IAEA workshop

Modularization Construction Experiences of World First AP1000 Unit

2011-12-12
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1 Retrospect on Sanmen AP1000 Modularization Construction
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Overview

1) There are four AP1000 units being built in china, Sanmen1# is the world first one.
2) Features:
   . Simplified design
   . Passive safety system;
   . Modularization construction;
   . Civil and erection parallel construction
3) Parties
   . Owner: SMNPC, SDNPC
   . Design Institute: WEC consortium
   . Project Management: JPMO (WEC, SHAW, SNPEC)
   . Constructor: CNF, CNI22, CNI24
Overall Schedule

Sanmen
- Unit 1
  - ATP+0
  - Unit 2
  - ATP+71

Haiyang
- Unit 1
  - 6 month
  - 4 month
- Unit 2
  - 6 month
Milestones Schedule of Sanmen 1#Unit
2、Retrospect on Sanmen AP1000 NPP Construction
1#NI excavation started on 2008-02-26

The dental concrete started on Aug, 24, 2008

1#NI Basemat Construction
On Sep. 18, 2008, lower mudmat concrete of 1#NI finished.

On Jan. 12, 2009, basement of 1# NI rebar finished.
On Jan. 22, 2009, first equipment module KB10 was set.

On Feb. 28, 2009, the embedded piping installation was finished and ready for FCD.
1#NI FCD on Mar. 29, 2009

Night Shift
On Mar. 31, 2009, monolithic concrete placement of more than 5000 m³ was achieved. It took 47 hours for 1#Unit.
AP1000 Modularization Construction Process

➢ Modularization Construction Flowchart

- shop Fabrication
- Module Transportation
- Module Assembly
- Module Lifting
- engineering
- Set
shop Fabrication of Structural Module
In August of 2008, CA assembly area was available.
By the end of 2008, the first batch of sub-modules of CA20 delivered on site.
Sub-modules
Fitting-up

Construction Progress Show – CA20 Assembly

CA20 Floor
Sub-modules Welding
The assembled subassemblies overturn and erected, ready for integrated assembly
Integrated assembly of structural module
Construction Progress Show – CA20
Transportation and Lifting

Two 25 axes hydraulic trailers

The structural module transported from assembly area to NI through heavy haul road
CA20 module, about 1000T, lifted and set in NI on Jun. 29, 2009
shop Fabrication of Equipment Module
Equipment Module Lifting

Construction Progress Show – Equipment Module Lifting
2 Modularization Construction Experiences of World First AP1000 Unit

1) modularization construction removes some work out of the NI into the module shop, The use of a module fabrication shop results in the easier implementation of lessons learned, then:

- Modularization permits better quality control than site construction;
- Less susceptible to whether conditions;
- High productivity in the shop;
- Less safety risk;
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2) Module fabrication shall be started prior to FCD to meet site construction requirement. The installation of bulk material shall be followed with the civil work closely. This parallel, close work relation needs:

- A detailed, integrated schedule shall be prepared prior to project construction and implemented to ensure continuous, smooth construction on site.

.
Detailed design must be preliminarily completed to meet the requirements of material procurement and module fabrication. The procurement of bulk material and equipment shall be started at an earlier time. The Time of award of the construction contract shall satisfy the construction requirements.
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3) The parallel/intercrossed construction for civil and erection needs closer coordination,

Logic relation. The construction logic is strictly required, if any deviation of schedule on any link, such as design, equipment and material supply, the progress for major structure will be slowdown, and even local suspension will be caused, so that the labor efficiency become lower
Concrete placement for layer 4

Concrete placement for layer 3

Concrete placement for layer 2

Concrete placement for layer 1

Typical Construction Logic Figure
On Apr. 28, 2009, CR10 module was set.
On Aug 1, 2009, exterior foundation layer A was poured.
On Aug. 1, 2009, CVBH was set.
On Jan 12, 2010, interior structure layer 1 was poured.
On Jan 26, 2010, the lifting of CA04 module was successfully performed.
On Feb. 10, 2010, interior structure layer 2 was poured.
On Mar. 11, 2011, interior structure layer 3 was poured.

On Feb. 28, 2010, CA05 module was set.
CV Internal Structure Construction

CA01 Transportation
CV Internal Structure Construction
On Mar. 27, 2010, CA01 module was successfully set.

CV Internal Structure Construction
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4) compared with stick installation the modularization construction makes the work at shop (module fabrication) easier, while some of the site work (module transportation, assembly, lifting, erection) more difficult.

Structure module assembly:
  . overhead position (4G) welding required;
  . Irregular shaped assembly structure, hard to locate the CG;
  . The deformation control during structural module fabrication, assembly and installation;
  . Integral outline dimension need to be controlled due to fabrication and assembly deviation accumulation.
Equipment module

The location precision is high, and as the precision requirements for multi-location and multi-points need to be met, otherwise the alignment and connection of piping is difficult to be performed after the module set.
Site connection issues after these two modules are set: as the accumulated deviations for module fabrication and installation, the pipe position is difficult to be aligned.
5) heavy load equipments for lifting and transportation is required for a long duration.

<table>
<thead>
<tr>
<th>Equipment</th>
<th>AP1000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy load Crane</td>
<td>2600T/3200T, for the whole construction period</td>
</tr>
<tr>
<td>Medium Crane</td>
<td>Two 400T</td>
</tr>
<tr>
<td>Hydraulic Transporter</td>
<td>1000T, 400T</td>
</tr>
</tbody>
</table>
2 Construction Experiences of AP1000 First Unit

6) The layout for each building of AP1000 is compact, the Open-Top method shall be adopted, so that the layout of site cranes, location of tower cranes and operation management to make safe and efficiency are critical.
2 Construction Experiences of World First AP1000 Unit
7) Weather Protective Measures
   . Temporary cover;
   . Hard and soft cover for individual items;
   . Paint after permanent covered.
7) Weather Protective Measures
8) Prior to design finalization, the detailed constructability & maintenance evaluation and optimization must be performed:

. Module lifting and transportation passage.
. The evaluation of maintainability is also very important: equipment moved-in through Open-Top Method and the operation space and passage moveout of equipment components during maintenance must be considered.
Operation space while installation (scaffolding, welding and NDE).

The distance between floor module and cable tray is very short, so that the cable layout and maintenance is very difficult to be performed.
The decoration (finish paint) after module set is very difficult to be performed, so that the final decoration must be finished before module setting.
2 Construction Experiences of AP1000 First Unit
9) Flexible site module adjustment

The actually delivered KB15 module is not completed, and the unfinished parts inside module, such as piping, will be installed on site.

Integrated KB15 module in 3D Model
10) Prior to design finalization, the detailed economy evaluation and optimization must be performed on:

. Whether module shall be adopted or not, big or small size shall be used.

. Considering the costs for integrated link (design, fabrication and site construction).
modularization construction removes some workforce out of the NI island into the module shop – resulting in reduced NI construction staff levels, this conduce to some cutdown of the construction cost, but on the otherhandsome aspect of Construction Cost is Increased:

. The fees for lifting&transportation equipment are increased.

.More manpower resources: due to the parallel construction of civil and erection, the construction period for these two disciplines has been extended, and the construction work not continuous which caused that the manmonth input has been increased.
Possibility of lower labor efficiency:

The construction logic is strictly required, if any deviation of schedule on any link, such as design, equipment and material supply, the progress for major structure will be slow, and even local suspension will be caused, so that the labor efficiency become lower.

Heavy haul road, module assembly field and facilities shall be added.
large quantity for temporary steel structure
large quantity for temporary steel structure
Conclusion

The most valuable contribution for modularization is that the construction period (FCD~CO) reduced, so as to reduce the total investment, however, more careful project control and site coordination is needed to make sure the construction going smoothly.
Thanks!

www.cnfc.net.cn
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