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Report title:

Laboratory and numerical study of buckling behavior cylindrical shells of GFRP under external uniform pressure

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Issues:

- **Article of the behavior of cylindrical tanks under uniform pressure, January 2019, Fifth National Conference on Recent Achievements in Civil and Urban Engineering, University of Tehran**
- **Simulation and theory examination**
- **Laboratory examination**

- **Buckling and Nonlinear Analysis by Finite Element Method:**

The ABAQUS software [۱۴] has been used to provide finite element modeling. The models are ۳۰۰ and ۱۵۰ mm in height and ۱,۶ mm thick in tanks. In the modeling of multilayer composite cylindrical shell in ABAQUS software, used for the mesh of four-sided and four-node elements (S۴R), which is a two-curved element and has the ability to analyze large strains. The loading and boundary conditions of the model are determined in the loading environment. To apply external pressure, the inner surface of the cylinder is first selected. The loading method is also such that uniform pressure is introduced into the tanks environmentally. The supporting conditions of the specimen are arranged in detail. The bottom part is tangential in the three radial, tangential, and axial directions. At the top, the specimens have only radial and tangential Constraint, and the axial movement is free. (Fig. ۱) shows how to load and apply boundary conditions.

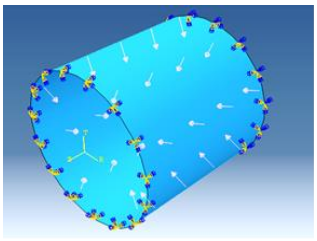

Figure (۱) of the specimen under loading and applying boundary conditions

Since linear buckling analysis does not allow prediction of post-buckling behavior, a geometric nonlinear analysis using Riks algorithm was used to find out the post-buckling behavior. For example, the buckling pattern and the special value for the first mode in Fig. ۲ and the shape of the deformation and the buckling capacity versus displacement are shown in Figures ۳for the Spec-Gf۲ specimen.

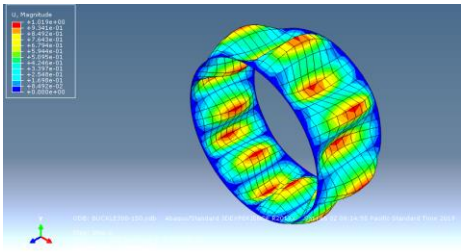

Figure (۲) Igen values of the first mode

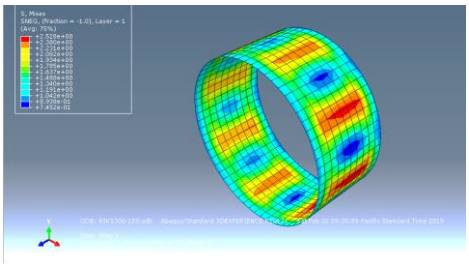

Figure (۳) non-linear deformation

- **Laboratory investigate**

In order to study the buckling behavior of thin shells of composite under external uniform pressure, two laboratory specimen were prepared at this stage, which had the same mechanical properties and only the variable factor was shell height. (Table ۱). Selection of appropriate R / t was selected based on thickness limitations for these shells at the factory and some laboratory limitations of ۳۰۰ mm diameter and ۱,۶ mm thick were selected. To produce these shells were used ۲۰۰ grams of woolen fibers. In the examples used in this investigation, two different ratios of L / R will be desirable. As a result, the laboratory specimen used in this investigation are compared to real tanks in various industries with a one-to-one scale.

Table ۱: specimen Geometric Specifications

Row	Sample name	Diameter (mm)	Length (mm)	Thickness of each layer (mm)	Fiber type	Number of fiber layers	The angle of the fiber
۱	Spec-Gf۱	۳۰۰	۳۰۰	۰,۴	woolen	۴	۹۰،۰
۲	Spec-Gf۲	۳۰۰	۱۵۰	۰,۴	woolen	۴	۹۰،۰

- **Loading laboratory specimen**

There are three holes in the top plate, which is located above the cylindrical shell, the first hole connected to the suction and performing the air discharge operation. The second hole is connected to the drain valve and is responsible for controlling the drain discharge tank. The third hole is connected to the pressure gauge for measuring the internal pressure shown in (Fig. ۶).

Figure (۵) - Uniform lateral pressure test system

Figure ٦ - The location of the loading valves and the internal pressure measurement of the cylindrical shell

- **Conclusion:**

- Shell behavior against steady-state pressure increase and the trend of strain increase versus pressure increase indicates behavior with constant gradient.
- The results obtained in the laboratory due to some physical and geometric disadvantages are less than the theoretical and numerical load, But they are well adapted.
- The number of buckling modes in analytic relationships is ۱ to ۲ modes more than buckling and investigate, and this difference is less in specimen with larger lengths.