig. 8.4-15: Reinforcement work for the basemat of the Tokamak Complex Seismic Pit, November 2011.



Fig. 8.4-16: Work on the seismic pads progresses, February 2012.



Fig. 8.4-17: First phase works nearly completed in the Tokamak Pit.

An aerial photograph from September 2011 illustrates the progress that was accomplished in the first year of ITER construction (see Figure 8.4-18). A four-tank batching plant to the left of the photo had already been established—over the years it would deliver approximately 250,000 cubic metres of concrete to the Tokamak Complex worksite and other buildings. Pouring operations had begun in the centre of the photo at the bottom of the seismic pit and, on the far side of the platform, cladding and roofing operations were underway on the Poloidal Field Coils Winding Facility. Another project is also visible near the platform dedicated to the scientific installation: the 20,000m² Headquarters Building (bottom right) of the ITER Organization is just one year away from completion.



Fig. 8.4-18: Aerial Photo of ITER site, September 2011.

Another structure was required for the handling and/or pre-assembly of machine components—some of them as tall as a five-storey building and heavier than a fully loaded jumbo jet—before their transfer into the tokamak pit. The Assembly Hall would provide the vast space needed for staging and handling and for the bespoke heavy tools required by the pre-assembly and transfer activities. Work on this steel frame building (60 metres tall, 100 metres long, 60 metres wide)—quite a spectacular antechamber to the tokamak pit—began in June 2012 with a campaign of soil investigation to assess rock profile and resistance (see Figure 8.4-19), followed by the filling of “karsts” and the pouring of binding concrete over a surface in excess of 6,000m² (see Figure 8.4-20).



Fig. 8.4-19: Excavation work for the future Assembly Hall, 500 holes drilled down to 7 metres to profile the rock substrata.

Designed to support exceptionally heavy loads—such as the twin sub-assembly tools (SSATs) that weigh nearly 800 tonnes each and that host 1,450-tonne sector modules—the building would rest on a 1.2 to 2.2 metre-thick basemat, necessitating approximately 10,000 cubic metres of concrete and 1,400 tonnes of thick steel rebar (see Figure 8.4-21 and Figure 8.4-22).



Fig. 8.4-20: Excavation Assembly Hall: Vast antechamber to the Tokamak Building.



Fig. 8.4-21: Metal "chairs" are positioned on the bottom layer of crisscrossed rebar. Steel reinforcement will be built up to 1.5 metres before foundation pouring begins, June 2012.

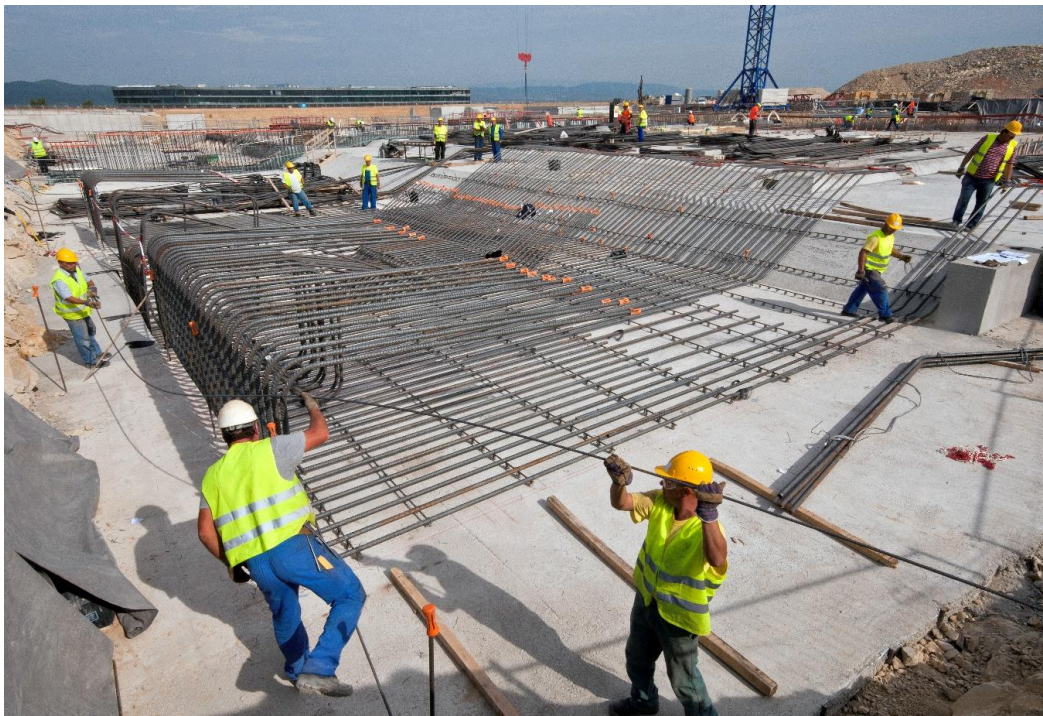


Fig. 8.4-22 : On top of the blinding layer of concrete, 1,400 tonnes of steel rebar will be placed according to a very specific diagram.

These figures appear modest, however, when compared to those of the main edifice on the ITER platform—the Tokamak Complex (see Figure 8.4-23). Rising 60 metres above platform level, with two basement levels, the 320,000-tonne construction (slightly heavier than the Empire State Building) is made up of the Tokamak Building proper flanked on either side by the Diagnostics Building and the Tritium Building. Launched in 2014, construction would last close to one decade, mobilize approximately 1,000 workers, and require 105,000 tonnes of concrete, 20,000 tonnes of steel reinforcement and 7,500 tonnes of steel structures (see Figure 8.4-24 to Figure 8.4-26).

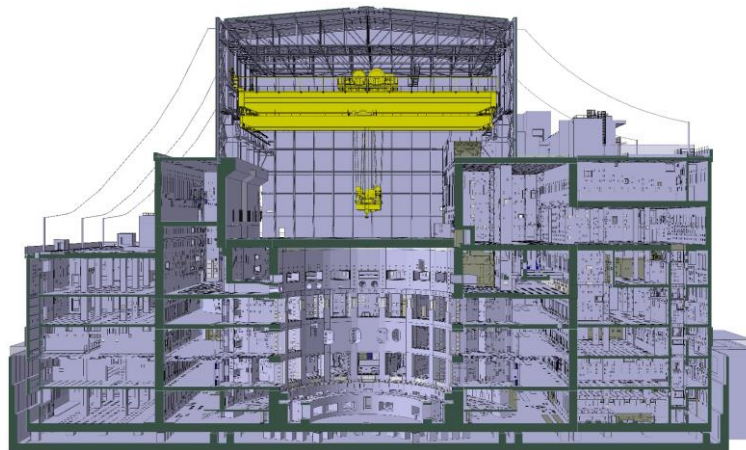


Fig. 8.4-23: European contractors have completed the full scope of civil engineering works in the ITER Tokamak Building under contract TB03, signed between the European Domestic Agency (Fusion for Energy) and the VFR consortium (Vinci, Ferrovial, Razel-Bec) — the culmination of ten years and millions of work hours.



Fig. 8.4-24: The Tokamak Complex "box" as seen by drone.



Fig. 8.4-25: Tokamak complex under construction as the clouds roll in, July 2018.

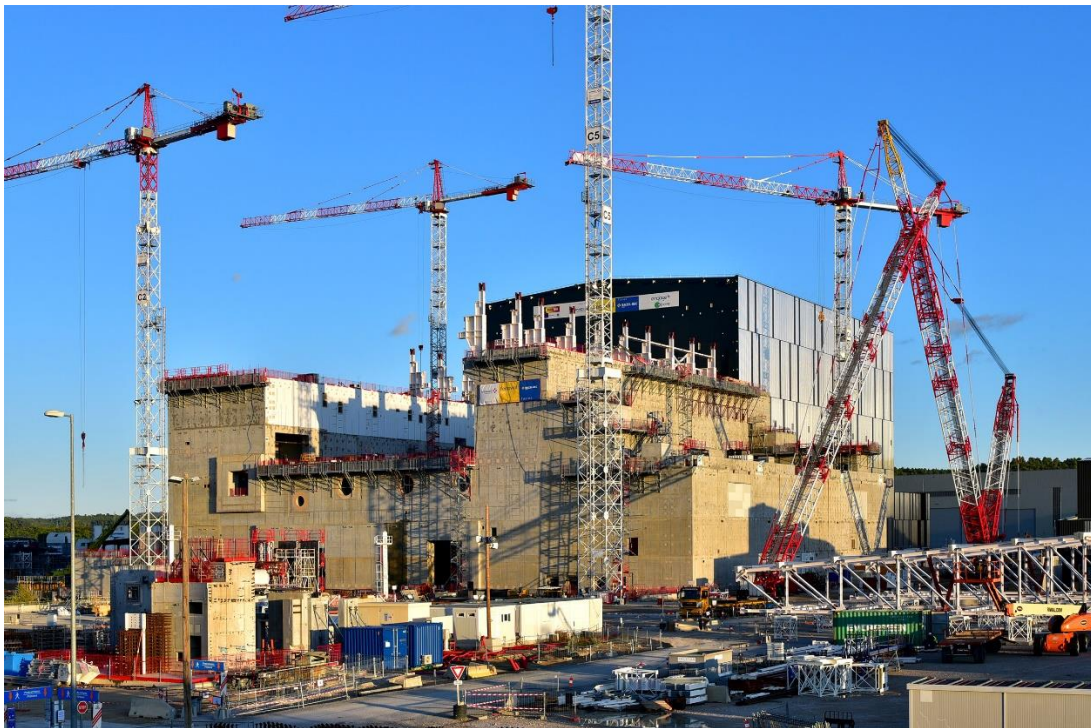


Fig. 8.4-26: To the right of the Tokamak Complex, contractors are assembling one of two crawler cranes that will be used to install the metal structure of the crane hall.

Civil works for the Tokamak Building were completed in November 2019, and in March of the following year the building reached the “Ready for Equipment 1B Stage 2” milestone that opened the way for machine assembly (see Figure 8.4-27).



Fig. 8.4-27 : Frame of the crane hall nearly complete and a first layer of cladding now covers the south wall and part of the roof, January 2020.

The ITER tokamak needed more than a home, however. In order to produce the plasmas that would demonstrate the feasibility of fusion as an energy source and fulfil the project’s scientific mission, the machine would require extensive industrial infrastructure: electrical power, cryogenic fluids and a whole range of utilities had to be provided along with plasma heating and heat rejection systems.

In April 2014, as work was progressing on the Tokamak Complex and Assembly Hall, the European Domestic Agency announced that no fewer than 16 building projects would be set in motion “in the months to come.” Among them was a Cleaning Facility where components would be prepped before entering the adjoining Assembly Hall (see Figure 8.4-29 and Figure 8.4-30) ; twin Magnet Power Conversion buildings, tasked with stepping down and converting alternative current (AC) from the grid into direct current (DC) for the magnets (see Figure 8.4-31 and Figure 8.4-32); the Radio Frequency Heating Building, originally destined to host both the ion and electron cyclotron heating systems, eventually devoted exclusively to the latter; the Control Building, to house the teams orchestrating the workings of the entire installation and its millions of “process variables”; and the Site Services Building—an unassuming name for a building devoted to the strategic activity of distributing a large number of industrial services such as compressed and breathable air (for operators in ventilated nuclear suits), demineralized water for cooling circuits and detritiation systems, and cold water for air conditioning (see Figure 8.4-28).



Fig. 8.4-28 :Site Services Building construction, it will accommodate and distribute a large number of industrial support services that are indispensable for operating ITER.



Fig. 8.4-29: Construction of the Cleaning Facility is underway on the south side of the building, Before they enter into the Assembly Hall ITER components will need to be cleaned using a number of different techniques.



Fig. 8.4-30: The Assembly Hall is joined to two smaller buildings: the Cleaning Facility (left) and the Radio Frequency Heating Building (right).



Fig. 8.4-31 : Progress in the conversion building, January 2017.



Fig. 8.4-32: One of the long, low Magnet Power Conversion buildings, July 2017.

The largest and indisputably the most impressive of these projects was the soccer-field-size “cryoplant” whose construction began in October 2015 and was finalized two years later (see Figure 8.4-33 to Figure 8.4-37). The facility is home to the equipment and systems—compressors, “cold boxes,” loops, storage tanks—that produce and manage the cooling fluids distributed to the machine. Cryogenics are central to ITER operation, maintaining a superconducting state in the tokamak’s 10,000-tonne magnetic system and achieving high vacuum in the plasma chamber by cooling the cryosorption panels inside the cryopumps.



Fig. 8.4-33 : End-of-day light on the cryoplant worksite, teams working overtime to ready at least part of the facility for component installation activities.



Fig. 8.4-34: Cryoplat construction is progressing as the roof frame is being positioned.

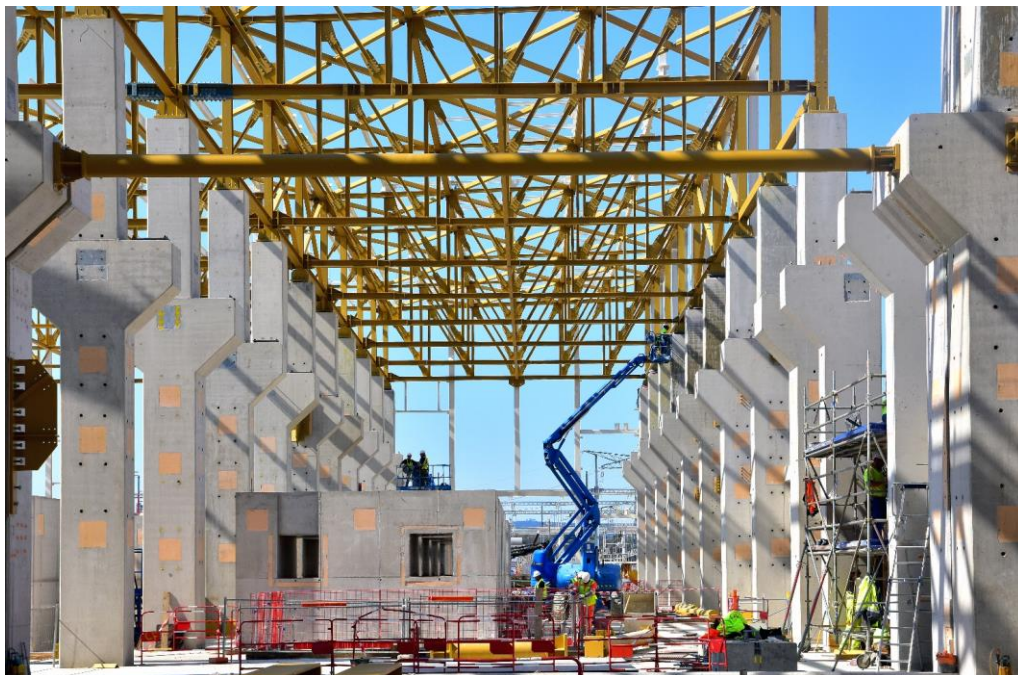


Figure 8.4-35: Roof frame of the cryoplat positioned.



Fig. 8.4-36: Construction of the world's largest concentrated cryoplant is progressing, April 2017.



Fig. 8.4-37: Cryoplant building's cladding nearly finalized and work is underway to pour the ground slab for the exterior storage area.

In the meantime, work was progressing on the only major building outside the scope of Europe's procurement—the Cryostat Workshop where India would assemble and weld the giant thermos that encloses the ITER machine and insulates it from the outside environment. Construction was launched in June 2013 and by February 2014, the light but sturdy steel structure (110 metres long, 44 metres wide and 27 meters tall) was completed. In December of the following year, India delivered the first elements of the Cryostat base, inaugurating a sequence that was to last more

than six years—the reception of the 54 massive elements which, once assembled and welded, would form the four main sections of the 3,850-tonne ITER Cryostat.



Fig. 8.4-38: The Poloidal Field Winding Facility and the Cryostat Workshop, side by side on the platform, June 2013.



Fig. 8.4-39: Adjacent to the Cryostat Workshop, the ancillary building under construction will house offices, machinery, power supplies and other utilities, August 2013.



Fig. 8.4-40: Workers complete rebar operations on the 5,500 square-metre slab of the Cryostat Workshop, adjacent to the Poloidal Field Coils Winding Facility, July 2013.



Fig. 8.4-41 :Completed Cryostat Workshop in the early morning, April 2014.

In the early months of 2020, the Covid-19 pandemic imposed its severe constraints on worksite activities. Whereas the workforce over the previous years had averaged 2,500 people, the new way of working—focused on “critical operations”—reduced it to just a few hundred at the pandemic’s peak.

Despite the pandemic context, ITER was preparing for the opening act of machine assembly, an immensely challenging and highly symbolic operation. On Tuesday 26 May 2020, in a scene reminiscent of a science fiction movie (Spielberg’s *“Close Encounters of the Third Kind”* came to

mind), the 1,250-tonne Cryostat base was gradually lifted from its frame, carried across the Assembly Hall to the Tokamak Building and eventually lowered into the Tokamak assembly pit (see Figure 8.4-42). The Cryostat Lower Cylinder followed the same path in August (see Figure 8.4-43) and by September 2021 the Lower Cylinder Thermal Shield, Poloidal Field Coils # 6 and # 5 (see Figure 8.4-44) and the first of the bottom Correction Coils were transferred to the Tokamak pit.



Fig. 8.4-42: Between the overhead heavy lift cranes and the component are yellow "spreader beams" that share the weight of the component and eliminate any tilt.

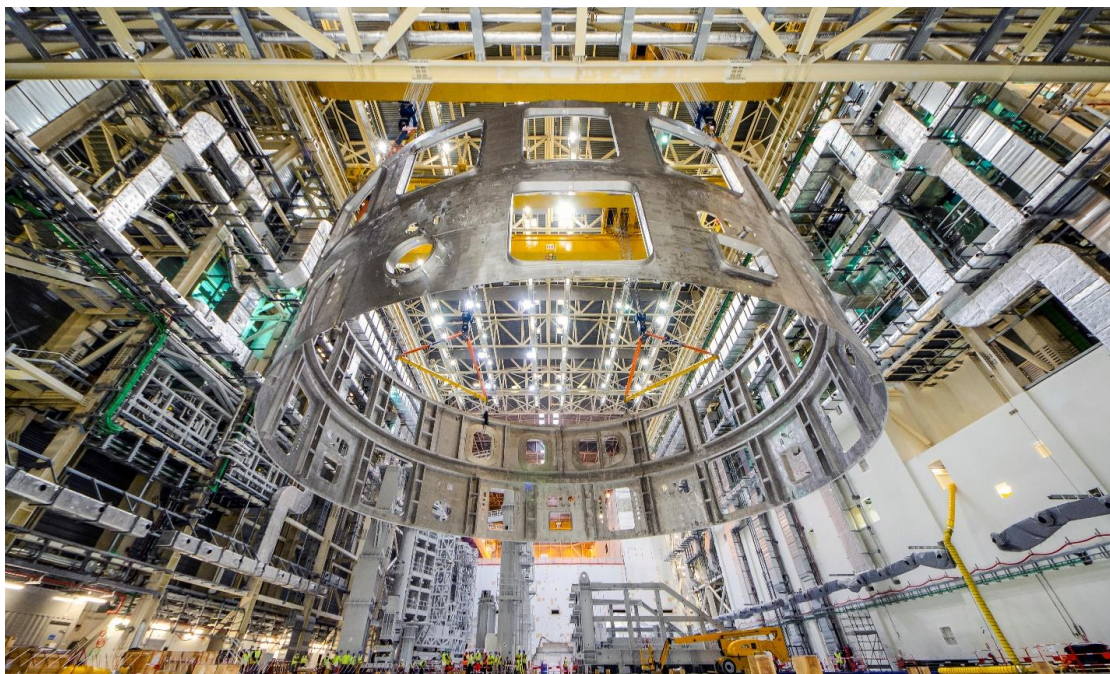


Fig. 8.4-43 : The 375-tonne component is lifted by overhead crane and delivered to the Tokamak pit on the opposite side of the building.



Fig. 8.4-44: The assembly teams lower poloidal field coil #5 into the Tokamak pit.

By that time, many major buildings had been completed and handed over to the ITER Organization and equipment installation was progressing. But civil work for the scientific installation was not over yet: in January 2021, preparation work began for the buildings and infrastructure of the neutral beam power supply system (see Figure 8.4-45). Work also resumed on the Tritium Building (see Figure 8.4-46) which, because its main functions are directly linked to full-power operation at ITER, would not be needed for another decade. (Activity had been put on hold in late 2018 in order to concentrate efforts on the Tokamak and Diagnostics buildings).



Fig. 8.4-45: metal structure of the neutral beam power supply's High Voltage Building.

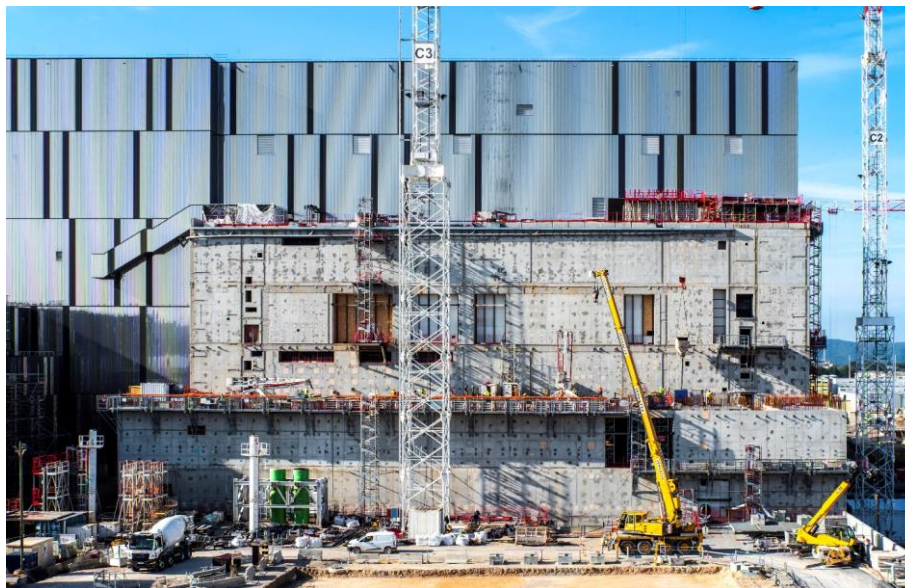


Fig. 8.4-46 : Working on L3 of the Tritium Building.

Sixteen years have now passed since that day in August 2010 when worksite machinery arrived on site to begin excavating the tokamak seismic pit and clearing the soil for the foundations of the Poloidal Field Coils Winding Facility. Over this decade-and-a-half, an estimated 15,000 people, working for 5,000 different companies and hailing from close to one hundred countries, have been involved in the myriad activities that building ITER requires.

The ITER platform has now acquired its near final and definitive appearance (see Figure 8.4-47). Covered in alternating cladding of mirror-like stainless steel and grey-lacquered metal, the installation's permanent buildings reflect both the ever-changing shades of skylight and seasons (see Figure 8.4-48) and, in the architects' words, "the precision of the research work being performed by ITER."



Fig. 8.4-47 : Aerial view of ITER site, May 2025.



Fig. 8.4-48 : Aerial view of ITER site, late afternoon.