Evaluation of the fire resistance of the steel structure of a waste treatment plant using structural fire safety engineering

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INTRODUCTION

❑ In the Portuguese Technical Regulations for Buildings Fire Safety, two approaches are allowed for assessing the safety of structures exposed to fire:
  ▪ a prescriptive approach using the standard fire curve ISO 834
  ▪ and a performance based design using the natural fire safety concept (the natural fire curve definition takes into account the size of the fire compartment, the ventilation conditions and the compartment lining materials).
❑ According to Part 1-2 of EC3, the stability check can be made verifying that:
  ▪ with the standard fire the structure collapse does not occur before the fire resistance time defined by the regulation
  ▪ or with the natural fire and advanced calculation methods the structure collapse does not occur during the complete duration of the fire including the decay phase or during a required period of time.
❑ In this work, the studies, performed to assess the fire resistance of the steel structure of a waste treatment plant in Gaia (Portugal), are presented.
❑ Advanced calculation methods were used, both for the:
  ▪ natural fire characterization (software Ozone),
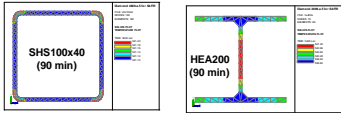 ▪ and to simulate the thermo-mechanical behaviour (finite element software SAFIR).

FIRE SCENARIOS TEMPERATURES

❑ Scenario 1 - Fire in the reception unit (central building)
❑ Scenario 2 - Fire in the post - composting unit
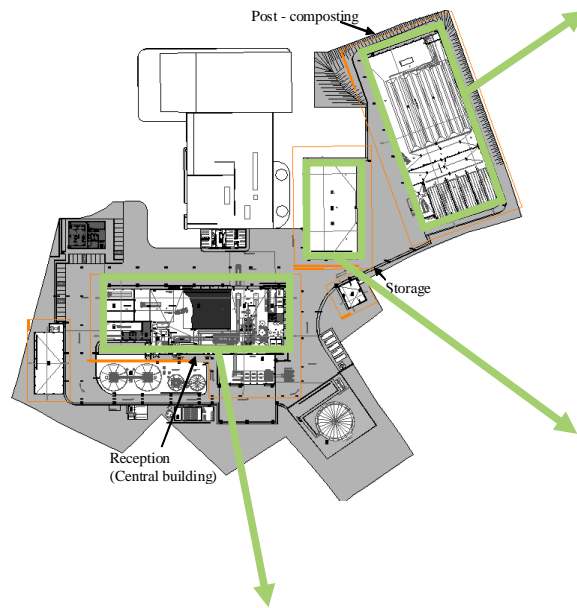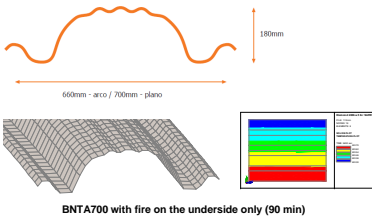❑ Scenario 3 - Fire in the storage unit
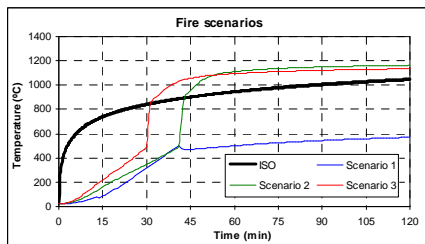
THERMAL ANALYSIS

❑ Commercial profiles
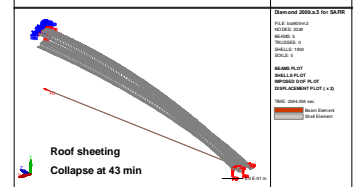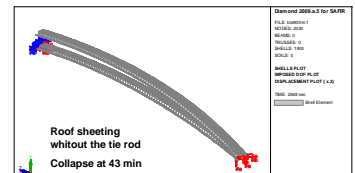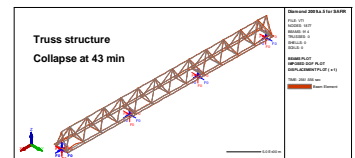

SHS100x40 (90 min)

HEA200 (90 min)

❑ Thin-walled cold formed steel sheeting
  ▪ self-supporting roofs composed of thin-walled cold formed steel sheeting, which had to be analysed using finite shell elements.
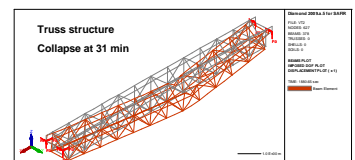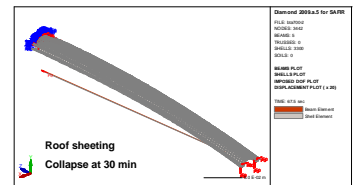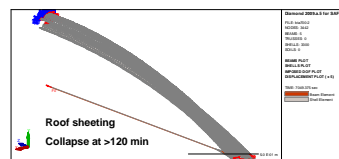

180mm

660mm - arco / 700mm - plano

BNTA700 with fire on the underside only (90 min)

LOAD COMBINATION

❑ Portuguese National Annex of EN 1991-1-2

$$\sum G_k + \psi_{1,1} \cdot Q_{k,1} + \sum \psi_{2,i} \cdot Q_{k,i} + \sum A_d$$

  ▪ Category H for roofs

$$1.0G_k + \psi_{1,1}Q_{k,1} = 1.0G_k + 0.0Q_{k,1}$$

MECHANICAL ANALYSIS

❑ Post - composting unit

Truss structure Collapse at 43 min

Roof sheeting whitout the tie rod Collapse at 43 min

Roof sheeting Collapse at 43 min

❑ Storage unit

Truss structure Collapse at 31 min

Post - composting

Storage

Reception (Central building)

❑ Reception unit

Truss structure Collapse at > 120 min

Roof sheeting Collapse at >120 min

Roof sheeting Collapse at 30 min

CONCLUSIONS

❑ Based on studies conducted within European projects, the steel structure temperatures development, resulted from a fire in a waste treatment plant, in Gaia (Portugal), was analysed, in which the several compartments fit the classification of a large compartments. More over, the use of finite element models on the mechanical analysis, has been applied, for better predict the actual behaviour of these structures in case of fire.
  ▪ The temperatures obtained with this analysis are relatively high, when compared to a prescriptive assessment following the standard ISO 834 fire curve.
  ▪ These higher temperatures were only achieved relatively later, resulting in high fire resistance times.