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# A Preliminary Design and Structural Analysis on the Central Column for Supporting the Full 40° Sectors at Tokamak In-pit

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## 1. Introduction

The ITER Tokamak machine is composed of nine 40° sectors shaped of torus. Each 40° sector is made up of one 40° vacuum vessel (VV), two 20° toroidal filed coils and associated vacuum vessel thermal shield (VVTS) segments which consist of one inboard and two outboard VVTS. The VV/TFC/VVTS 40° sectors are sub-assembled at assembly building respectively at sector sub-assembly tool and then nine sub-assembled 40° sectors are finally assembled at in-pit of Tokamak building. ITER sector assembly tools are the purpose-built assembly tools to assemble nine 40° sectors into the complete ITER Tokamak machine at Tokamak in-pit. Based on the design description document, final report prepared by the ITER organization (IO) [1,2] and tooling requirements, Korea has carried out the conceptual and preliminary design of these assembly tools [3-8].

Especially, the central column is the main tool, which is composed of some hollow cylinders, to support full nine 40° sectors at Tokamak in-pit. Configuration and structural analysis of the central column are presented.

## 2. Configuration and Analysis

### *2.1 Configuration of Central Column*

The central column, as shown in Fig. 1, is composed of the major three parts; the bottom cylinder anchored to floor of Tokamak in-pit, TF inner supports located between upper column and bottom cylinder, and the upper column comprising upper, equatorial and lower cylinders. The central column was designed to endure approximately half of the dead weight of the nine VV sectors (One VV is 440 tonne in irregular type.), nine VVTS sectors (One VVTS is about 40 tonne.) and 18 TF coils (One TF coil is about 310 tonne.).

The bottom cylinder was designed to support the upper column, TF inner supports and approximately the half of dead weights of nine VV sectors, VVTS including associated segments, 18 TF coils and nine radial beams, which are about 6200 tonne in total. Also, TF PCR installation tools are integrated into the bottom cylinder. The bottom cylinder provides a main man access hole of 1200 mm to provide workers access.

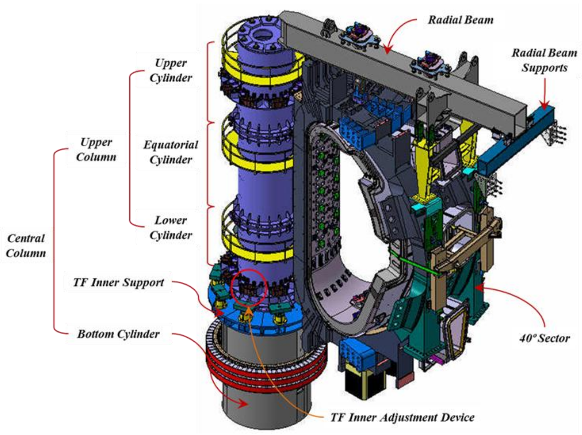


Fig. 1. Configuration and structure of central column; bottom cylinder, TF inner support and upper column.

TF inner supports are positioned between the upper column and the bottom cylinder in order to support the inboard load of TF coils and to adjust the level of them corresponding with the level of TFC outboard supports installed on cryostat base.

The upper column is a steel structure of hollow cylinder shape with outer diameter of 2.7 m. Full height except for that of TF inner supports and bottom cylinder and dead weight are approximately 14.9 m and 160 tonne, respectively. The upper column is split into and delivered in three pieces, each one about 5 m long, for ease of transportation, assembly and disassembly.

### *2.2 Structural Analysis*

The structural analysis of the central column was carried out considering its dead weight, external load and seismic load. Fig. 2 shows full finite element (FE) mesh model for structural analysis of the central column. The Analysis has been carried out in all 9 cases with static dead weight and considering seismic load respectively. The material applied to all structures is SM490YB; yield, tensile strength and allowable stress intensity are 325, 490 and 216.7 MPa respectively. The results of stress intensity have been evaluated according to ASME Section VIII, Division II. The results of analysis are given in Table 1. In stress results, $S_m$, $P_L$ and $P_b$ means allowable, primary membrane, primary local and bending stress.

For just applied their dead weight, the maximum vertical displacement is 12.8 mm, as shown in Fig. 3 and the maximum stress intensity is 225 MPa as shown in Fig. 4 (local primary stress) and this stress value is below the allowable stress 325 MPa. For applied dead weight and seismic load simultaneously, the maximum vertical displacement is 5.0 mm and the maximum stress intensity is 257 MPa and this stress value is below the allowable stress 325 MPa as shown in Table 1.

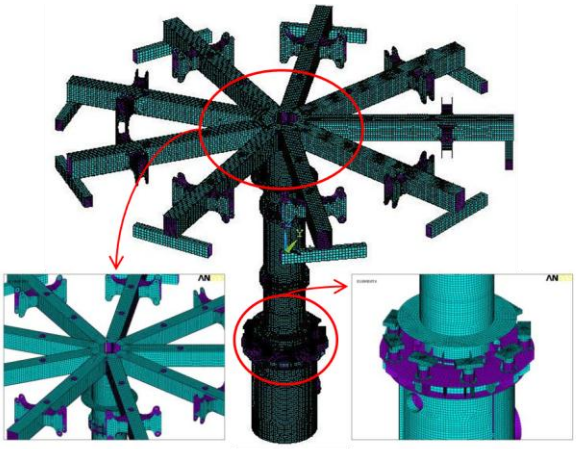

Fig. 2. FE mesh model of the central column with radial beams and their supports.

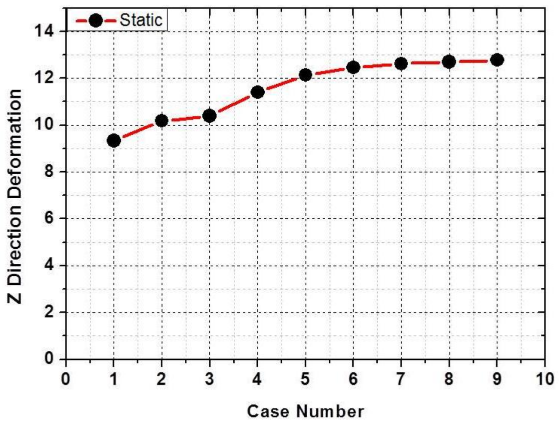


Fig. 3. Vertical direction deformation of central column in case of each sector loading.

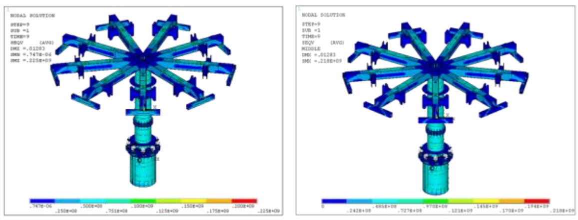

Fig. 4. Stress intensity, $P_L$ and $P_L$+$P_b$, analysis results of central column considering just static dead weight in condition of all sectors loading.

Table I: Analysis results of the central column with radial beams and their supports using ANSYS code according to ASME Section VIII, Division II

| | Maximum stress intensity (MPa) | | Allowable values (MPa) | |
|---|---|---|---|---|
| | $P_L$ | $P_L+P_b$ | 1.5Sm ($P_L$) | 1.5Sm ($P_L+P_b$) |
| Static Load | 225 | 218 | 325 | 325 |
| +Seismic Load | 257 | 245 | | |

## 3. Conclusions

The preliminary design of central column has been developed. The design of this column developed by ITER Korea to satisfy ITER assembly plan and technical requirements for assembly of the full 40° sectors. The structural stabilities of central column have been studied using ANSYS code for verifying structural strength for this column. In the results of the analysis for assessing structural stabilities of the central column considering dead weight and seismic load, all stress intensities of the central column are less than allowable stress in each case. Work continues to develop the final design of the ITER assembly tools by March 2013..

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