NEW TECHNOLOGY ON PREDICTIVE STUDIES

CFD FIRE MODELLING FOR BUILDINGS

OVERVIEW OF PRESENTATION

- INTRODUCTION
- MAIN FEATURES OF CFD SOFTWARE
- ENGINEERING PRINCIPLES
- PROCESSES OF CFD ANALYSIS STRUCTURE
- CRITICAL PARAMETERS
- CFD SIMULATIONS IN FIRE SCENARIO
- CONCLUSIONS

INTRODUCTION

- ✓ **CFD MODEL SIMULATION IS AN ENGINEERING-APPROACH METHODOLOGY IN PREDICTING BEHAVOIR OR EVENT OCCURRENCE GIVEN A SET OF INPUT PARAMETERS FOR AN ASSUMED SET OF BOUNDARY CONDITIONS.**

INTRODUCTION

- ✓ **MANY APPLICATIONS ACROSS A DIVERSE INDUSTRIES SUCH AS BUILDING, AERONAUTICAL, MEDICAL, ENVIRONMENTAL, MANUFACTURING AND MANY OTHERS CAN ADOPT CFD MODEL SIMULATIONS.**

INTRODUCTION

- ✓ **A COST-EFFECTIVE METHODOLOGY IN EVALUATING A POSSIBLE OR AN OPTIMISED SOLUTION TO A COSTLY ISSUE OR PROBLEM IF IT IS ACTUALLY BUILT FOR TESTING OR EVALUATION.**

FEATURES OF CFD SOFTWARE

- 2-D & 3-D GEOMETRIES
- COMBUSTION MODELLING
- CHEMICAL REACTION
- SPECIES MODELLING
- PARTICLES TRACKING
- RADIATION MODELLING
- SINGLE OR MULTI-PHASE FLOW
- NON-NEWTONIAN FLOW

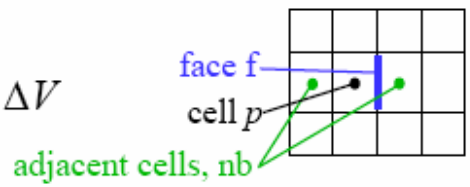
ENGINEERING PRINCIPLES

- CONSERVATION OF ENERGY
- CONSERVATION OF MASS
- CONSERVATION OF MOMENTUM

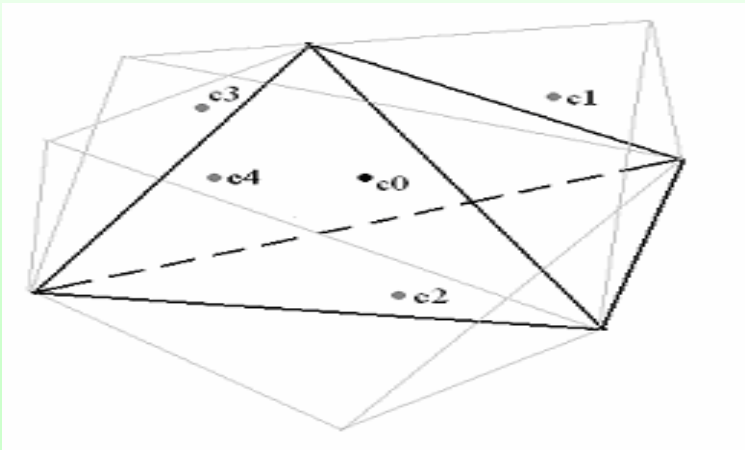
ENGINEERING PRINCIPLES

- General conservation (transport) equation for mass, momentum, energy, turbulence, species, etc.
- For the conservation equation for variable Φ, the following steps are taken:
  - Integration of conservation equation in each cell.
  - Calculation of face values in terms of cell-centered values.
  - Collection of like terms.

$$\frac{\left(\rho\phi_p\right)^{t+\Delta t}-\left(\rho\phi_p\right)^{t}}{\Delta t}\Delta V+\sum_{\text{faces}}\rho_f\,\phi_f\,V_f\,A_f=\sum_{\text{faces}}\Gamma_f\left(\nabla\phi\right)_{\perp,f}\,A_f+S_\phi\,\Delta V$$



ENGINEERING PRINCIPLES



- Finite Volume Method
- Domain Discretized into CV's
- Integral Form of Equations Applied
- Commercial Code Used (Fluent)

$$\iiint_{\Omega}\left[\int_{t}^{t+\Delta t}\rho\frac{\partial\phi}{\partial t}dt\right]d\Omega+\int_{t}^{t+\Delta t}\sum_{j}\left[\oiint_{Sj}\left[\rho\vec{V}\phi\right]d\vec{S}\right]dt-\int_{t}^{t+\Delta t}\sum_{j}\left[\oiint_{Sj}\left[\Gamma_{\phi}\nabla\phi\right]d\vec{S}\right]dt=\int_{t}^{t+\Delta t}\left[\iiint_{\Omega}S_{\phi}d\Omega\right]dt$$

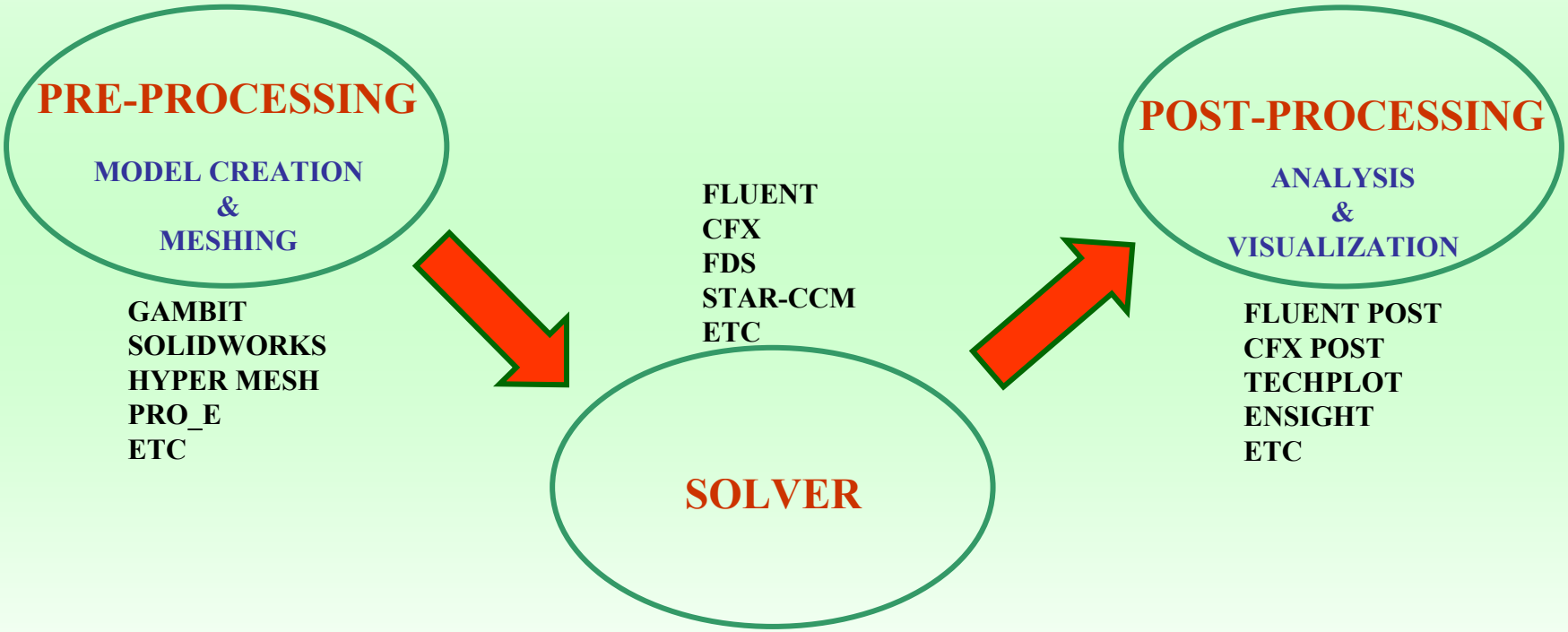
Rate of Increase of ϕ of CV

Net Rate of Decrease of ϕ due to Convection Across Boundaries of CV

Net Rate of Increase of ϕ due to Diffusion Across Boundaries of CV

Rate of Creation of ϕ in CV

PROCESSES OF CFD ANALYSIS STRUCTURE



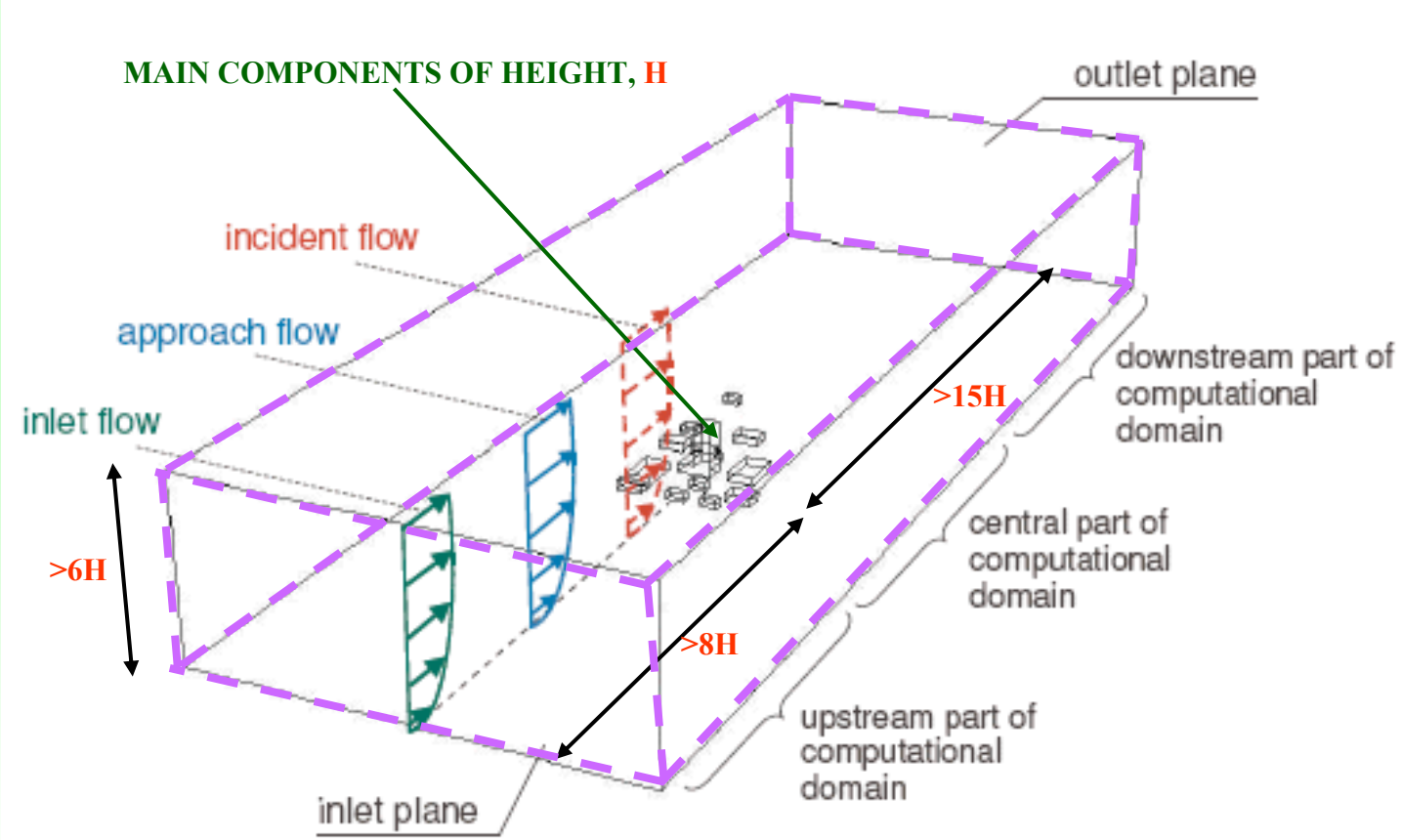
CRITICAL PARAMETERS

- GEOMETRY OF 3-D MODEL
- FIRE MESH SIZE (15 TO 20CM)
- DOMAIN MESH SIZE (20 TO 50CM)
- MESH SKEWNESS (<0.85)
- TURBULENCE MODEL & ITS PARAMETERS
- MV FLOW RATES

CRITICAL PARAMETERS

- JET FANS (RECIRCULATION INLET/OUTLET)
- WIND SPEED & DIRECTION (~2 M/S NNE & SSW)
- FIRE SIZE (HEAT & SOOT RELEASE RATES)
- OTHER BOUNDARY CONDITIONS
- CONVERGENCE

CRITICAL PARAMETERS

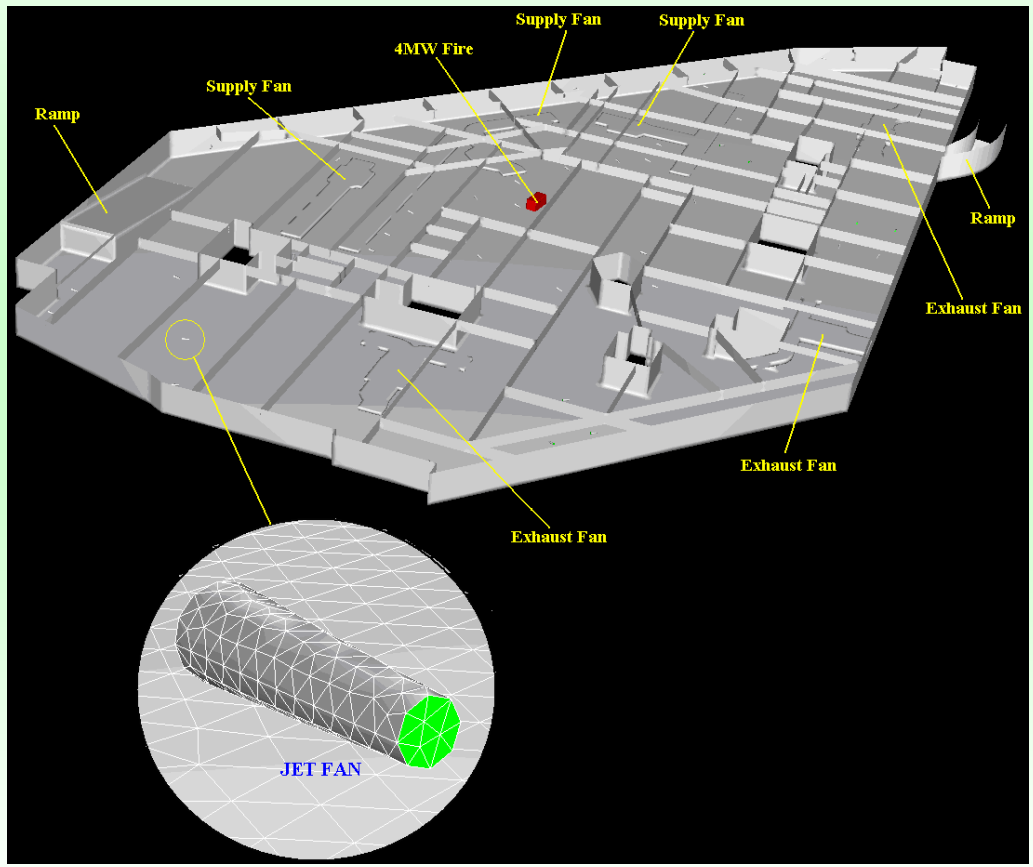


CFD SIMULATIONS IN FIRE SCENARIO

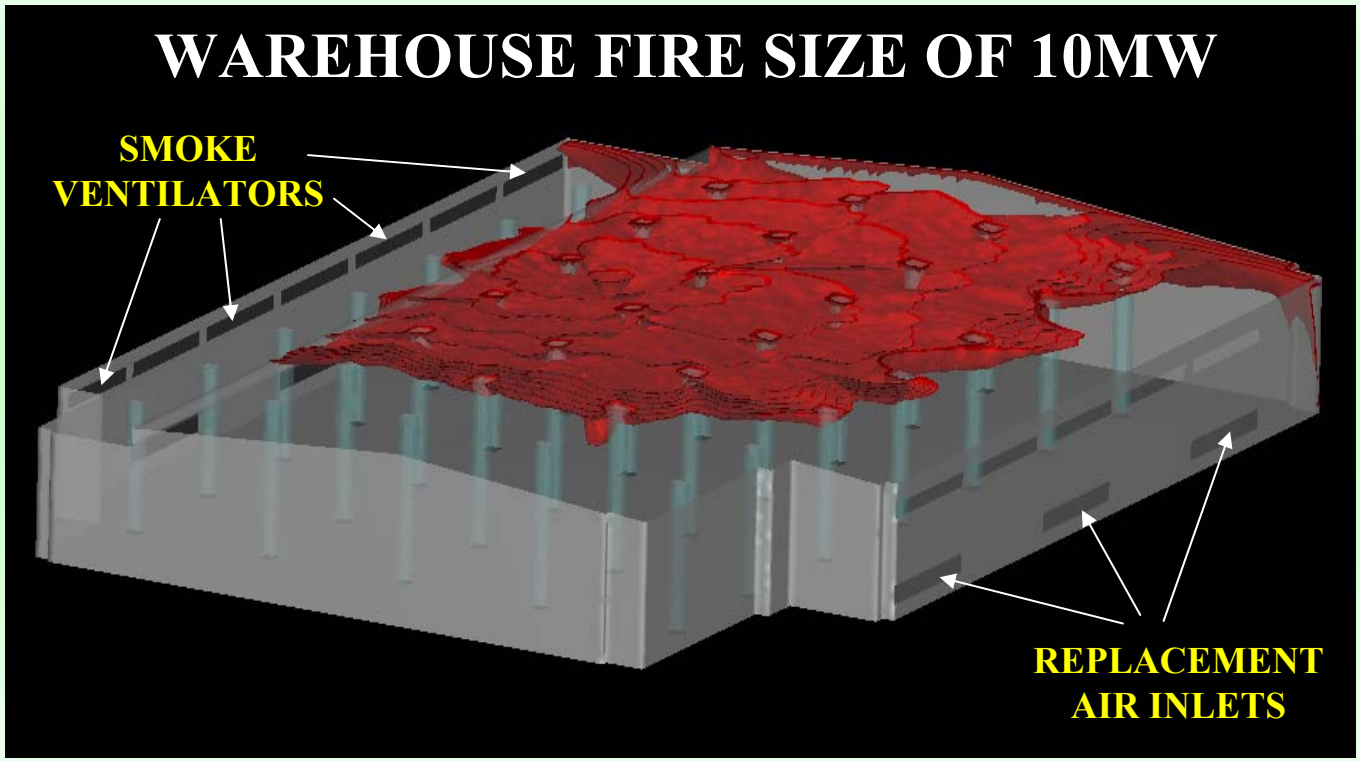
- ✓ DUCTLESS JET FAN MV SYSTEM FOR CARPARKS
- ✓ ENGINEERED SMOKE CONTROL SYSTEM FOR WAREHOUSE
- ✓ RADIANT HEAT FLUX ON SITE BOUNDARY FOR PETROL KIOSK

CFD SIMULATIONS IN FIRE SCENARIO

- VOLUMETRIC HEAT & SMOKE MODELLING OF A 4MW CAR FIRE.
- TRANSCIENT SIMULATION FOR 2 MINS WITH MV SYSTEM IN NORMAL MODE & A FURTHER 18 MINS AT FIRE MODE.
- AFTER 20 MINS OF THE SIMULATED FIRE SCENARIO, ACCEPTANCE CRITERION TO BE ; FOR VISIBILITY BELOW 5 METRES MUST BE < 1000 M^2 & FOR TEMPERATURE MUST BE < 250^0C (EXCEPT AT NEAR VICINITY OF FIRE ORIGIN.



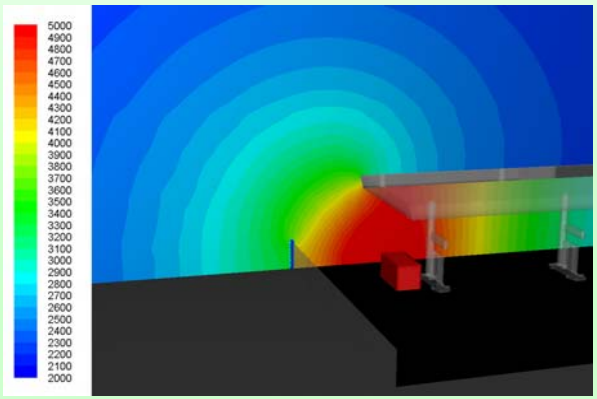
CFD SIMULATIONS IN FIRE SCENARIO

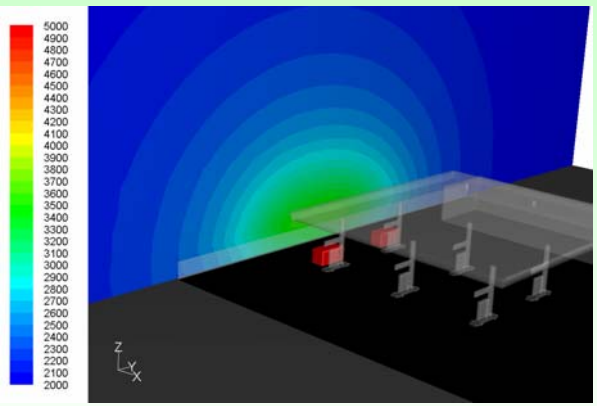


✓AUTOMATIC SMOKE VENTILATORS TRIGGERED TO OPEN BY SMOKE DETECTORS
- TIME TAKEN FOR SMOKE LAYER TO REACH 2.5METRES (ABOVE HUMAN HT) = 15 MINS
- TIME REQUIRED FOR EVACUATION (BY EVACUATION SIMULATION MODEL) = 2 MINS

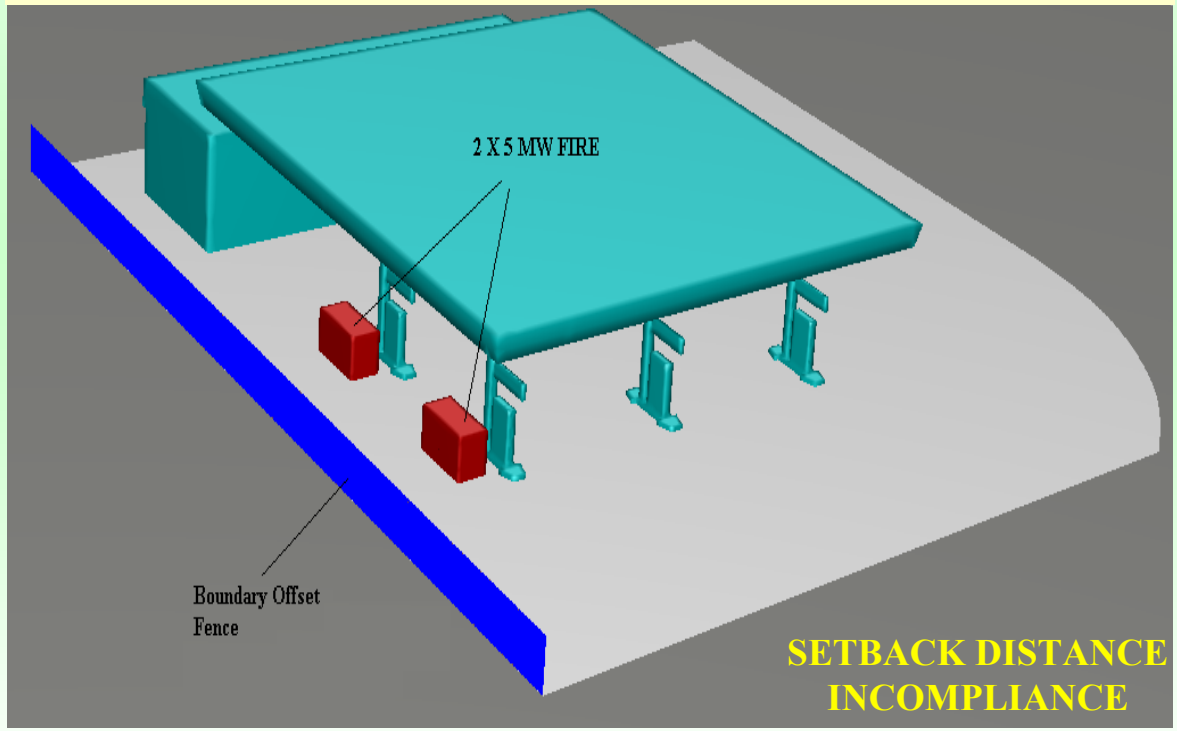
✓SAFETY FACTOR (ASET/RSET) > 2 TIMES

CFD SIMULATIONS IN FIRE SCENARIO





2 SIMULTANEOUS CAR FIRES @ PETROL KIOSK



CONCLUSIONS

- ✓ **CFD SIMULATIONS CAN PROVIDE GOOD PREDICTION OF A PARTICULAR DESIGN SOLUTION TO AN ISSUE OR A PROBLEM**

- ✓ **CFD SIMULATIONS CAN BE BENEFICIAL IN TERMS OF TIME & COST IMPACTS IF COMPARED TO BUILDING AN ACTUAL DESIGN FOR TESTING OR EVALUATION**