



FIRE DYNAMICS IN INFORMAL SETTLEMENTS

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(Sullivan photography)

OVERVIEW OF PRESENTATION

- Background on informal settlement fires
- Imizamo Yethu case study
- Enclosure fire dynamics in terms of ISDs
- Standardized ISD burn test
- Test results of full-scale burn tests
- Two zone modelling of ISDs
- Preliminary CFD modelling of ISDs

BACKGROUND

- **WHAT IS A SHACK?** An unplanned settlement on land which has not been surveyed or proclaimed as residential, consisting mainly of informal dwellings.
- **THESE DWELLINGS ARE CHARACTERISED BY:**
 - Scarce water and sanitation
 - Poor health and education
 - Inadequate structures
 - Lack basic services

These poor living conditions leave the population that reside in informal settlements extremely vulnerable to fires.



BACKGROUND

INFORMAL SETTLEMENTS ARE SPONTANEOUSLY EMERGING AS DISTINCT AND DOMINANT COMMUNITIES



Greater Khayelitsha 2014/07/30
(Google Earth, 2018)

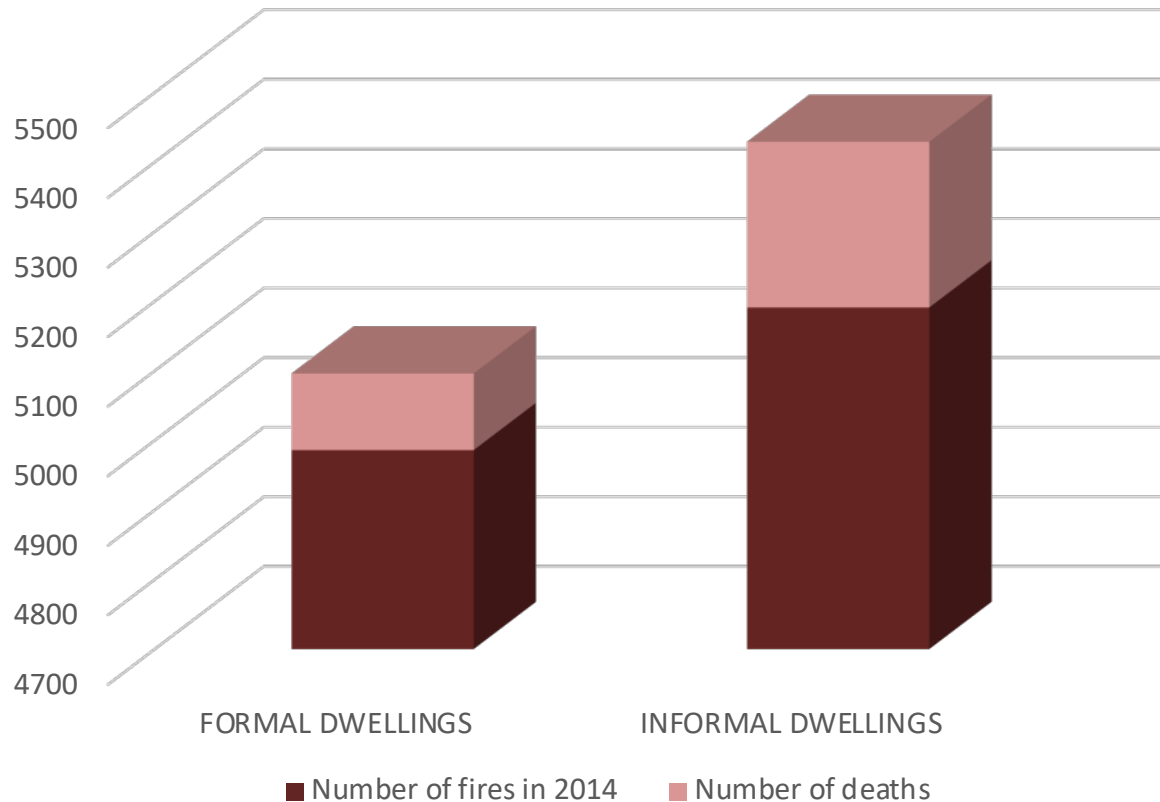


Greater Khayelitsha 2015/07/30
(Google Earth, 2018)

BACKGROUND

FIRES IN INFORMAL DWELLINGS VS FIRES IN FORMAL DWELLINGS

According to National Statistics from FPASA (2014 stats were published in 2016)



BACKGROUND

Date	Settlement Name	Affected dwellings	Fatalities
14-Nov-17	Foreman Road informal settlement	1000 shacks, 3000 displaced	2 deaths
27-Oct-17	Skietpoort informal settlement	80 shacks	1 death
22-Oct-17	Primrose informal settlement	50 shacks	No deaths
19-Jun-17	Vrygrond	10 shacks, 25 displaced	No deaths
15-May-17	Khayelitsha	3 shacks	1 death
14-May-17	Nomzamo, in the Strand	7 shacks, 16 displaced	1 death
16-Apr-17	Imizamo Yethu	100 shacks, 300 displaced	1 death
7-Apr-17	Nomzamo	18 displaced	5 deaths
12-Mar-17	Imizamo Yethu	2194 shacks	3 deaths

(Kahanji et. al, 2018)

IMIZAMO YETHU FIRE – 11 MARCH 2017

- Summary of the incident:
 - 2197 structures destroyed
 - Four fatalities
 - 9700 people left homeless / displaced
 - Extensive damage to the local infrastructure (electrical, water, sanitation and road).
 - Cost of damage to be finalised but expected to be in well in excess of \$10 million damage.

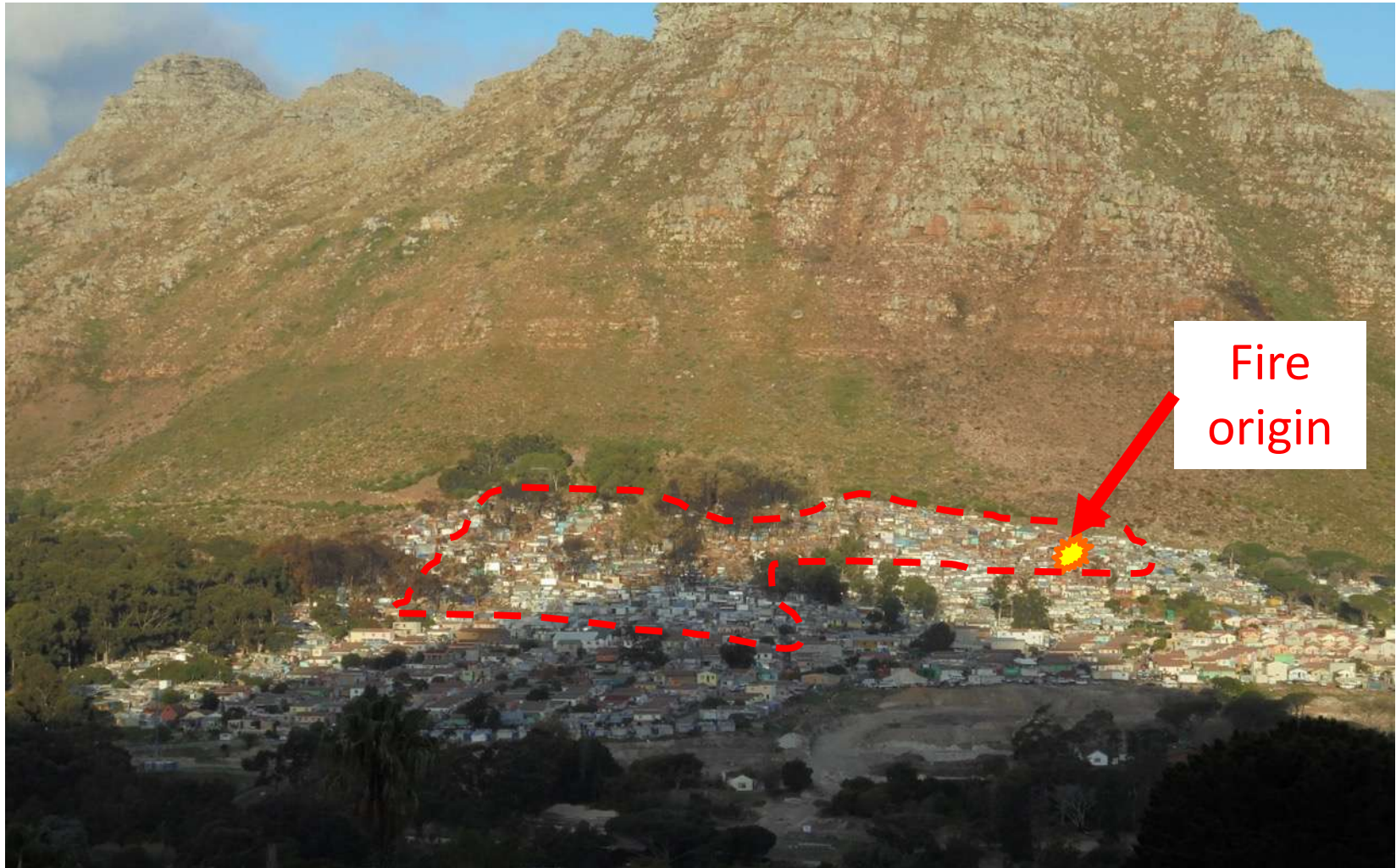
(Walls, 2018)

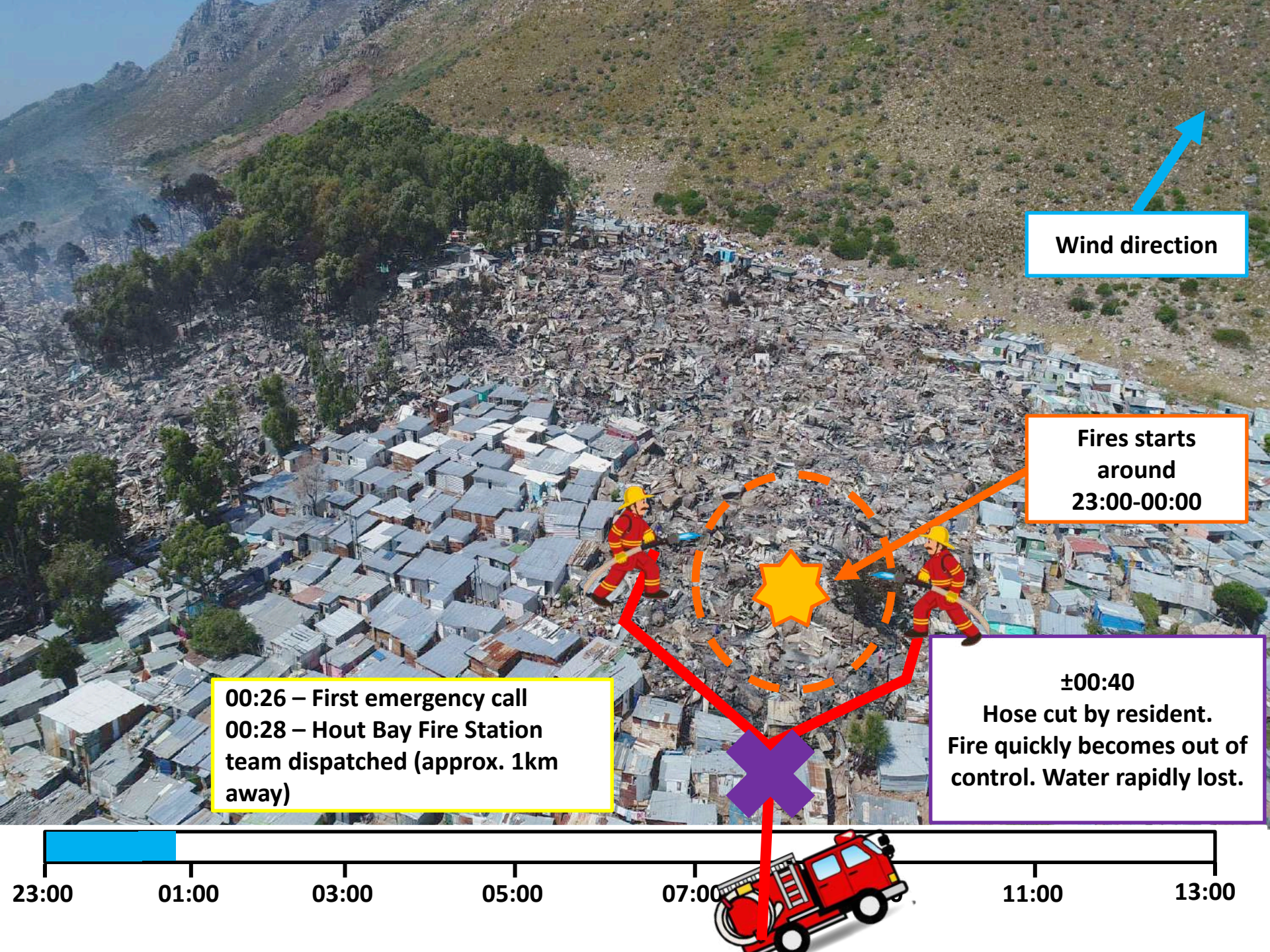
IMIZAMO YETHU FIRE – 11 MARCH 2017

- Response effort:
 - No. of firefighters: 176
 - No. of helicopters: 2
 - Duration of fire: ± 13.5 hours
 - Total area burnt: ± 19 acres

(Walls, 2018)

IMIZAMO YETHU FIRE – 11 MARCH 2017



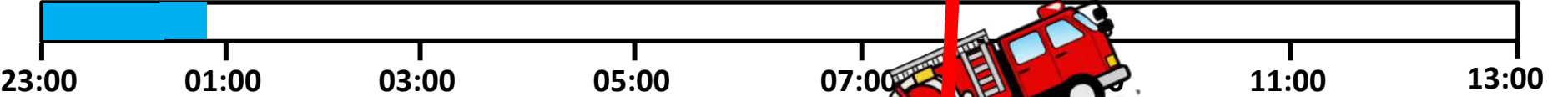


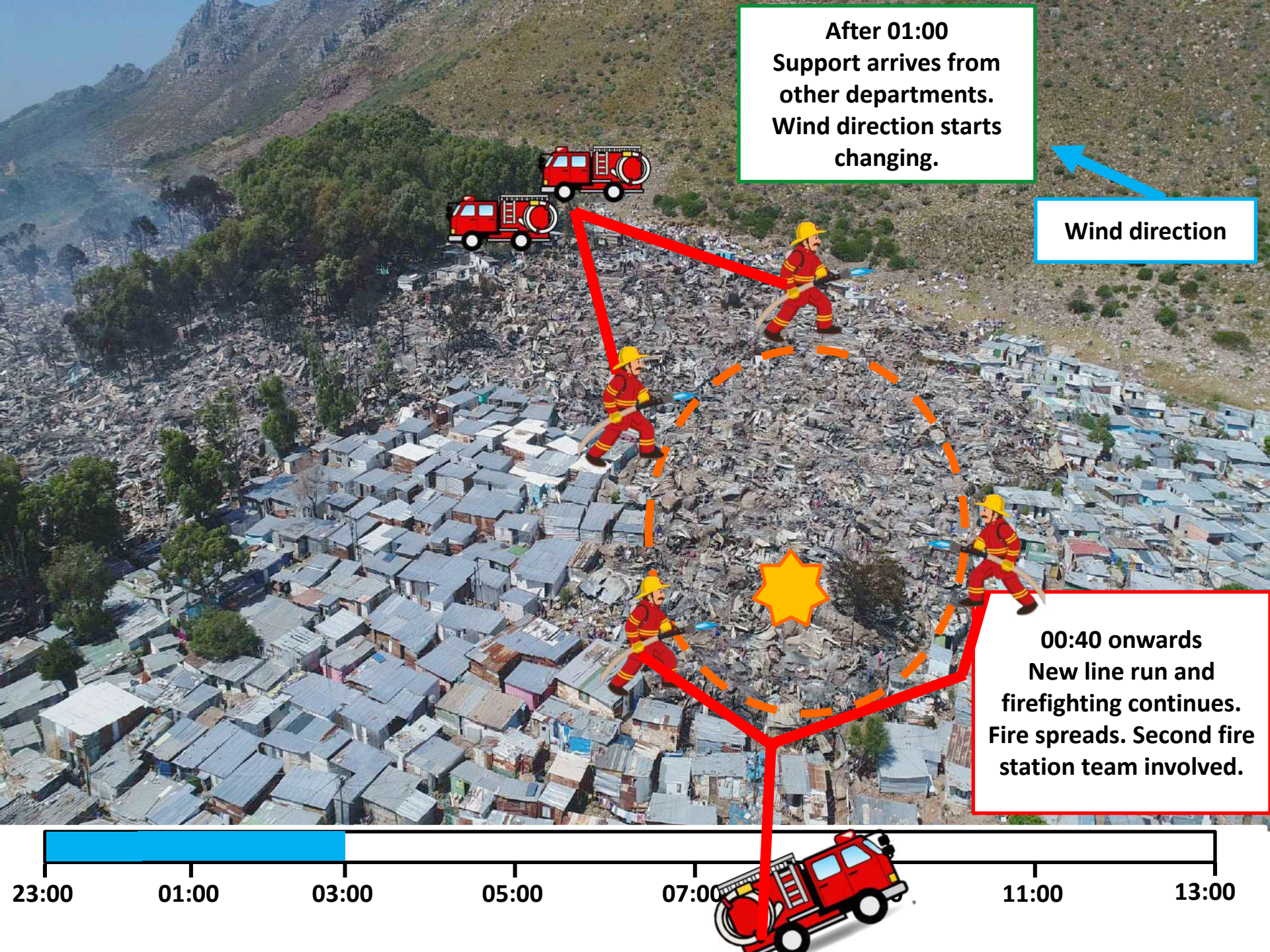
Wind direction

Fires starts around 23:00-00:00

00:26 – First emergency call
00:28 – Hout Bay Fire Station team dispatched (approx. 1km away)

±00:40
Hose cut by resident.
Fire quickly becomes out of control. Water rapidly lost.

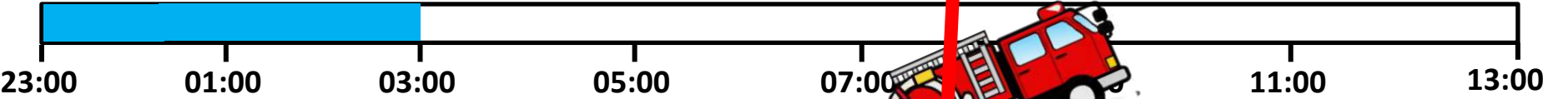


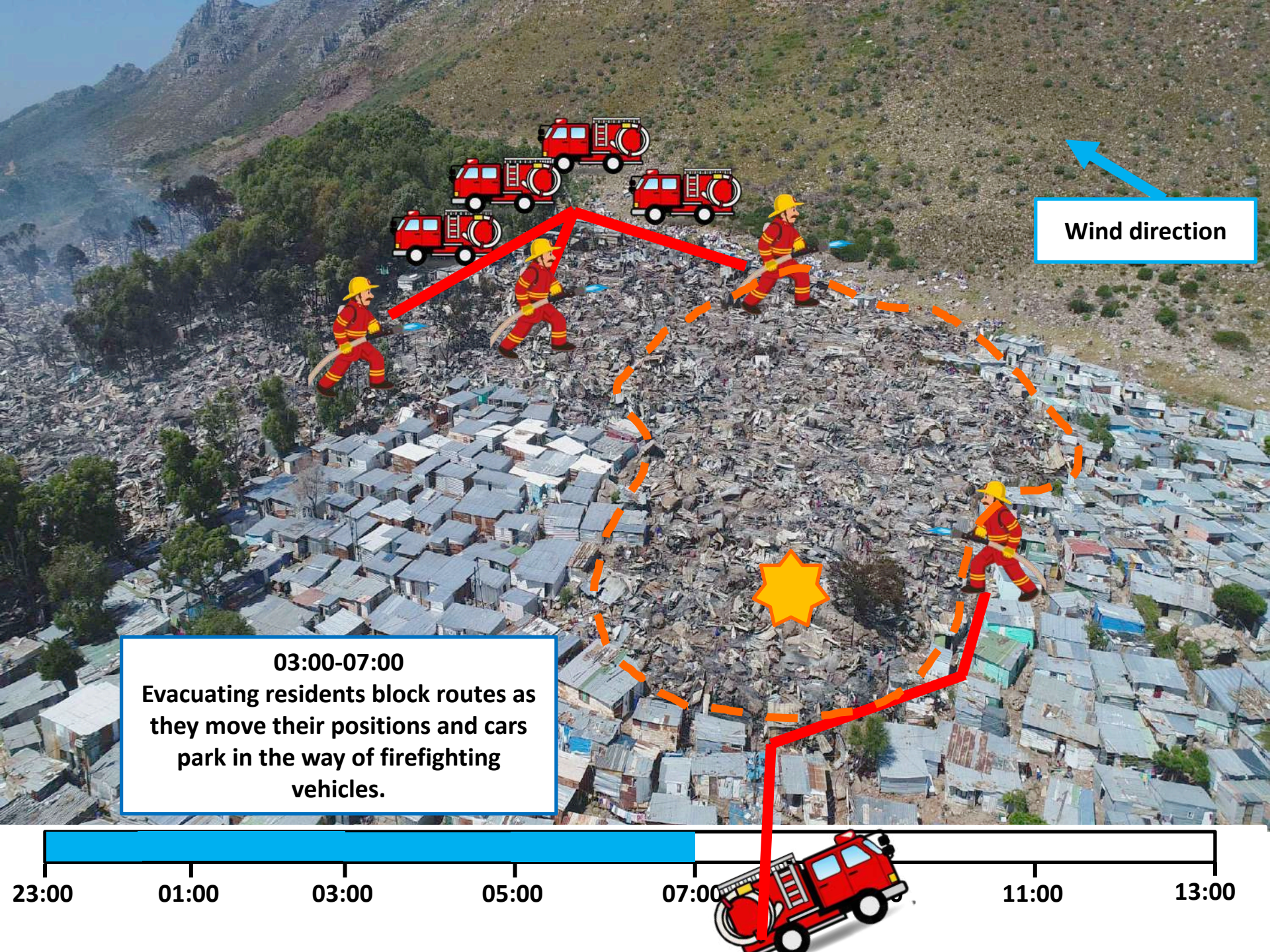


**After 01:00
Support arrives from
other departments.
Wind direction starts
changing.**

Wind direction

**00:40 onwards
New line run and
firefighting continues.
Fire spreads. Second fire
station team involved.**





Wind direction

03:00-07:00
Evacuating residents block routes as they move their positions and cars park in the way of firefighting vehicles.



07:30-09:00

**Fire moves downslope,
propelled by wind. Terrain
makes access difficult**



Wind direction

±07:30

**Fire line reaches trees which
catch fire. Fire spreads
rapidly and becomes
extremely intense.**



09:00-13:00
Aerial operations with
water bombing.

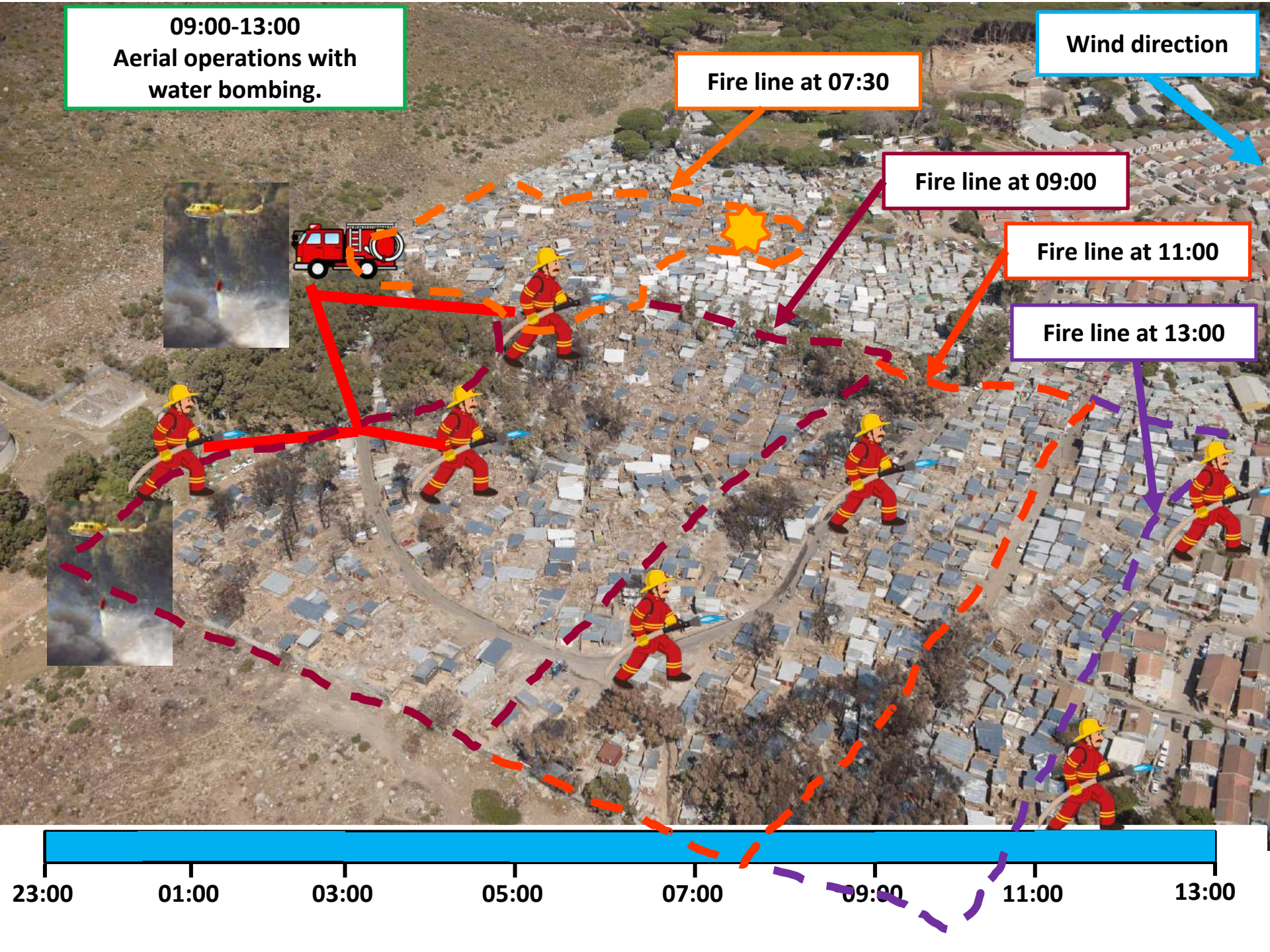
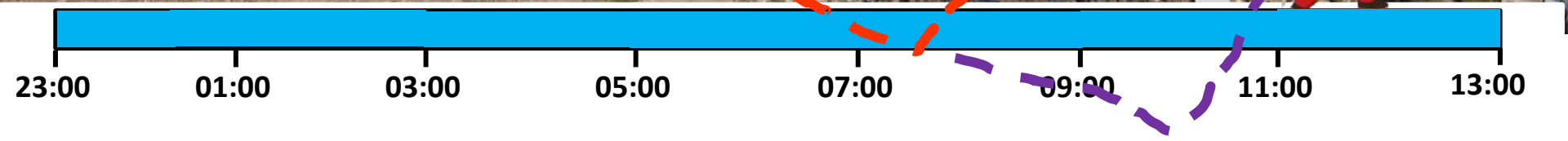
Wind direction

Fire line at 07:30

Fire line at 09:00

Fire line at 11:00

Fire line at 13:00





@HeydersRyan

Photos used permission of Ryan Heydenrych (Vulcan Wildfire Services)



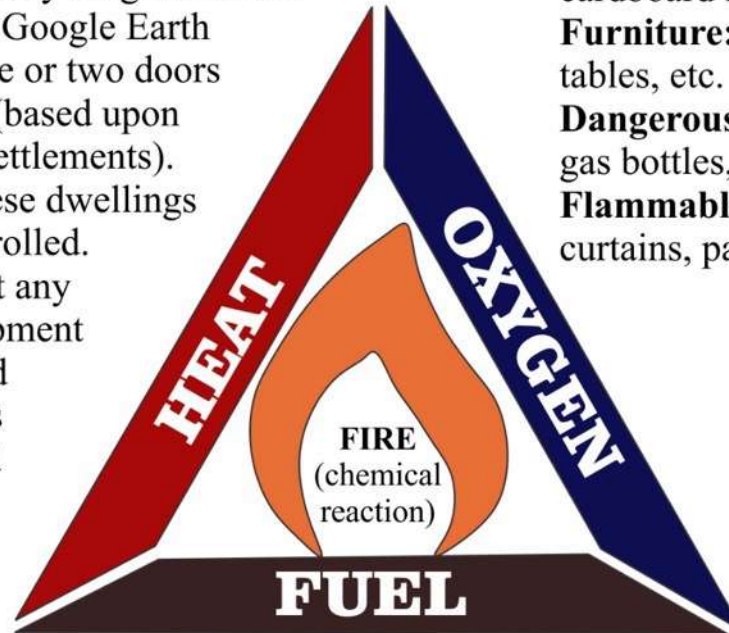
@HeydersRyan

Photos used permission of Ryan Heydenrych (Vulcan Wildfire Services)

ENCLOSURE FIRE IN TERMS OF ISDs

Ventilation conditions in ISDs

The floor area of ISDs typically range between 5m² and 30m² (verified with Google Earth Data) and typically have one or two doors and windows, respectively (based upon authors' visits to informal settlements). The above indicates that these dwellings are usually ventilation controlled. However, this can change at any stage during a fire's development as a result badly constructed walls dislodging walls. This phenomenon was witnessed during the full-scale tests.



Common fuel in ISDs

The structure: Timber frame, cladding, cardboard insulation

Furniture: Beds, couches, carpet, TV sets, tables, etc.

Dangerous substances: Paraffin, gas bottles, stored alcohol

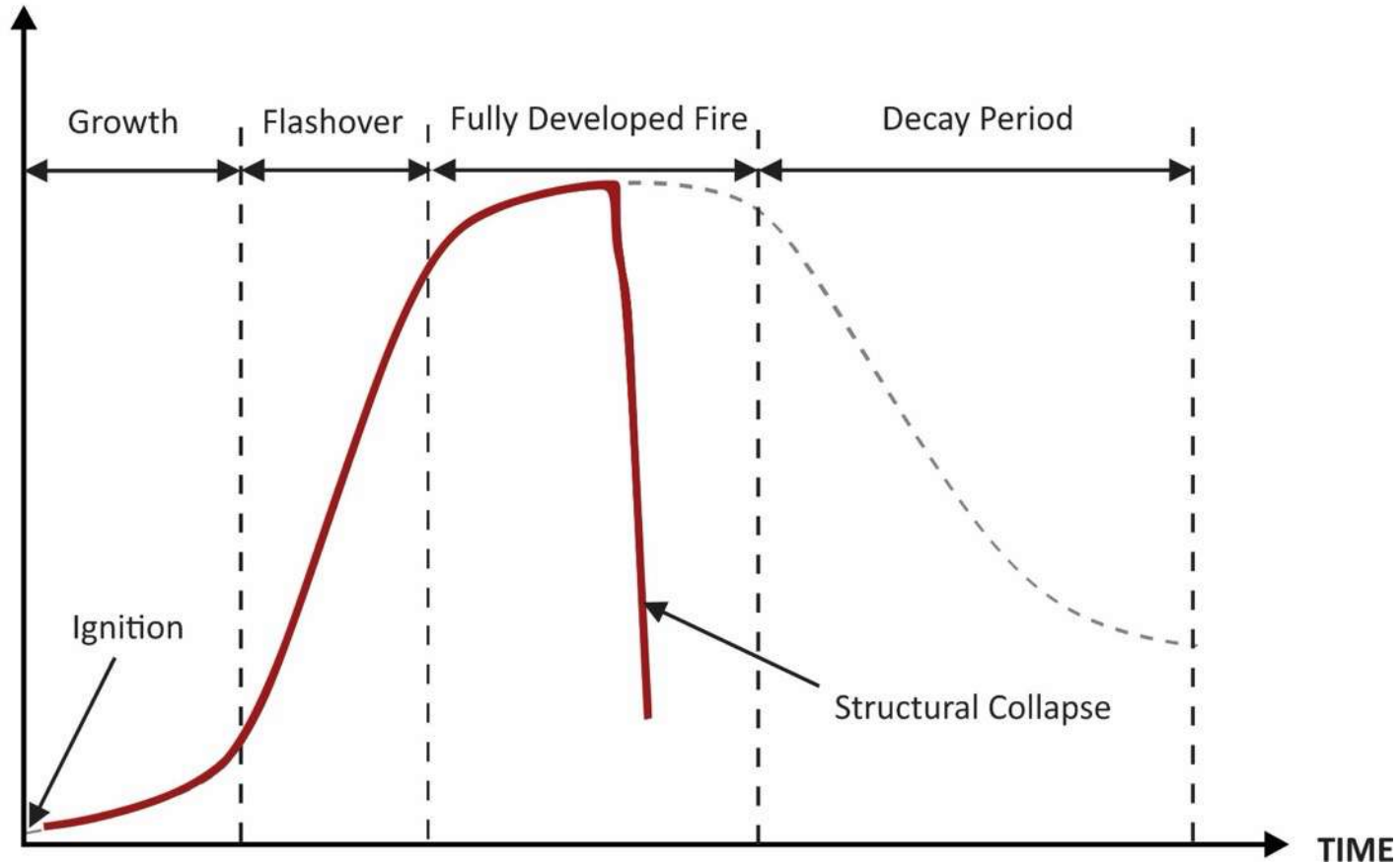
Flammable materials: Clothing, curtains, paper, etc.

ISDs capacity to retain heat

Timber cladding retains heat better compared to the thin sheeting, which allows heat to radiate out faster. However in the case of a fire, the timber cladding will contribute towards the fuel load

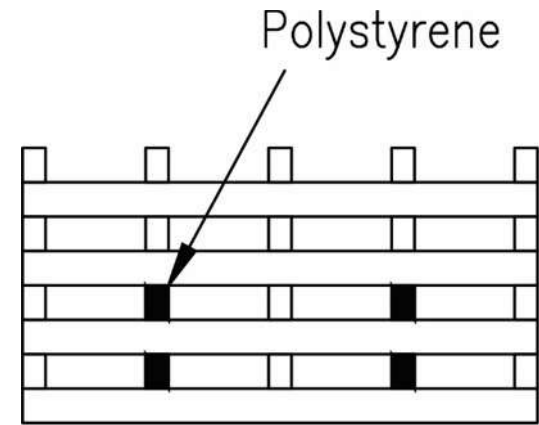
ENCLOSURE FIRE IN TERMS OF ISDs

TEMPERATURE

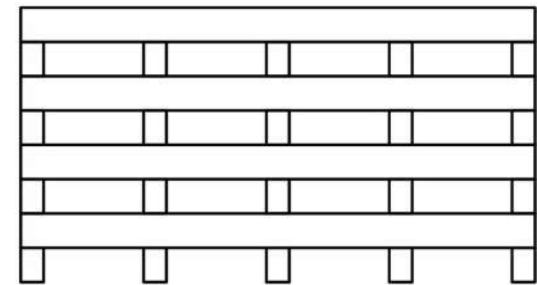


STANDARDIZED ISD

- **FUEL LOAD: 45 kg/m² according to EU Code**



Front View



Side View

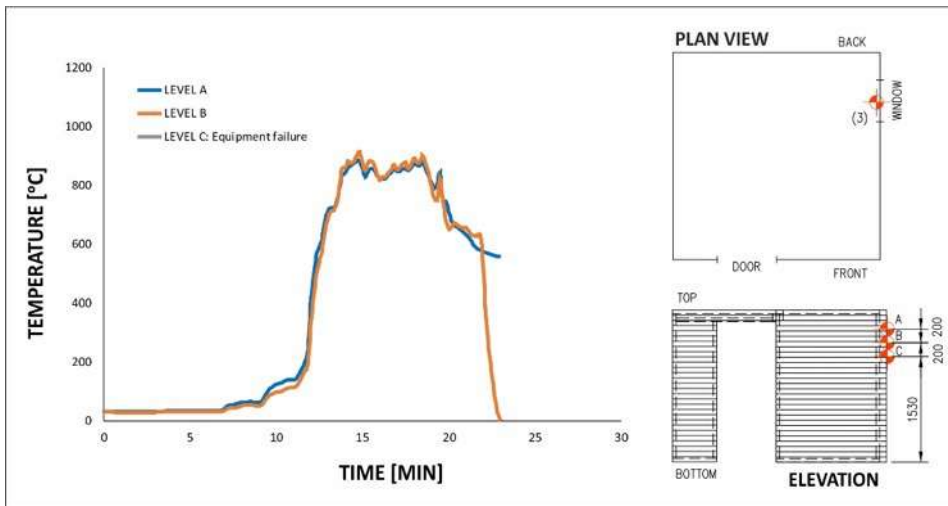
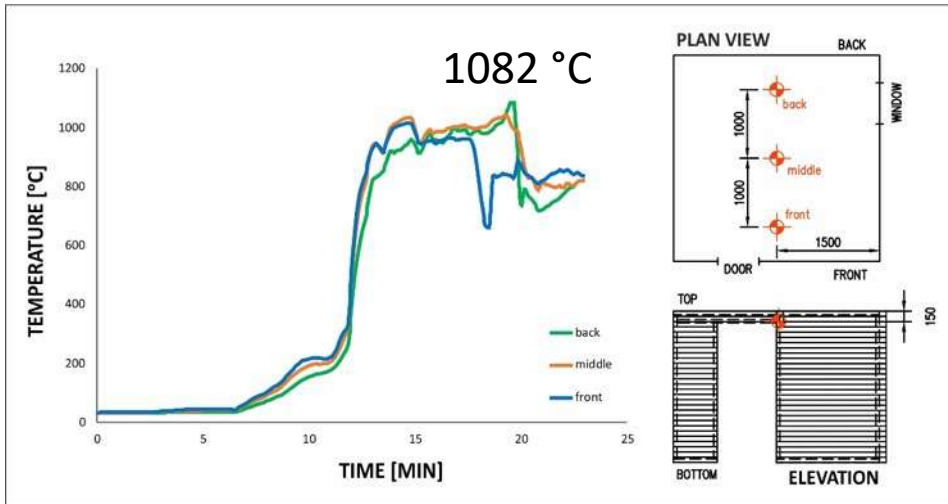
STANDARDIZED ISD

- **WHY USE A STANDARDIZE ISD?**

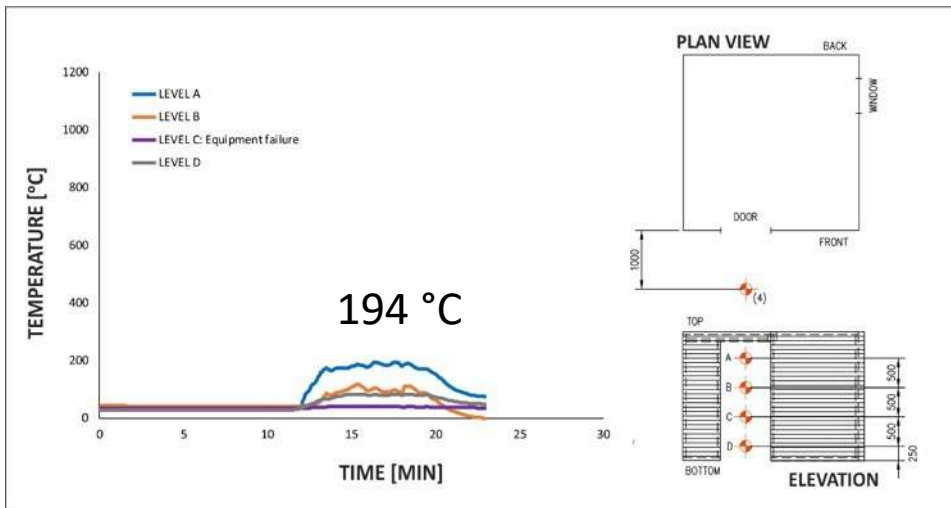
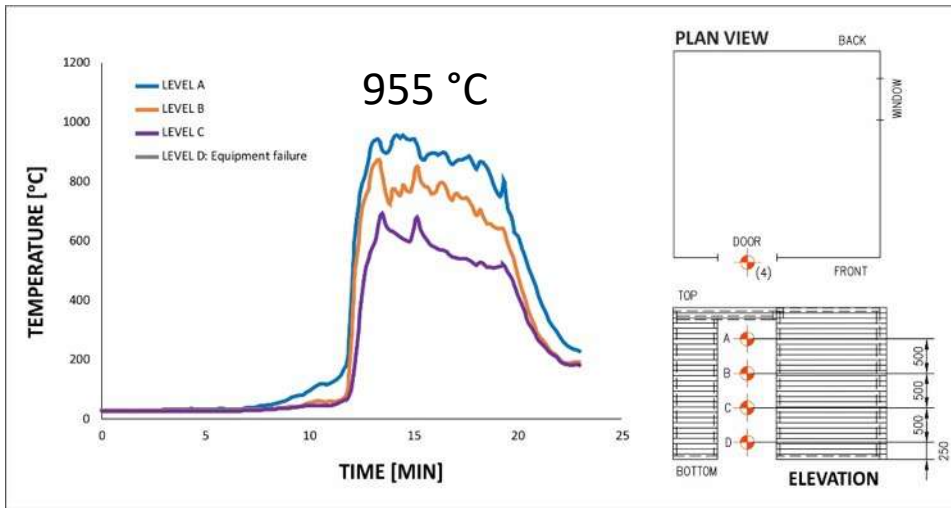
- To develop a benchmark.
- Repeatable
- To create a burn test that can be executed anywhere in the world.
- To test new solutions/innovations (intumescent paints etc.) and compare the results to the standard test.
- To prevent industries from setting up a test to suit their product(s).
- To prevent unpractical solutions.
- To compare results to CFD models



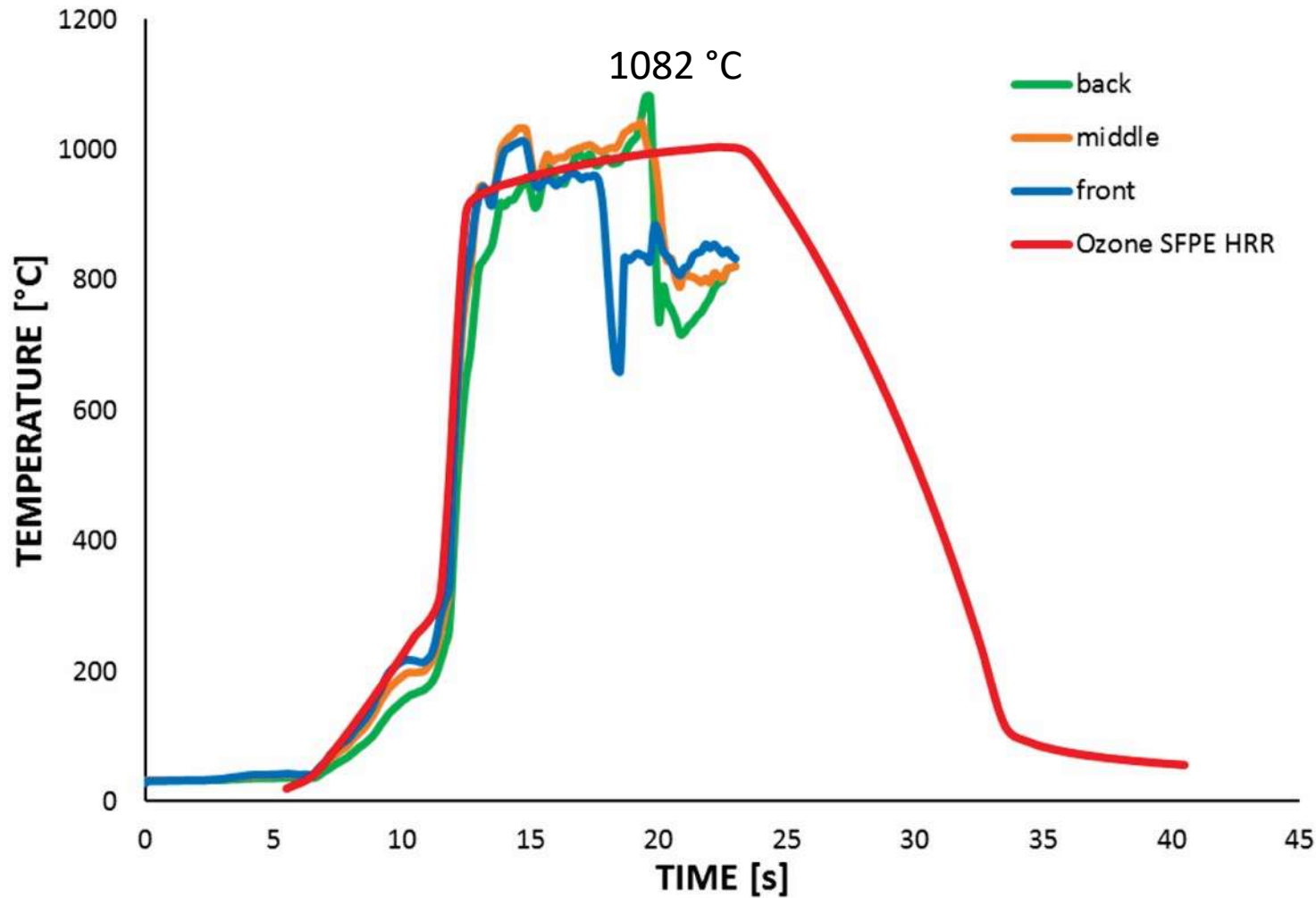
RESULTS: SINGLE STEEL SHEETING ISD



RESULTS: SINGLE STEEL SHEETING ISD



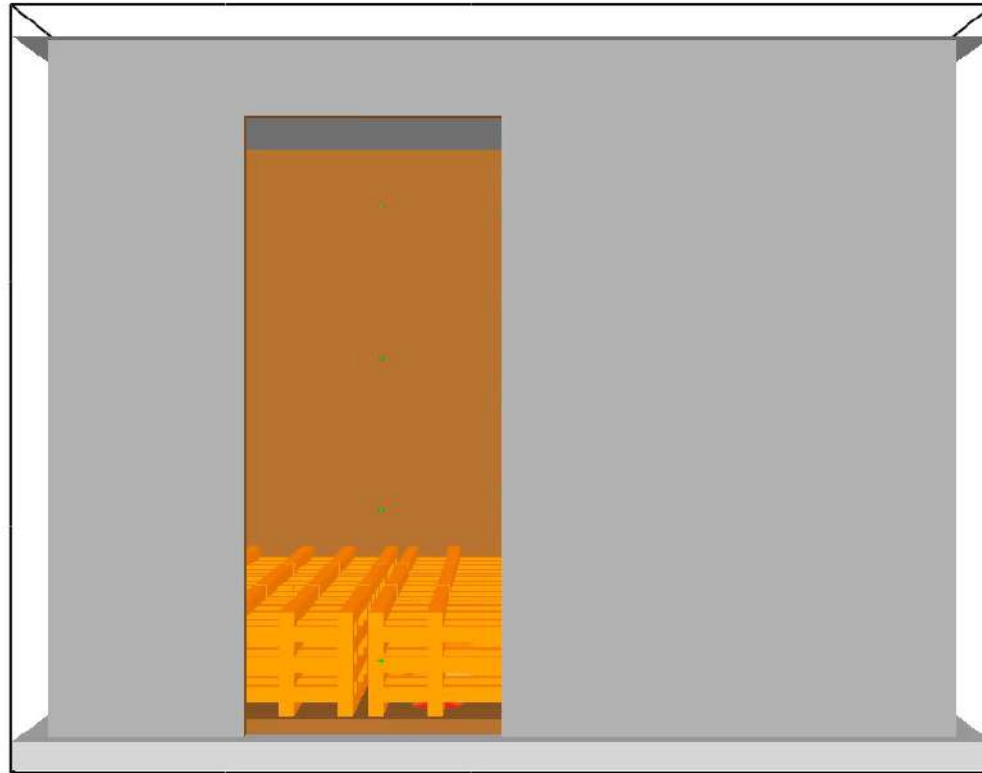
TWO ZONE MODEL REPRESENTATION OF RESULTS



PRELIMINARY CFD MODEL BEHAVIOUR

TEST

— □ ×



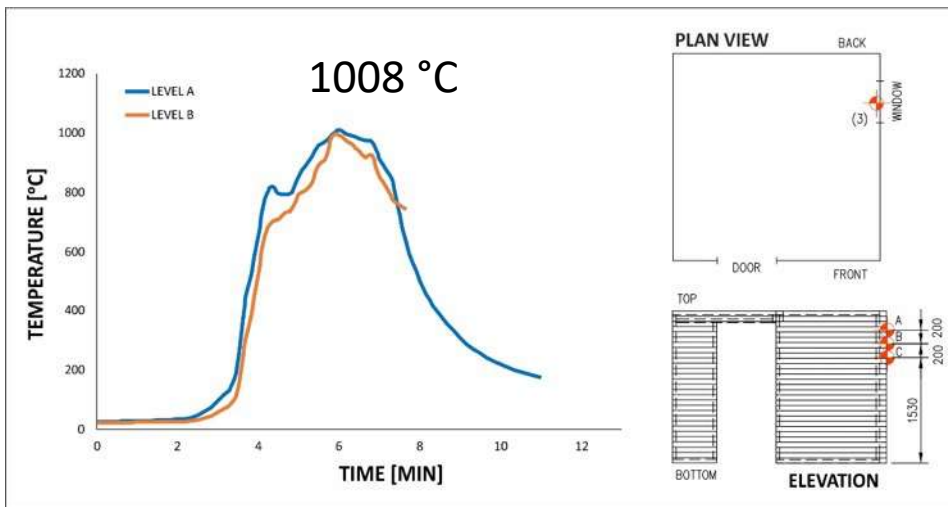
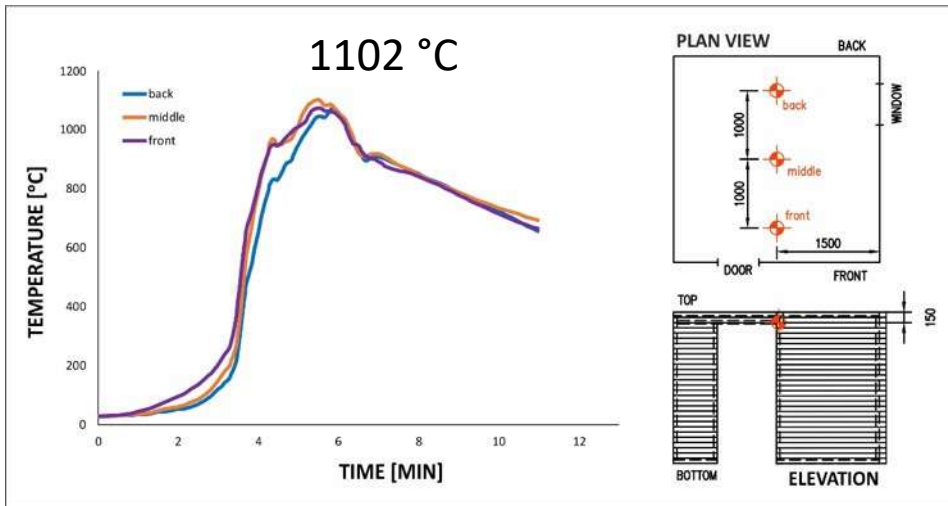
Time: 240.0



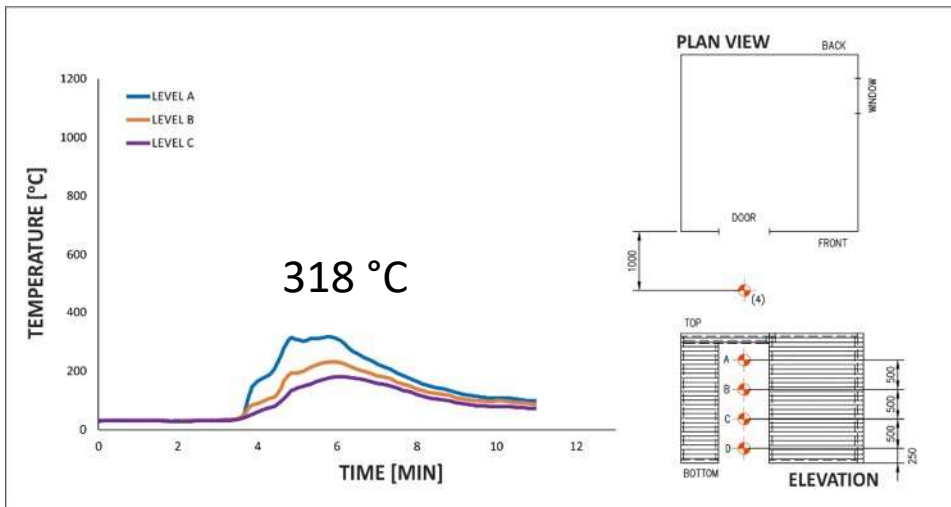
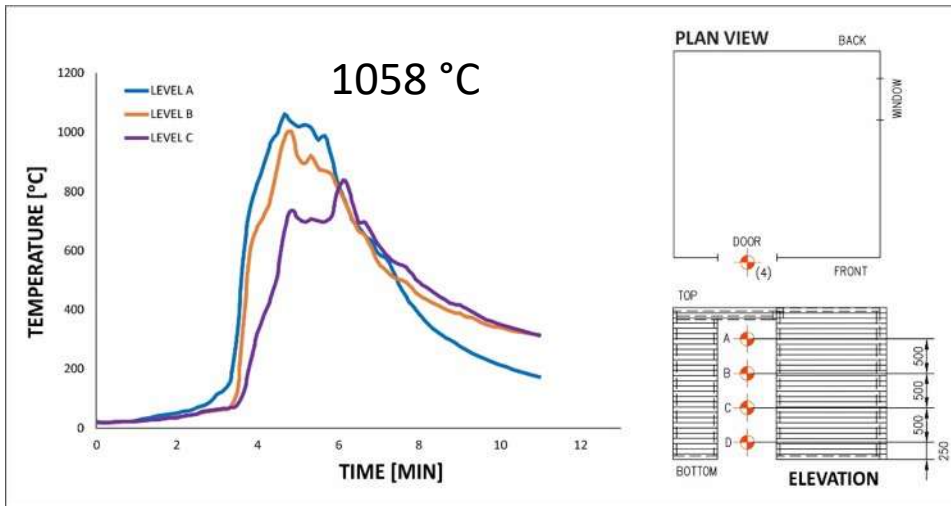
TEST RESULTS TIMBER CLAD



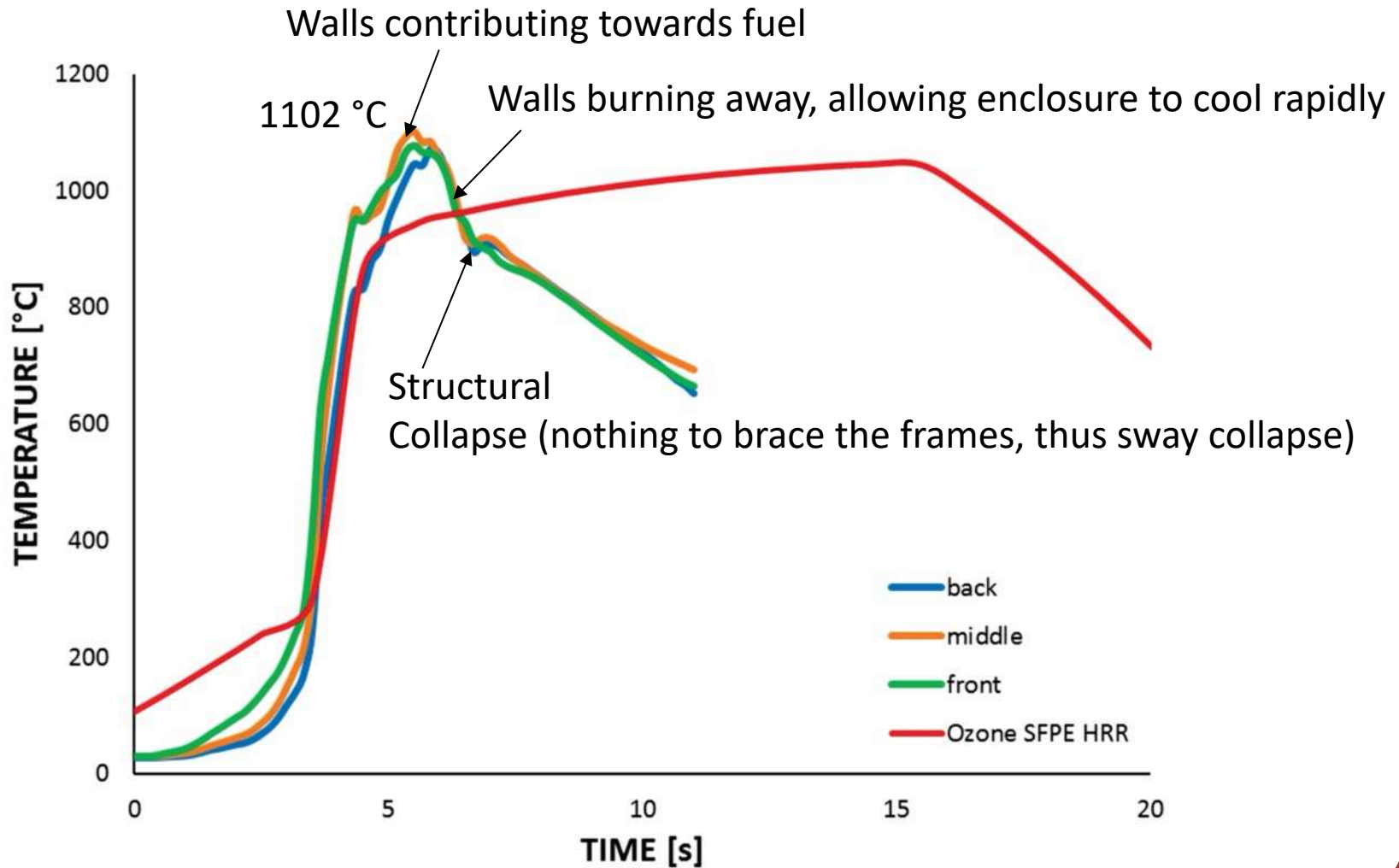
RESULTS: SINGLE TIMBER ISD



RESULTS: SINGLE TIMBER ISD



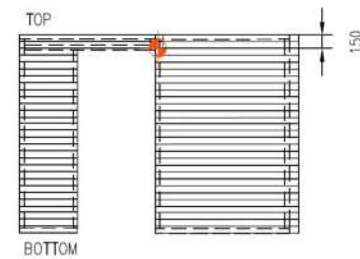
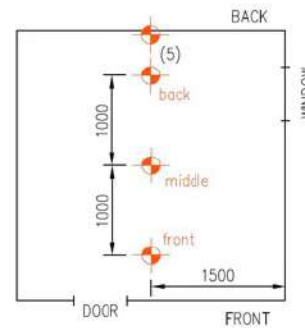
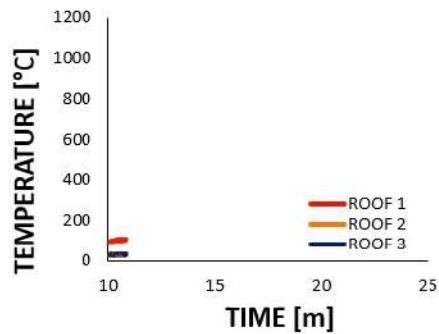
TWO ZONE MODEL REPRESENTATION OF RESULTS



Collapse



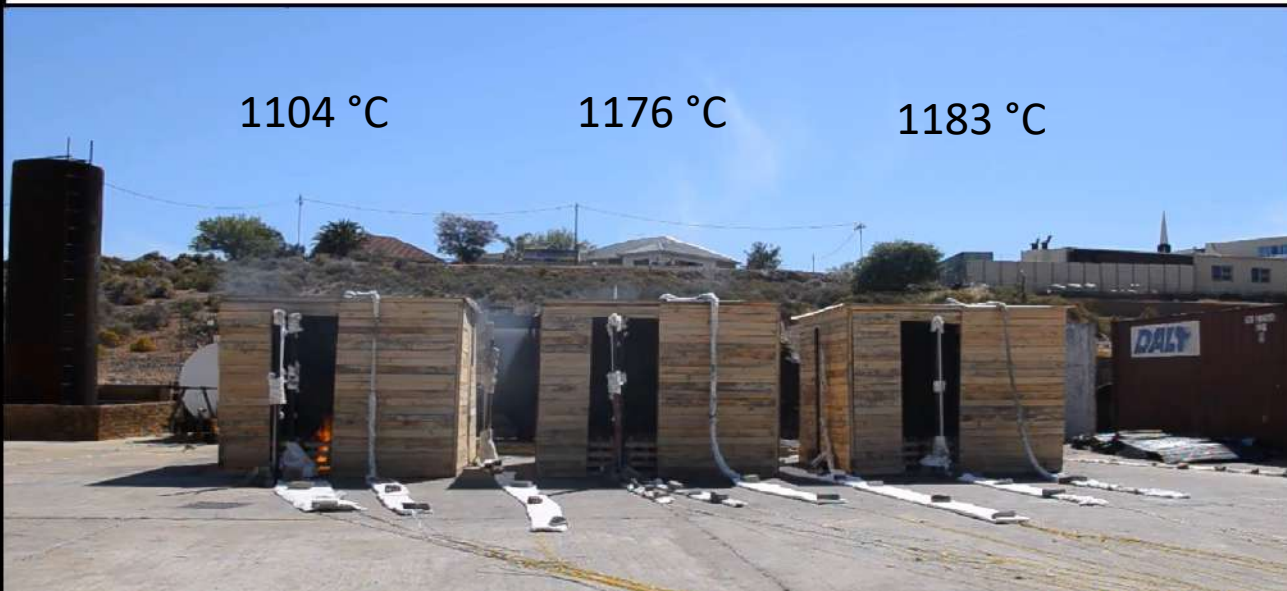
RESULTS: MULTI-ISD ROOF TEMPERATURES



1104 °C

1176 °C

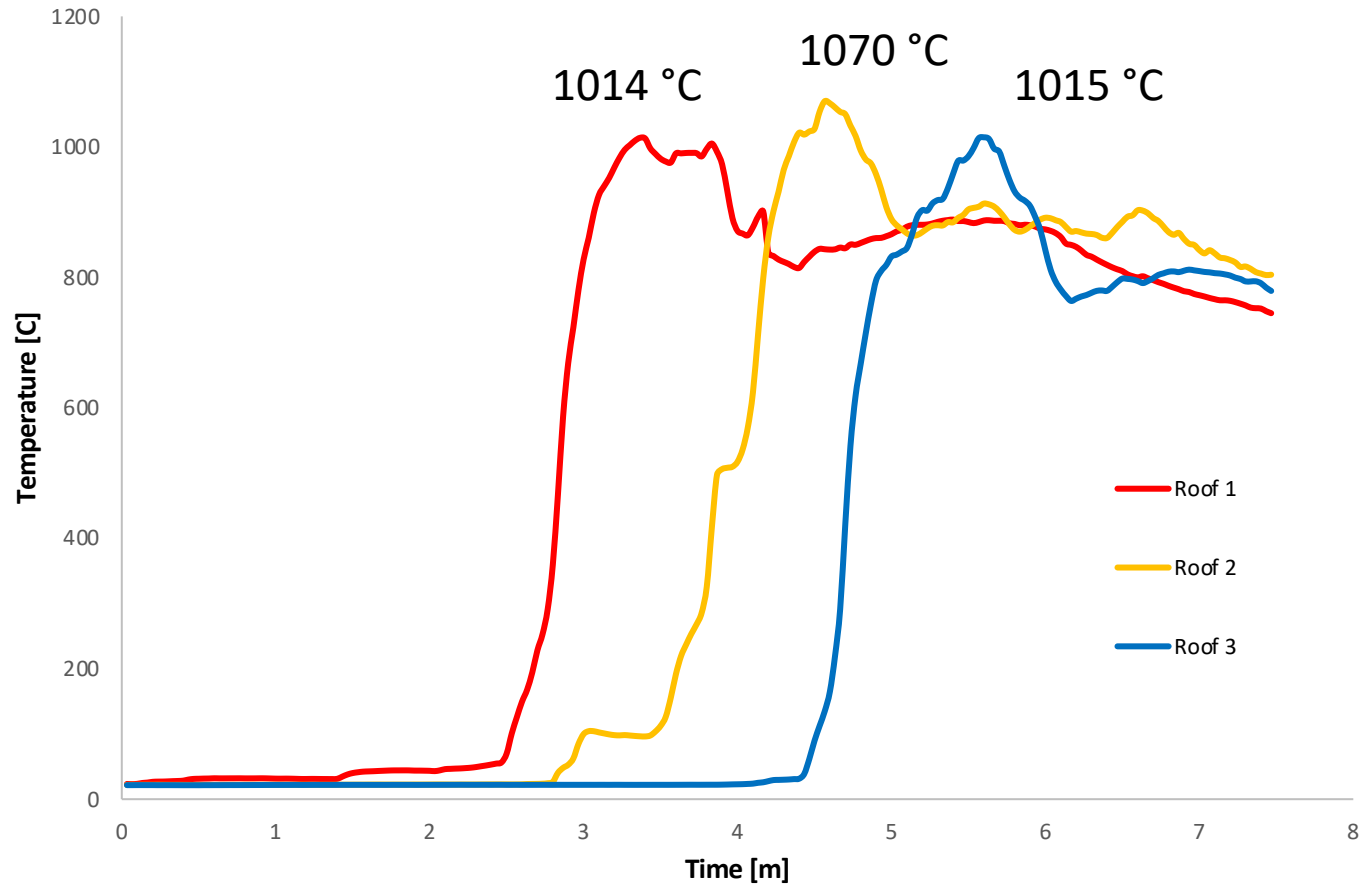
1183 °C



MULTI-ISD STEEL CLAD TEST



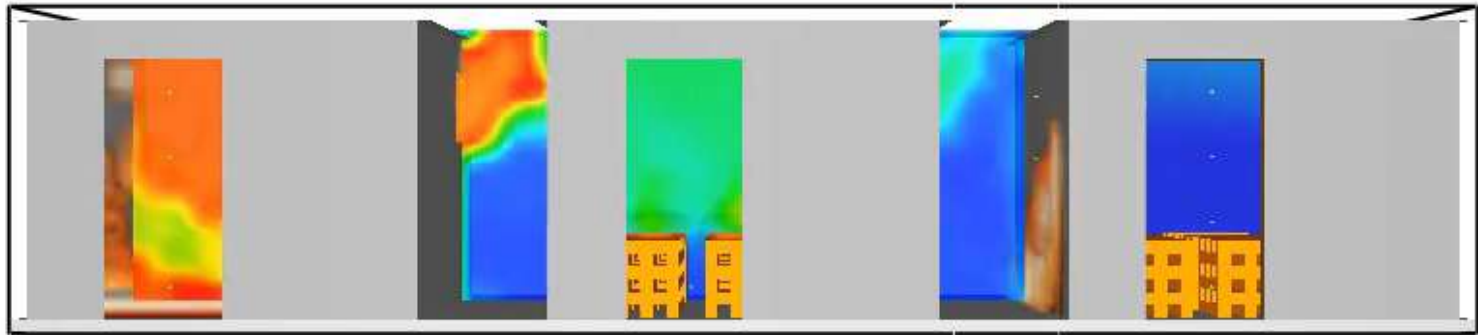
MULTI-ISD STEEL CLAD TEST ROOF TEMP



MULTI-ISD STEEL CLAD TEST

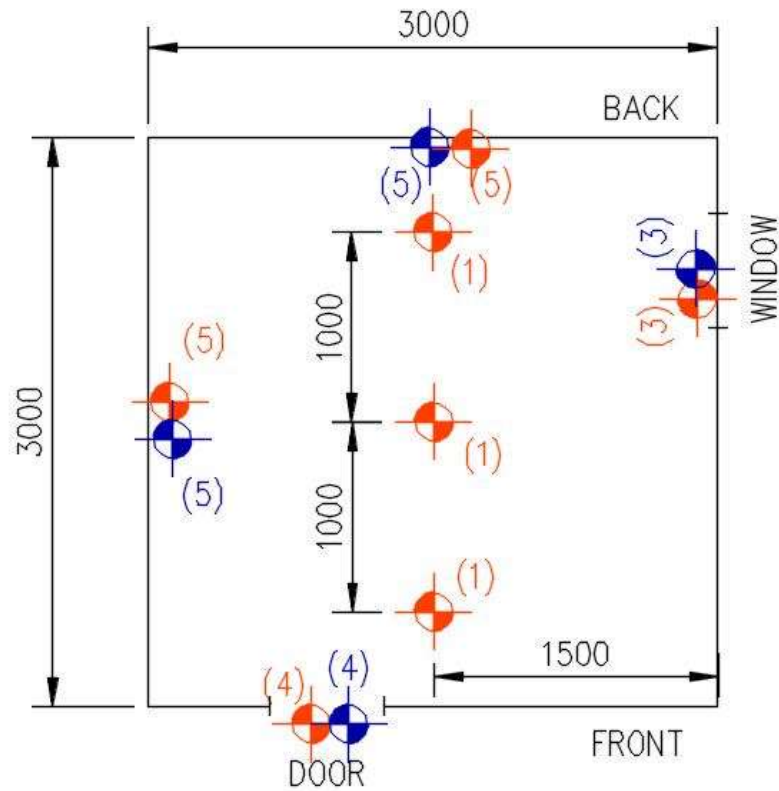


CFD MODELLING



QUESTIONS OR SUGGESTIONS?

TEST SETUP: SINGLE STEEL ISD



EXPERIMENTAL EQUIPMENT KEY



THERMOCOUPLES

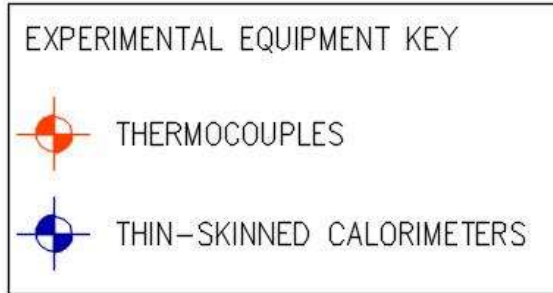
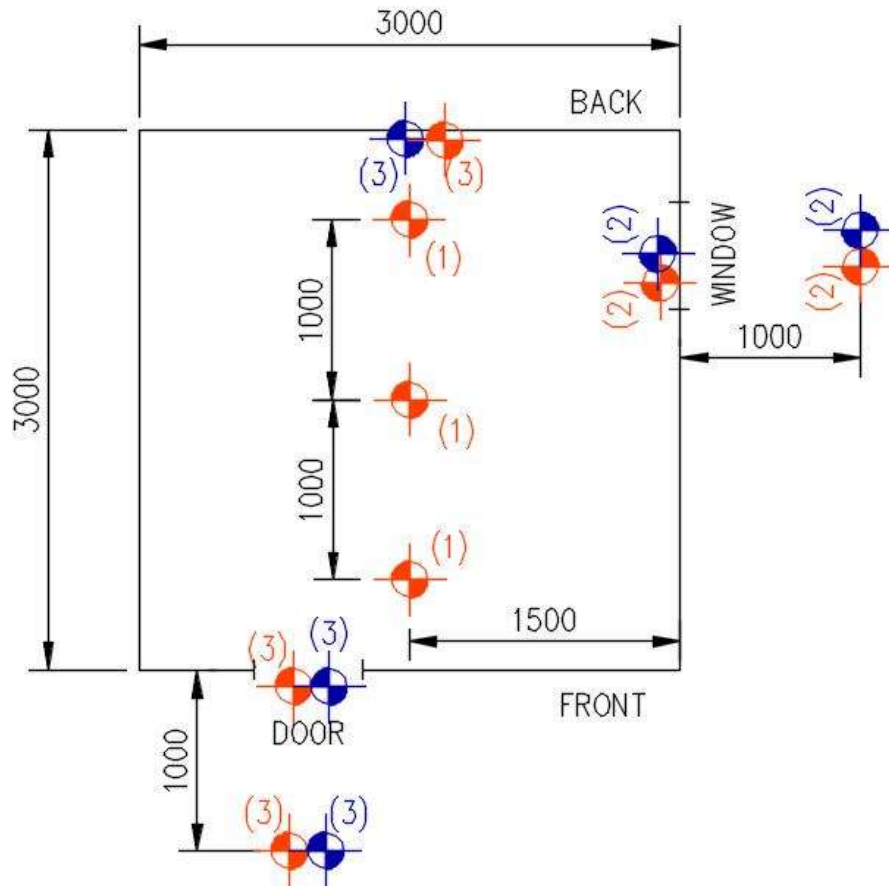


THIN-SKINNED CALORIMETERS

SINGLE SHACK TEST

PLAN VIEW

TEST SETUP: SINGLE TIMBER ISD



SINGLE SHACK TEST

PLAN VIEW

TEST SETUP: MULTI-TIMBER ISD

