

Substructure Module - ABAQUS

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Overview

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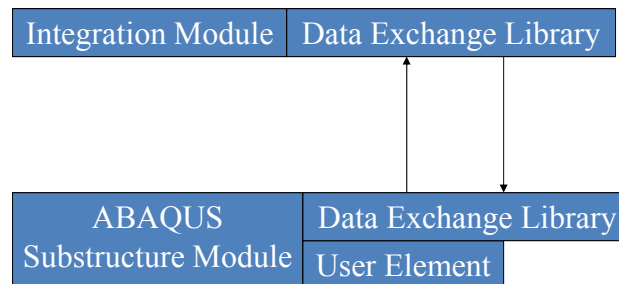


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Communication Method

- ❑ **User element**
 - ◆ Defined in a substructure for exchanging data
- ❑ **Data exchange library**
 - ◆ A dynamic link library contains UTNP



System Setup

- ❑ **Accessing the user subroutine**
 - ◆ Required software:
 - ABAQUS
 - Fortran and C++ Compilers
 - ◆ Link compilers to enable the subroutine function
 - Commanded package: ABAQUS 6.13, Visual Studio 2012, Intel Composer XE 2013
 - Add the path of compilers to the system environment variables
 - Add command lines in the batch file of running ABAQUS
 - A step-by-step instruction is in the manual chapter 6.5

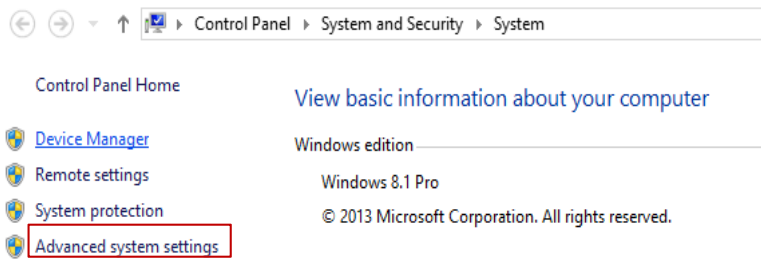


System Setup

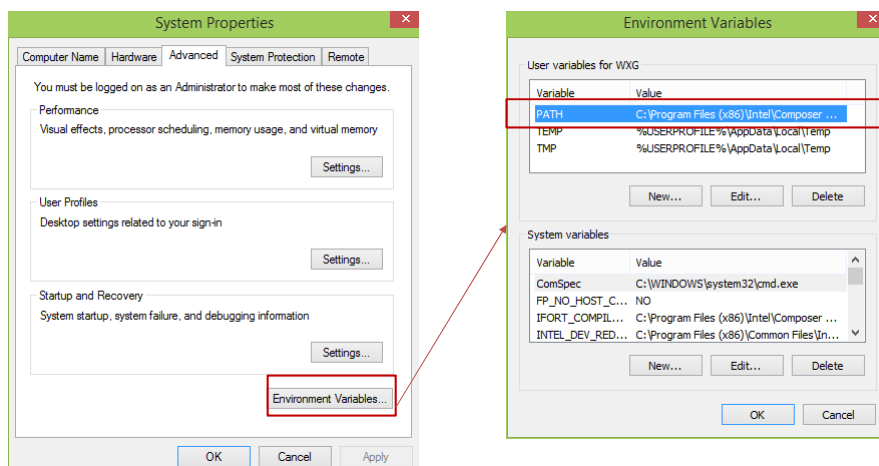
❑ Add path of the compilers

- ❖ 'ifort.exe' Location: C:\Program Files (x86)\Intel\Composer XE 2013\bin\intel64
- ❖ 'Ifortvars.bat' Location: C:\Program Files (x86)\Intel\Composer XE 2013\bin

Control Panel → System and Security → System

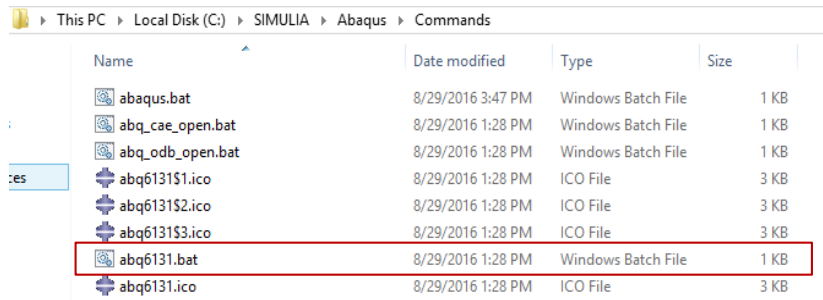


System Setup



System Setup

- ❑ Add command lines in the batch file of running ABAQUS

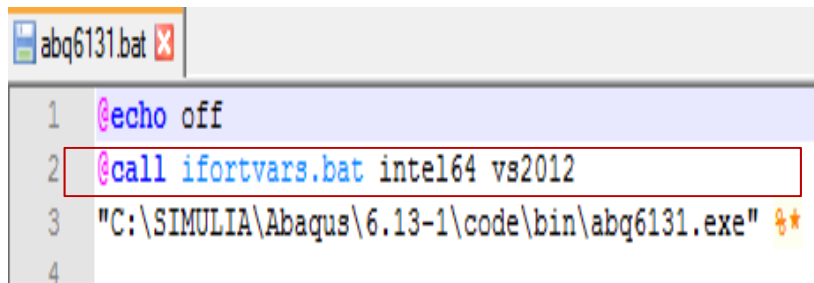


Name	Date modified	Type	Size
abaqus.bat	8/29/2016 3:47 PM	Windows Batch File	1 KB
abq_cae_open.bat	8/29/2016 1:28 PM	Windows Batch File	1 KB
abq_odb_open.bat	8/29/2016 1:28 PM	Windows Batch File	1 KB
abq6131\$1.ico	8/29/2016 1:28 PM	ICO File	3 KB
abq6131\$2.ico	8/29/2016 1:28 PM	ICO File	3 KB
abq6131\$3.ico	8/29/2016 1:28 PM	ICO File	3 KB
abq6131.bat	8/29/2016 1:28 PM	Windows Batch File	1 KB
abq6131.ico	8/29/2016 1:28 PM	ICO File	3 KB



System Setup

- ❑ Call compilers when run the batch file of ABAQUS
- ❑ Change the name and version of compilers accordingly



```
1 @echo off
2 @call ifortvars.bat intel64 vs2012
3 "C:\SIMULIA\Abaqus\6.13-1\code\bin\abq6131.exe"
4
```

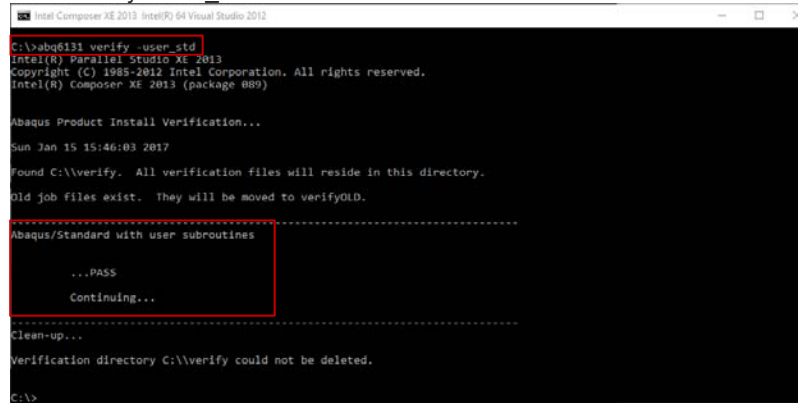


System Setup

❑ Accessing the user subroutine

◆ Verifying the subroutine function

- Verify the subroutine function is working properly using ABAQUS 'verify -user_std' command



```
Intel Composer XE 2013 Intel(R) 64 Visual Studio 2012
C:\>abq6131 verify -user_std
Intel(R) Parallel Studio XE 2013
Copyright (C) 1985-2012 Intel Corporation. All rights reserved.
Intel(R) Composer XE 2013 (package 889)

Abaqus Product Install Verification...
Sun Jan 15 15:46:03 2017
Found C:\verify. All verification files will reside in this directory.
Old job files exist. They will be moved to verifyOLD.
-----
Abaqus/Standard with user subroutines
-----
...PASS
Continuing...
-----
Clean-up...
Verification directory C:\verify could not be deleted.
C:\>
```



System Setup

❑ Accessing the data exchange library

◆ Adding the data exchange library to ABAQUS library folder

- Copy the library files into the 'bin' folder under the ABAQUS directory

◆ Customizing the ABAQUS environment file

- Adding the path of added library into the ABAQUS environment file 'abaqus_v6.env' (location: ... \SIMULIA\Abaqus\6.13-1\SMA\site)

```
link s1='LINK',
'/noLogo', '/NOENTRY', '/INCREMENTAL:NO', '/subsystem:console', '/machine:AMD64',
'/NODEFAULTLIB:LIBC.LIB', '/NODEFAULTLIB:LIBCNT.LIB',
'/NODEFAULTLIB:OLDNAMES.LIB', '/DEFAULTLIB:LIBIFCOREMD.LIB', '/DEFAULTLIB:LIBIFPORTMD', '/DEFAULTLIB:LIBMVD.LIB',
'/DEFAULTLIB:kerne132.lib', '/DEFAULTLIB:user32.lib', '/DEFAULTLIB:advapi32.lib',
'/FIXED:NO', '/d11',
'/def:AE', '/out:8U', '8F', '8A', '8L', '8B',
'oldnames.lib', 'user32.lib', 'ws2_32.lib', 'netapi32.lib', 'advapi32.lib', 'C:\SIMULIA\Abaqus\6.13-1\code\bin\DataExchange.lib'
```



Substructure Input File

❑ ABAQUS Standard Input File

- ◇ Generate from ABAQUS user interface
- ◇ Create using text editor (Template provided in the package)

❑ User Element

- ◇ Only for the purpose of transmitting data
 - Can overlap with other members in the model
 - Very large stiffness compare to other members in the model
- ◇ Define user element using ABAQUS key words in the input file using text editor
 - `*USER ELEMENT'`
 - Define basic information of the user elements and calls the subroutine
 - `*UEL PROPERTY'`
 - The subroutine file, *subsub.for*, is provided in the package



Substructure Input File

❑ User Element

```
21 *****
22 *** Define DataExchange Element ***
23 *****
24 *Node
25 9998, 0., 0., 3.20000005
26 9999, 6000., 3300., 3.20000005
27 *USER ELEMENT, TYPE=U1, NODES=2, COORDINATES=6, PROPERTIES = 3, VARIABLES = 12
28 1, 2, 6
29 *ELEMENT, TYPE=U1, ELSET=Adapter
30 999, 9998,9999
31 *UEL PROPERTY, ELSET=Adapter
32 8090, 1, 10000000.
33 *Nset, nset= Constraint1 , generate
34 138, 1104, 138
35 *Nset, nset= Constraint2 , generate
36 1, 967, 138
37 ** Constraint: E1
38 *Rigid Body, ref node=9998, tie nset=Constraint1
39 ** Constraint: E2
40 *Rigid Body, ref node=9999, tie nset=Constraint2
41 *boundary
42 9998,3,5
43 9999,3,5
```



Substructure Input File

❑ Define Analysis Steps

- ◆ The subroutine only compatible with ABAQUS standard (implicit) analysis, but the integration model can be explicit
- ◆ The number of increments in the substructure model must be much greater than the number of increments in the integration model
- ◆ Using fixed increment to control the minimal number of steps

```
*****  
**                               Steps  
*****  
*Step, name= , nlgeom= , inc=100000000  
*** The increment number in the substructure should be  
*** much larger than it in the integration structure  
*Static  
1.0,100000000,1,1
```



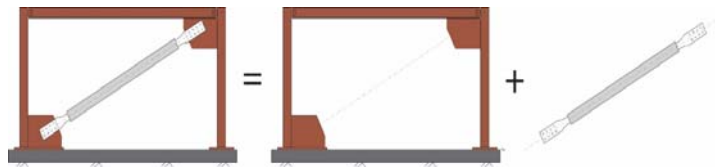
Running the Analysis

- ❑ **Have the input file and the subroutine file, *SubSub.for*, in the same folder**
- ❑ **Creating batch file to run the analysis or type ABAQUS command in the command line**
- ❑ **Abaqus job= *file name* user = *SubSub***
 - ◆ The ABAQUS command is NOT case sensitive.
 - ◆ Do not include file extension
 - ◆ The execution information can be shown in the command window while running analysis by adding '- interactive' command. However, log file will be created when this command is absence.
- ❑ **When the substructure is ready, it shows 'waiting for connection' in the command line window**



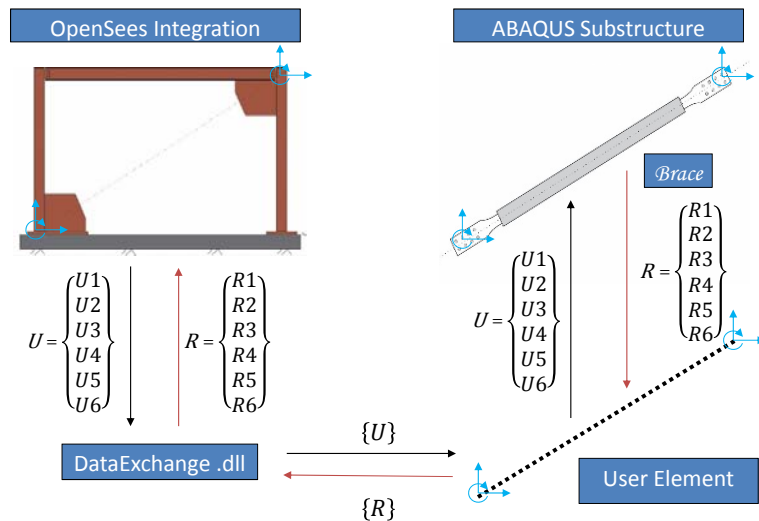
Braced Portal Frame Example

- ❑ Portal frame with BRB brace
- ❑ The brace is buckling restrained and has bi-linear material response
- ❑ Brace is modeled using ABAQUS solid element (C3D8R, 8 nodes linear brick element with reduced integration) as the substructure
- ❑ Frame is modeled using frame elements in OpenSees as the integration model



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Braced Portal Frame Example



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Braced Portal Frame Example

- Push over analysis with 165mm lateral displacement is carried out on both the hybrid and OpenSees Standalone models

