THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

OpenFIRE: An Open Computational Framework for **Structural Response** to **Real Fires**

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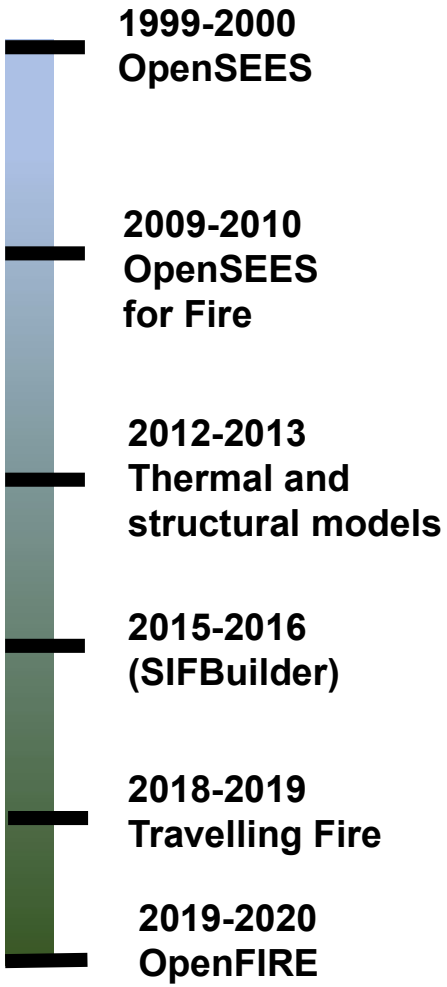
Why we need CFD ?

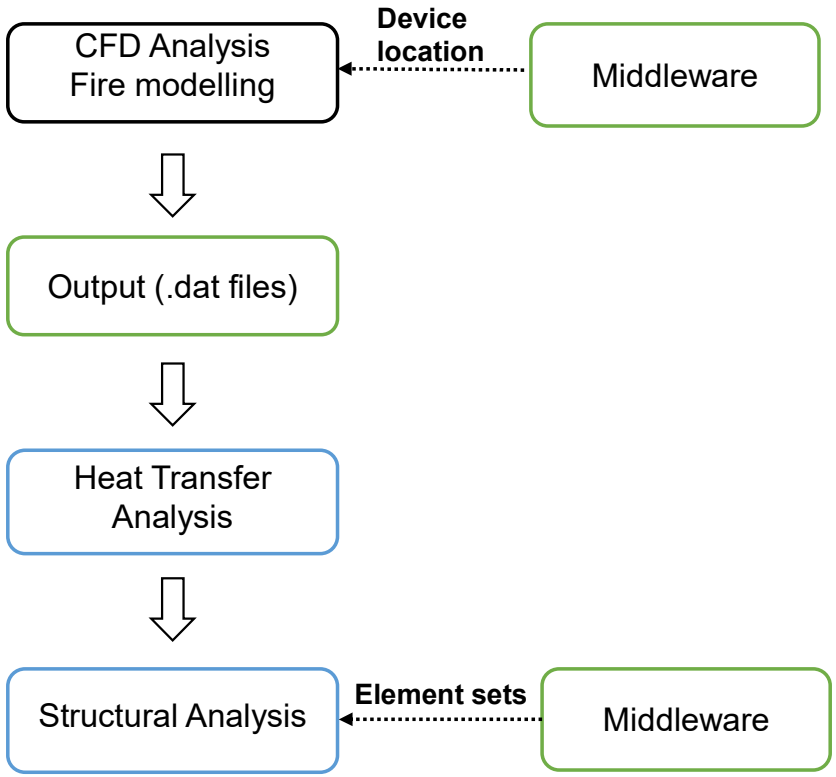
- Experiments are costly and sometimes not feasible
- Idealized Fire Model
  - Fire models do not explicitly consider type of materials stored
  - Well representation of ventilation-controlled fire scenarios only
  - No information on the distribution of fuel load
  - Unique and modern architectures
- CFD can generate realistic fire scenarios

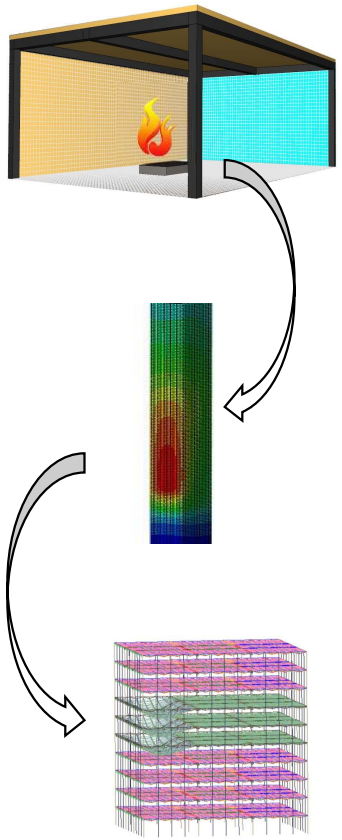
OpenSEES for FIRE

- OpenSEES: An open-source FE tool
  - UC Berkeley : Frank McKenna
  - Earthquake engineering
- OpenSEES for Fire: Began in University of Edinburgh
- Current Capability
  - Standard Curves
  - Parametric Curves
  - Travelling fire models
  - Localised fire curve
- OpenFIRE can provide whole sequence of solution

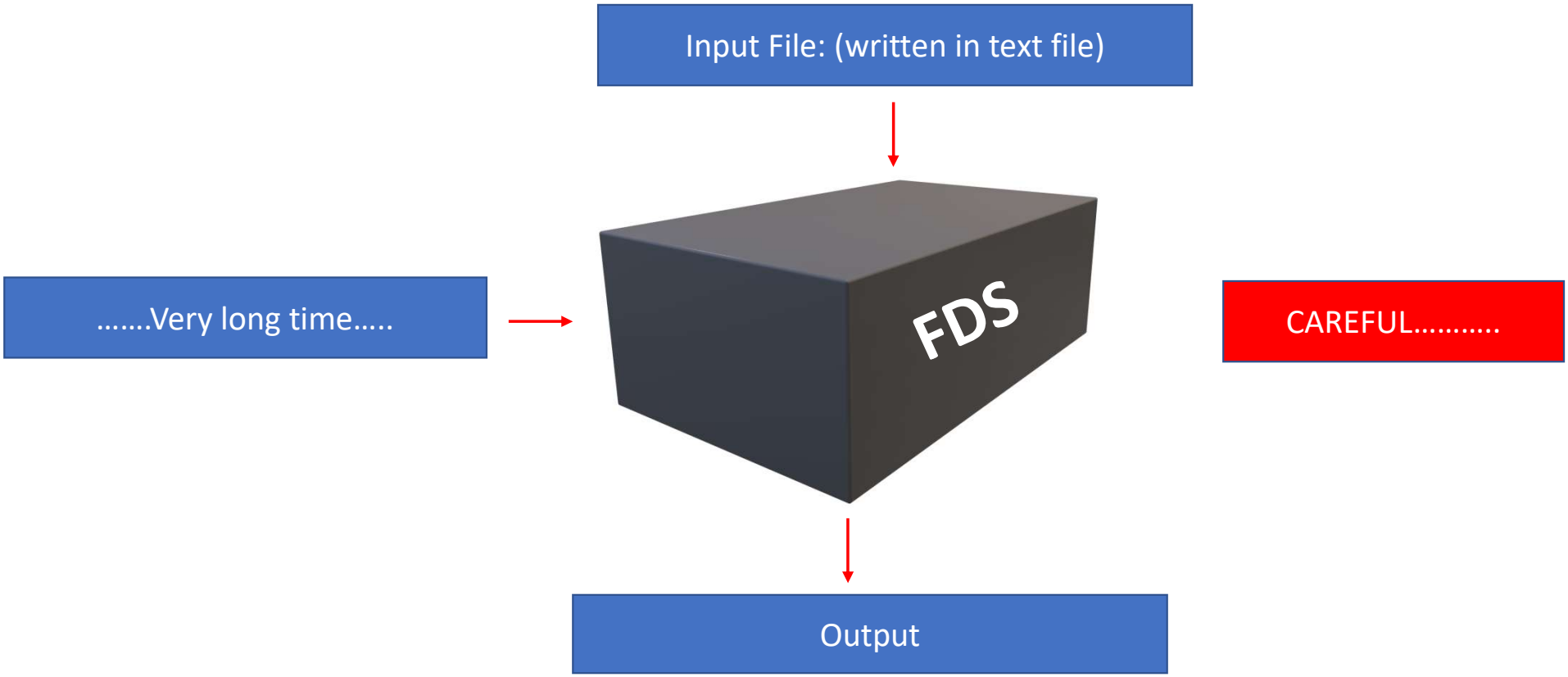


FDS-OpenSEES Coupling





FDS


Input File: (written in text file)
.....Very long time.....
FDS
CAREFUL.....
Output

FDS

- In FDS we have to define ….
  - Geometry
  - Boundary conditions such as fire size (HRRPUA), ignition temperatures
  - Output devices to record data

FDS Input file …….

- FDS is written in Fortran
- Use an existing input file rather than creating a new one from scratch
- CHID – Naming the input file:

// Setup of FDS file

&HEAD CHID='Testing', TITLE='Trial' /

- Meshing

// Grid spacing

&MESH IJK=60,80,30, XB=0.0,6.0,0.0,8.0,0.0,3.0 /

Xi, Xf, Yi, Yf, Zi, Zf

FDS Input file ……..

- Geometry : Walls, furniture, solid boundries etc are defined as Obstruction

  &OBST XB=6.2,6.4,1.6,6.6,0.0,2.4

- Open Boundaries as Vent (Windows, openings etc.)

  &VENT ID='X_Max (Door)', SURF_ID='OPEN', XB=0.75,0.75,0.0,0.45,0.0,1.8/

- Material and Surface definition

  &MATL ID='STEEL' , SPECIFIC_HEAT=0.46, CONDUCTIVITY=45.8, DENSITY=7850.0/

  &SURF ID='Steel', COLOR='GRAY 60', MATL_ID(1,1)='STEEL', MATL_MASS_FRACTION(1,1)=1.0, THICKNESS(1)=1.0E-3/

FDS Input file ……..

- Define fire

&SURF ID='Burner’, COLOR='RED’, HRRPUA=580.0, RAMP_Q='Burner_RAMP_Q’, TMP_FRONT=25.0/

&RAMP ID='Burner_RAMP_Q', T=0.0, F=0.0/

&RAMP ID='Burner_RAMP_Q', T=1.0, F=1.0/

&RAMP ID='Burner_RAMP_Q', T=3599.0, F=1.0/

&RAMP ID='Burner_RAMP_Q', T=3600.0, F=0.0/

FDS Input file …….

- Output data : AST for structural temperature

&DEVC ID='AST1', QUANTITY='ADIABATIC SURFACE TEMPERATURE', XYZ=0.4,0.22,0.3, IOR=-1/

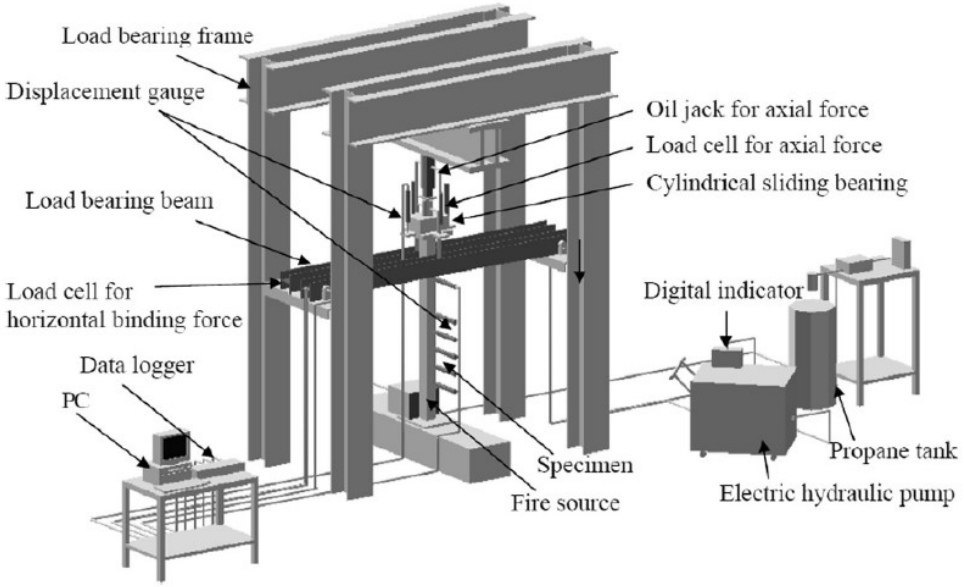
&DEVC ID='HF1', QUANTITY='HEAT FLUX', XYZ=0.4,0.22,0.3, IOR=-1/

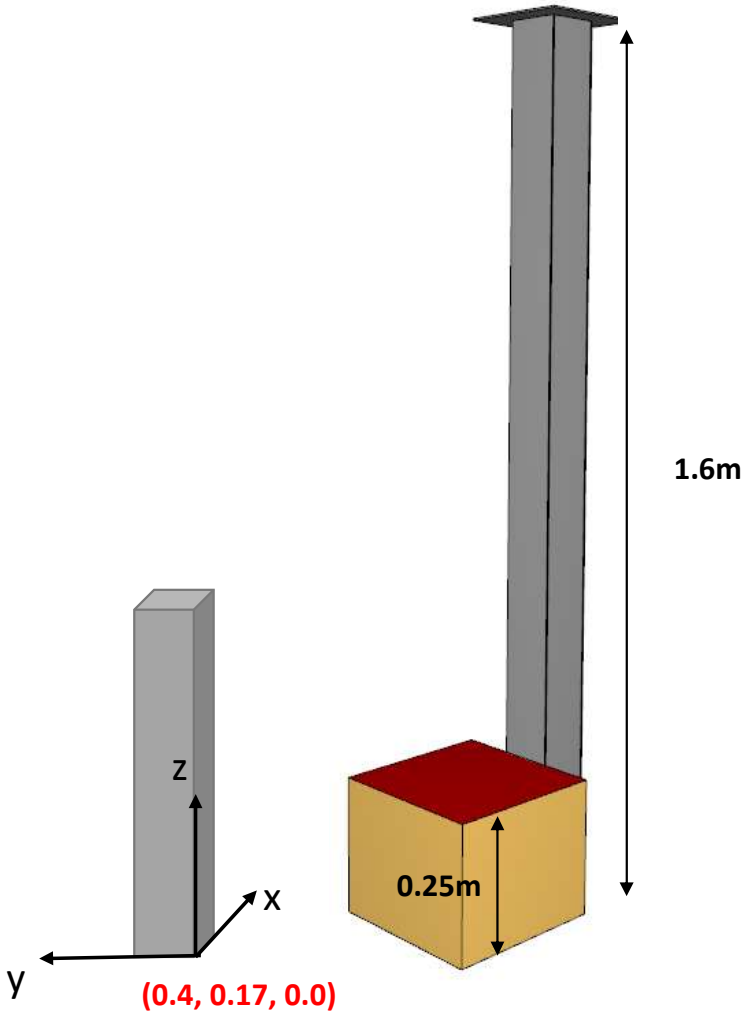
&DEVC ID='HTC1', QUANTITY='HEAT TRANSFER COEFFICIENT', XYZ=0.4,0.22,0.3, IOR=-1/

FDS and OpenSEES

- While defining the models ..
  - Only fire room is present in FDS
  - Global coordinates should be same
  - “Z” axis as vertical direction
  - Structural components are not required in the CFD model
- The common between OpenSEES and FDS is:
  - Device location (Where OpenSEES Heat Transfer entities are defined)

Let's begin….


Load bearing frame
Displacement gauge
Load bearing beam
Load cell for
horizontal binding force
Data logger
PC
Oil jack for axial force
Load cell for axial force
Cylindrical sliding bearing
Digital indicator
Specimen
Fire source
Propane tank
Electric hydraulic pump


1.6m
0.25m
z
x
y
(0.4, 0.17, 0.0)

Let's begin….

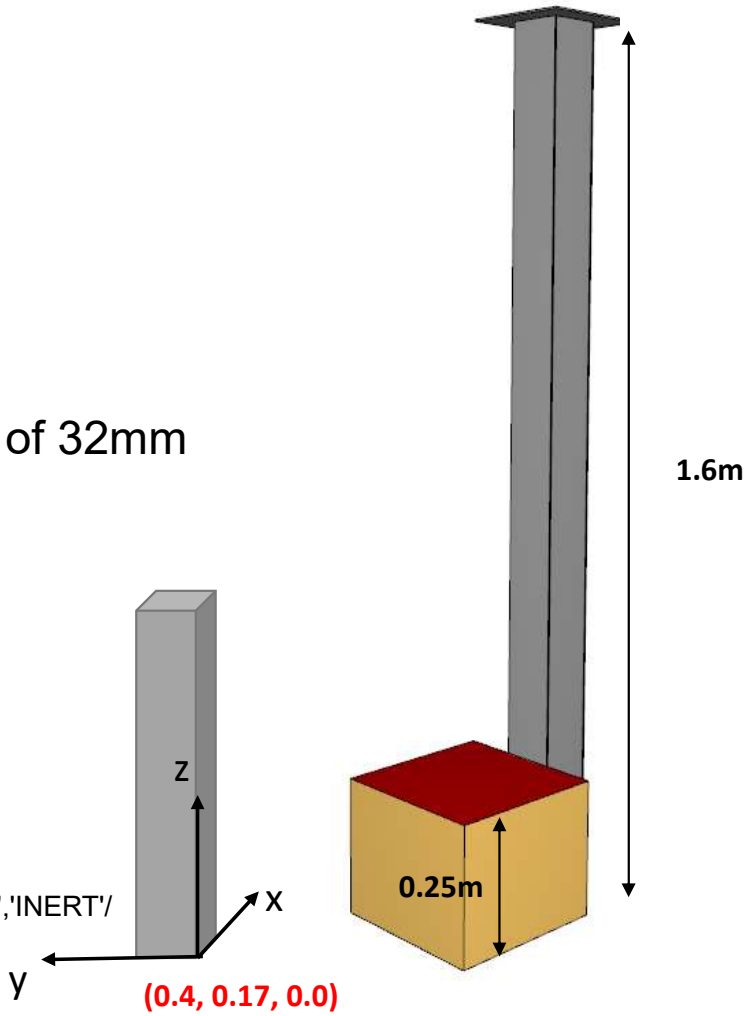
❑FDS File

Build a geometry in FDS

A hollow column 0.1 m thick column with steel thickness of 32mm exposed to fire

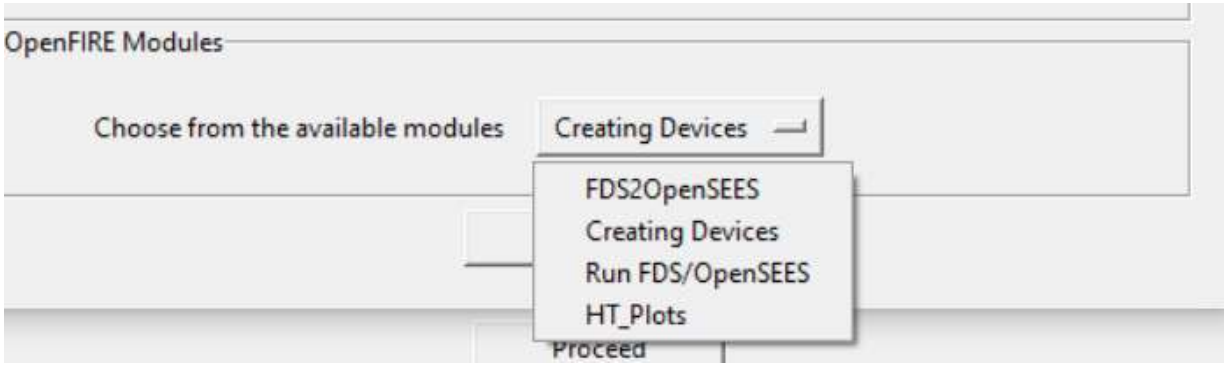
Burner height of 0.25m high

- ❑ &OBST ID='Front', XB=0.4,0.4032,0.17,0.27,0.0,1.6, SURF_ID='Steel'/
- ❑ &OBST ID='Back', XB=0.4968,0.5,0.17,0.27,0.0,1.6, SURF_ID='Steel'/
- ❑ &OBST ID='Side1', XB=0.4032,0.4968,0.17,0.1732,0.0,1.6, SURF_ID='Steel'/
- ❑ &OBST ID='Side2', XB=0.4032,0.4968,0.2668,0.27,0.0,1.6, SURF_ID='Steel'/
- ❑ &OBST ID='Burner', XB=0.1,0.4,0.066,0.366,0.0,0.25, SURF_IDS='Burner', 'INERT','INERT'/
- ❑ &OBST ID='Top', XB=0.35,0.55,0.12,0.32,1.6,1.6032, SURF_ID='Steel'/



Let’s built using GUI!!

- Building Devices and HT Entities
  - From the program choose ‘Creating Devices’

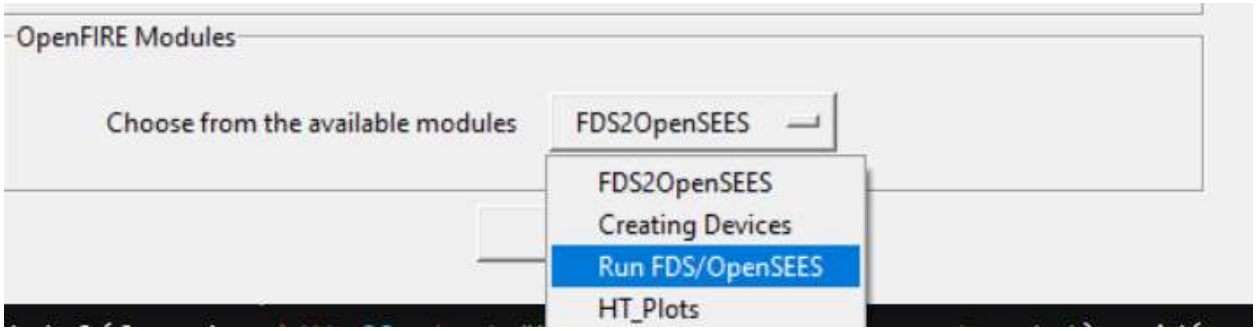


Let’s built using GUI!!

- Finalize both files
  - Append the devices in FDS file
  - Append entities and other information in OpenSEES file

Let’s built using GUI!!

- Transfer DATA from FDS to OpenSEES
  - FDS gives data in CSV format
  - Module “FDS to OpenSEES” to transfer data



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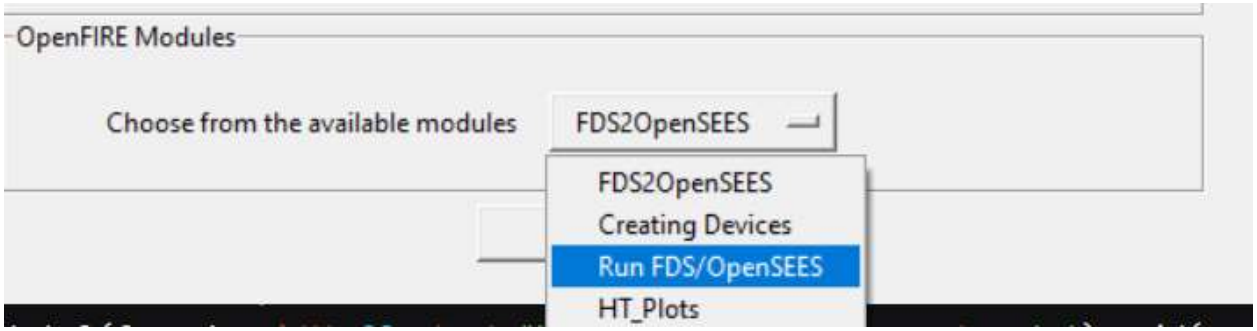
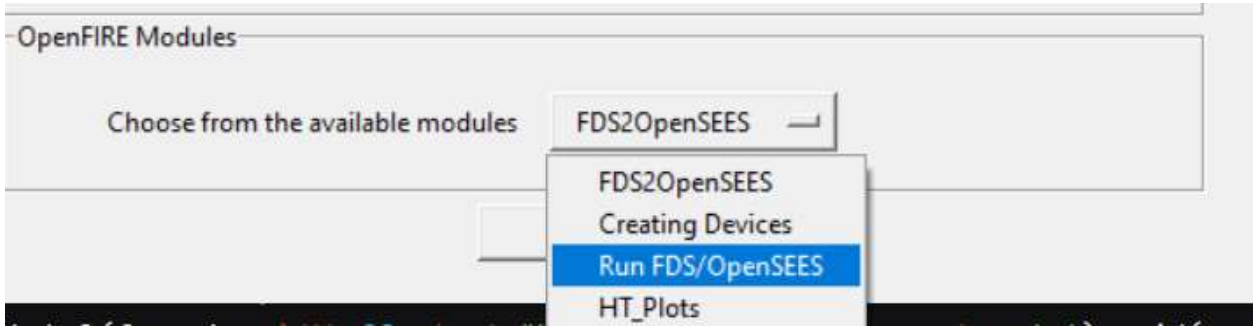
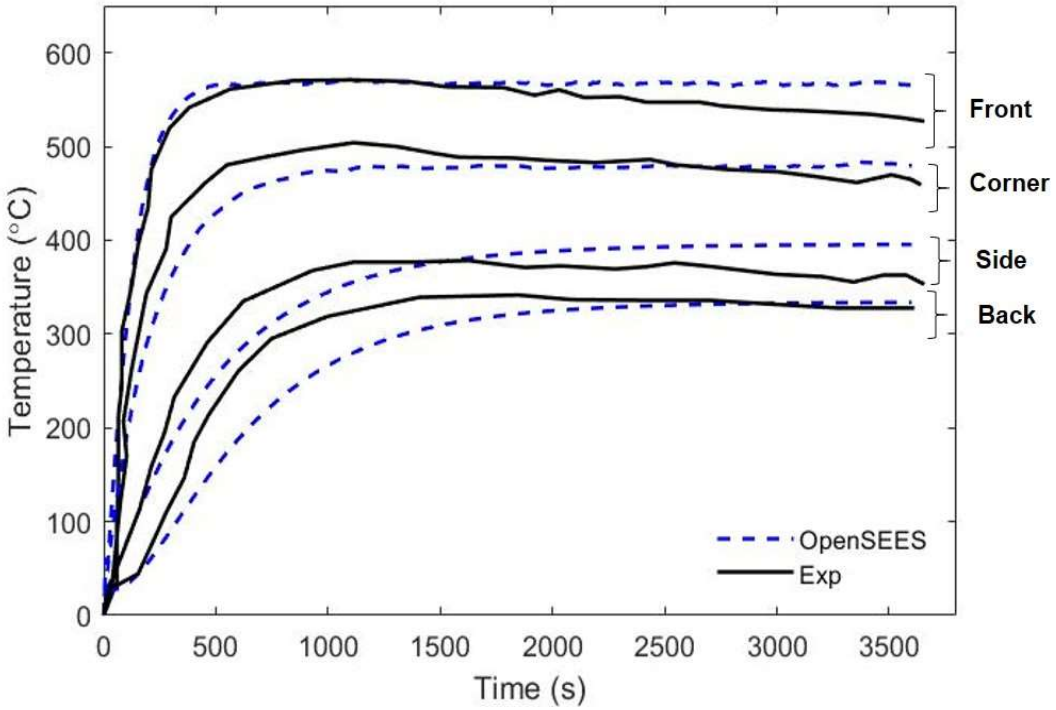


Let’s built using GUI!!

- Running OpenSEES



Let’s built using GUI!!



About me!!

- I am Aatif
- I am PhD Student in The Hong Kong Polytechnic University
- I am developing open source package for conducting CFD-FEM coupling (FDS-OpenSEES)
- I can be contacted : alikhan.aatif@connect.polyu.hk