

## FIRE PERFORMANCE OF CONCRETE SANDWICH PANEL UNDER AXIAL LOAD

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**Abstract:** In the present study, the performance of concrete sandwich panel against fire and axial load has been considered. A finite element model of a sandwich wall is presented and evaluated the performance under different temperature (200, 400, 600 °C). The ratio of width, thickness and length of wall are constant and the axial load enters on the top of wall. The maximum displacement and stress in different models shows the capacity of wall is increased at high temperature. The displacement has dramatically increased at temperature loading of 800 °C and it has gained which shows poor efficiency of wall at high temperatures.

**Keywords:** Sandwich panel, Fire, Axial load, ABAQUS, Finite element method

### 1. Introduction

Precast concrete sandwich wall panels are commonly constructed of two layers of concrete, which are separated by an insulation layer. This structure's setup allows obtaining excellent mechanical performance at least weight. The material of concrete layer and also insulating layer is really important for wall behavior. Using sandwich panel as a member of building is new research, which has been done during years as: Liviu Librescu et al. study the modeling and behavior of advanced sandwich constructions and present some recent development, which related to the modeling and stability of sandwich structures [1]. Byoung-Jun Lee in 2006 studied on the thermal behavior of precast concrete three the sandwich wall panels and compared thermal behavior of two-

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wythe panels with three-wythe panels. The result of study shows the performance of with three-wythe panels is better than two-wythe panels [2]. Galgano et al. [3] using predictive model for the fire behavior of sandwich panel and with this method shows the thermal response of the structure and their variation. Giunta [4] investigated on the behavior and safety of sandwich panel, the result of study develops on the further insight in possible hazards of steel insulated sandwich panels in the pre-flashover phase.

The aim of this study is to investigate the sandwich panel performance on the fire condition and pressure load and the previous research shows there is no general research on the fire and axial load in sandwich panel. So first the effect of fire is investigated on the behavior of sandwich part (wire, concrete and insulting layer) and after that axial load is entered on the tope of wall and the results of the investigation shows how different temperature could effect on the panel. Beleznaï et al. [5] studied on Finite Element Method (FEM) analysis of the seven-wire strand under axial load. Nino [6] studied on interaction for arbitrary cross section under biaxial bending and axial load.

## 2. Method

The basic purpose of this study is evolution of the sandwich panel performance under fire and axial load. The axial load, which is applied to the wall at the tope side also the temperature, is assumed as variable parameters. Several parameters as dimension of panel, layers and material are registered in ABAQUS [7]. Finally axial load entered on the wall and compared to the panel in different fire load condition. The following steps are assumed for modeling panel in the software:

Firstly, used fire data related to mechanical properties of concrete, steel fire and insulting layer, which considered in previous research [8], [9], as stress strain curves, conductivity, elastic module in different temperature.

Secondly, the fire load and axial load entered on the panel, tie is applied as the way of pasting the insulating layers to concrete (Tying rebar was done with a professional tie wire twister with looped tie wires). Employing pine condition in the bottom sides of wall the contact of wire meshes are embedded type in concrete layers. Displacement and stress obtained in different temperatures (200, 400, 800 °C).

Thirdly, coupled temp - displacement is elected to analyze model in this software, this way, which is also used with other researchers [9].

Ultimately, comparing panel in several temperature together and evaluated the stability of sandwich wall.

*Table I* shows the material and dimension of part, which has been modeled with ABAQUS software.

*Table I*

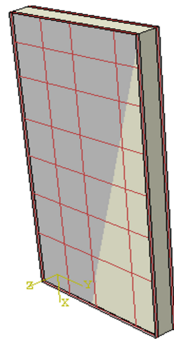
Specifications of the modeled building components in ABAQUS [10]

Material	Elastic module	Poisson ratio	Dimension	Density
Concrete	5.5e+009	0.3	4.2*3.6*0.1	2300
Wire	25 e+011	0.3	-	7870
Insulating layer	2.5e+009	0.3	4.2*3.6*0.1	2000

With using *Table I* different panels, which has been chosen for analyzing and obtained critical displacement and ultimate stress after taking under fire condition and pressure load.

### 3. Model with ABAQUS

The dimension and properties of material are listed in *Table I*. Some other properties of material as thermal conductivity, elastic module are entered into ABAQUS software. *Fig. 1* shows the concrete sandwich wall which was assembled in ABAQUS software. The stress-strain curve at different temperature for concrete and Fiberglass Reinforced Plastic (FRP) panel obtained from Lamont et al [10], [11]. The pressure load was constant and it is 40 kN and 60 kN.



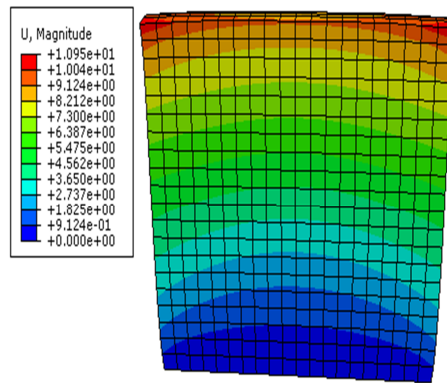
*Fig. 1.* The investigated sandwich panel wall with three layers

### 4. Results

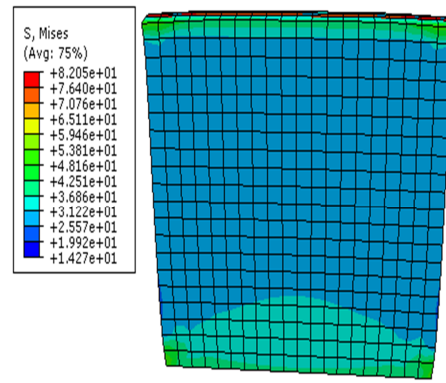
*Fig. 2* to *Fig. 15* shows the displacement and stress in different temperature. The variation of displacement and stress shows with counter in these pictures. As it clearly can be seen in these figures, stress and displacement increase with increasing temperature and pressure load. The main aim of this study is to investigate how the temperature and the pressure load influence on the panel behavior.

The study aims to investigate about the sandwich panels under pressing-thermal loading. It is important because the walls that are constructed in the buildings are under the dead and live loading, which is from the weight of materials and individuals' load. Therefore, the pressing load is known as the prevailing load of building design and combining this load with the thermal load is a proper and new subject that has not been considered in research of sandwich panels yet. Therefore, modeling a sandwich panel will be discussed in the first step. According to previous references, the use of materials and its thermal properties has been against the thermal loading. The thickness of the steel reinforcements and sandwich panels are assumed to be constant on all models and changes were studied in the temperature.

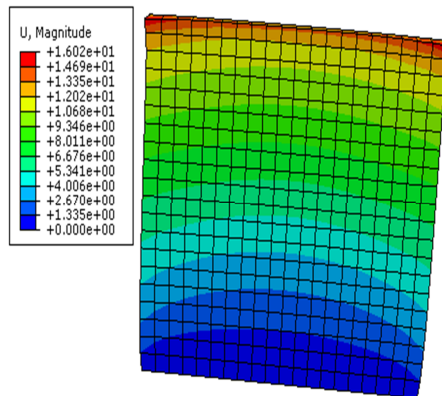
*Fig. 2 - Fig. 4* show the information about the maximum of the critical stress and displacement of panel with FRP layer and a thickness of 0.003 m. These stresses are the total of pressing-thermal stresses. The use of a panel with different temperature under loading in the high temperature indicates that this panel can bear the applied load and it resists up to 600 °C. It is assumed that the use of this layer should lead to an appropriate resistance of panels and this layer can transfer some applied stress to the insulation panel, therefore, the entered thermal load in the panel and the reaction of the insulation layer against the heat are investigated. *Fig. 5* shows the entered stress and displacement of the FRP panel.



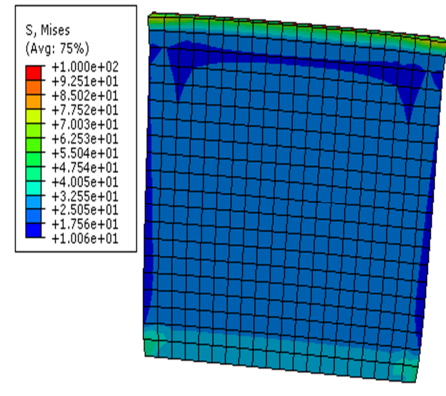
*Fig. 2.* Displacement for panel at 200 °C at 40 kN



*Fig. 3.* Stress for panel at 200 °C at 40 kN



*Fig. 4.* Displacement for panel at 400 °C at 40 kN



*Fig. 5.* Stress result for panel at 400°C at 40 kN load



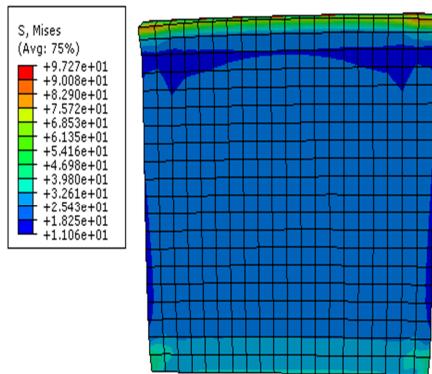


Fig. 6. Stress result for panel at 600 °C at 40 kN load

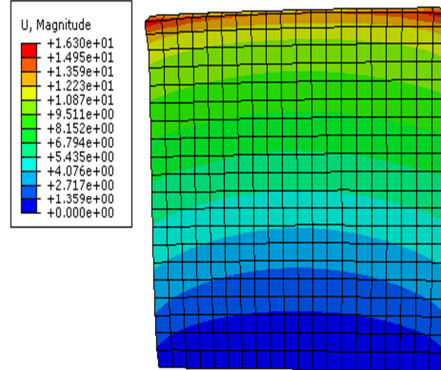


Fig. 7. Displacement for panel at 600 °C at 40 kN load

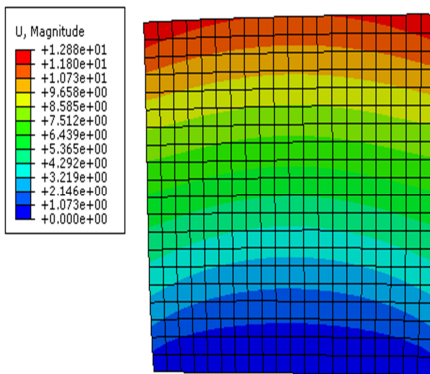


Fig. 8. Displacement result for insulating layer at 400 °C at 40 kN load

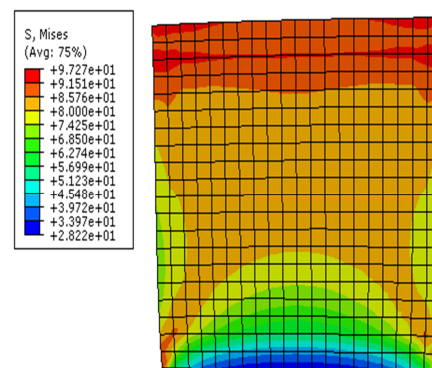


Fig. 9. Stress result for insulating layer at 400 °C at 40 kN load

The results of the chart show that the use of FRP layer leads to the resistance of the sandwich panel up to 600 °C and transfer some its tension to the insulation layer. The use of FRP layer in temperatures of 200 and 400 °C leads to reduce the rate of critical stress arising from pressure load layer and overall it shows a better thermal performance than the composite tank. As it is noted in the concrete publications that by increasing the temperature, the bearable stress rate of the structure is reduced, the reference of suggestion of the tension-strain graphs shows this reality that the tension rate of the concrete layers is reduced in the high temperature and the structure is not able to bear the stress. On the other hand, due to the reduction of structural instability, the panels have more displacement. In the following, the increase of the pressing load on the panel

head will be discussed to determine the reaction of the panels in the case of increasing the pressing in different temperatures.

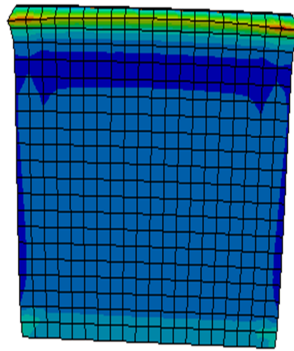
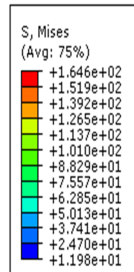


Fig. 10. Stress at 200 °C at 60 kN load

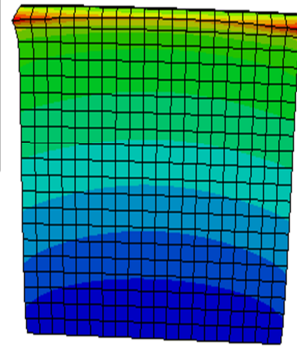
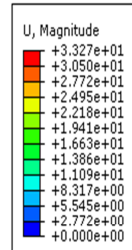


Fig. 11. Displacement for 60 kN load at 200 °C

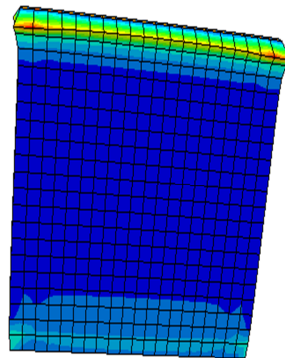
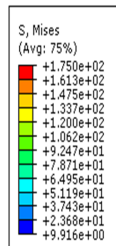


Fig. 12. Stress for 60 kN load at 400 °C

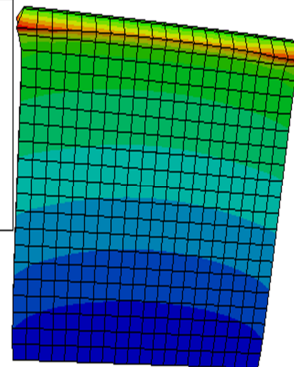
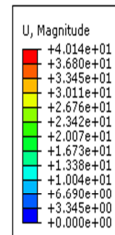


Fig. 13. Displacement for 60 kN load at 400 °C

Increasing the pressing load at 400 and 600 °C has led to increase the panel displacement as well as deformation in the confrontation place of the load with the panel in the high elements. The rate of displacement is increased with increasing temperature and the stresses entered on the panel has reached to about ten times when the load is 20 kN is reached, which shows the increase of temperature in more loading can impact on the panel behavior.

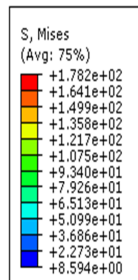


Fig. 14. Stress for 60 kN load at 600 °C

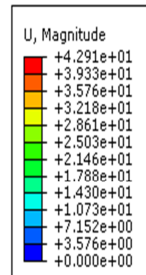


Fig. 15. Displacement for 60 kN load at 600 °C

## 5. Conclusions

Present research focused on sandwich panels and increasing the temperature and their behavior at different pressing loadings. The results of this study show that:

- Increasing temperature leads to increase the stress and displacement as well as the changes of these two parameters increase entered load;
- Increasing the pressure load led to increase the panel displacement and also deformation;
- The displacement on the panel has reached to about 2.46 times when the load reached to 60 kN at 400 °C;
- The displacement on the panel has reached to about 2.63 times when the load reached to 60 kN at 600 °C;
- The stresses entered on the panel have reached to about 10.78 times when the load reached to 60 kN at 600°C and 400°C;
- The capacity of panel decrease at high temperature, the deformation of panel shows this fact.

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