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EXTENDED ABSTRACT

Experimental and Numerical Investigation of the Behavior of Cylindrical Thin-Walled GFRP Shells under Dental Load

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1. Introduction

In this study, we attempt to have numerical and software analysis of behavior, deformation and strain caused by local dental loads (dent) in GFRP tanks. The load-displacement and the load- Strain diagrams in experimental and software conditions have also been analyzed, compared and evaluated. The research can be used in oil company projects, water organization and different types of tanks which are exposed to local loads. the experimental and theoretical researches on GFRP tubes and tanks under dental loads and concluded that all samples have linear behavior from beginning to end and proceed with the same slope which is due to the behavior of the GFRP materials (Zarrin, 2018). To test the behavior of experimental specimen under the influence of Dent's load, wedge is used. In another studies different types of dental loads are applied to the tanks like Dome-shaped dental load, Circular dental load and Rectangular dental load (Jajo, 2014). To understand the importance and necessity of research, we must first study the dental load, how it is applied to the tanks, the dangers of applying it to the tanks and the ways of resistance against these loads.

2. Methodology

2.1. FE modeling

Nonlinear analysis of dental load effect on tank by using finite element method. The ABAQUS software has been used to present the finite element model of the samples. Modeled samples are tanks with 500 and 700 mm height and diameter of 400 and 800mm. In multilayer composite cylindrical shell modeling in software ABAQUS, for meshing a quadrilateral and quadruple element (S4R), which is a two curve element and is capable of analyzing large strains, the reduced integration method was used to analyze the samples. In this study, in order to apply the boundary conditions of the tank, all properties of the nodes on the edge of the tank in that area are assigned to a point in their center so that the boundary conditions can be applied only at that point. There is a deformation to down in shape of concavity at the site of the local load in the middle of the crater (Fig. 1).

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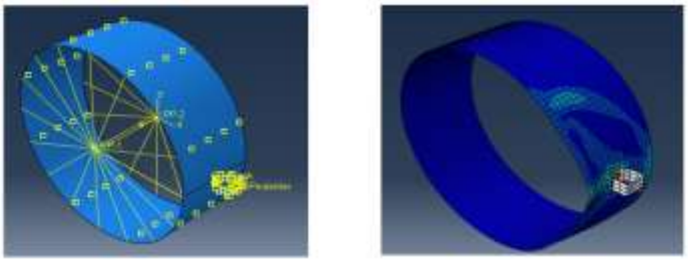

(a) (b)

Fig. 1. Finite element model: a) Boundary conditions, b) Final displacement

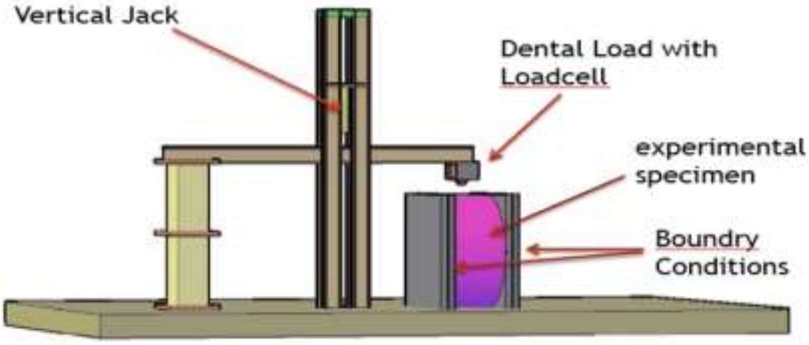

Fig. 2. Schematic mode of specimen

2.2. Experimental Investigation

In this study, to test the behavior of Composite thin shells under Dent load, four experimental specimen were prepared and tested which have the same mechanical properties (Table 1) and the only different variable in them is the height and radius of the shell (Table 2). The suitable R/t according to the thickness limit for these shells at the factory and laboratory limits, 200 mm and 400mm radius and thickness of 4 mm were selected. In the specimens used in this research, different ratios of R/t and L/R will be used. It should be recalled that in the behavior of thin shells under Dent load, dimensional geometric parameters R/t and L/R are considered as the most important parameters.

Table 1. Mechanical properties

Row	Parameter	Abbreviation signs	Amounts
1	Young's Modulus (Pa)	E1, E2, E3	21710000, 5602000, 5602000
2	Shear Modulus (Pa)	G12, G13, G23	1990000, 1990000, 2603000
3	Poisson's ratio	Nu12, Nu13, Nu23	0/273, 0/273, 0/076

Table 2. Geometric properties

Row	Specimen Name	Diameter (mm)	Height (mm)	Thickness (mm)	Number of fiber layers	Angle of fiber layers
1	Spec-1	800	500	4	3	90
2	Spec-2	800	700	4	3	90
3	Spec-3	400	500	4	3	90
4	Spec-4	400	700	4	3	90

In different parts of this specimen in the middle of the height different measuring instruments are installed. This tool includes a strain gauge to measure strain at a specific point in the intended direction and LVDT is used to measure the displacement values of different points on the shell. All measuring instruments by the interface cable send the obtained information to data logger and related software.

3. Results and discussion

After loading the first slight noise of crack is heard then other crack noises happened respectively and steady sounds of cracking is heard and at last extreme crack voice came out and dropped load. Fig. 3 shows the final load-displacement charts for LVDTs.

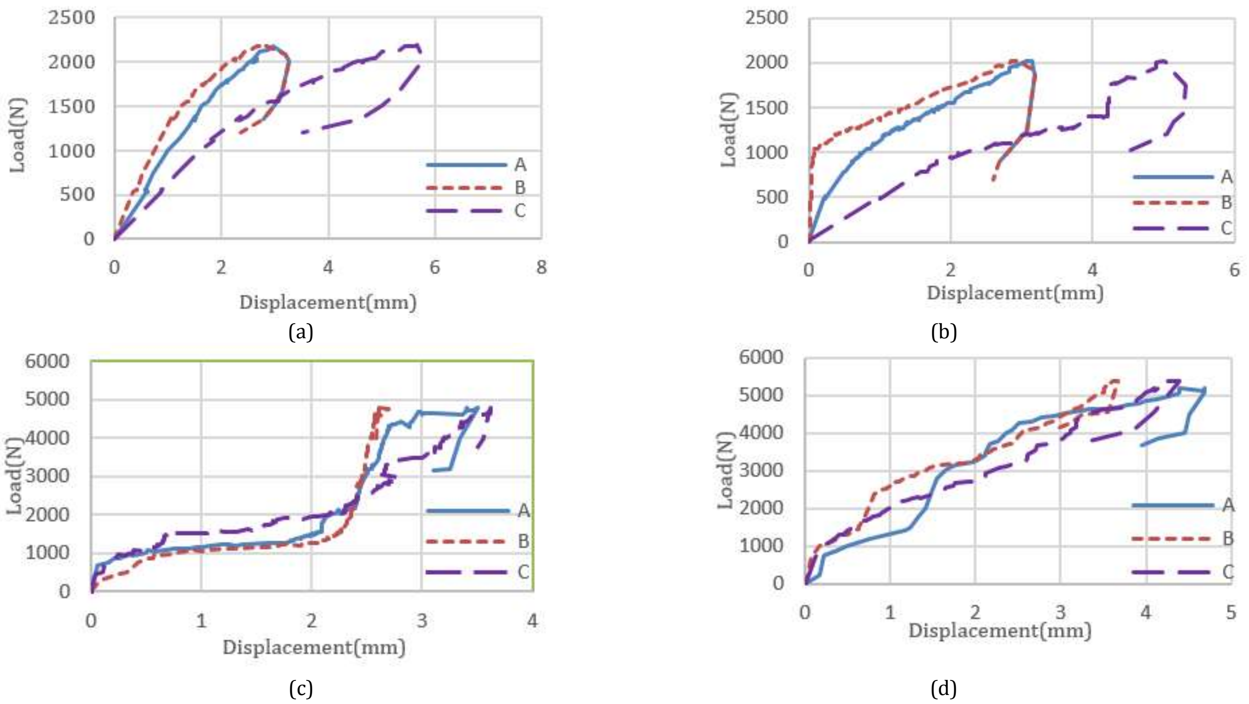

Fig. 3. Final charts: a) Load-Displacement- Spec 1, b) Load-Displacement- Spec 2, c) Load-Displacement- Spec 3, d) Load-Displacement- Spec 4

In the first Specimen after loading the first slight noise of crack is heard in the 612 (N) then other crack noises happened respectively in 1340, 1560, 1730 and 1920 (N) and in the 2180 (N) extreme crack voice came out . In the second specimen after loading the first slight noise of crack is heard in the 880 (N) then other crack noises happened respectively after 1090 (N) and in the 2006 (N) extreme crack voice came out. And in the third specimen after loading the first slight noise of crack is heard in the 2110 (N) then other crack noises happened respectively after 2180 (N) and in the 4810 (N) extreme crack voice came out. At last in the fourth specimen after loading the first slight noise of crack is heard in the 2337 (N) then other crack noises happened respectively after 3353 (N) and in the 5200 (N) extreme crack voice came out and then dropped load.

4. Conclusions

In the Table 3, P is the amount of dental load applied to the specimen which causes cracking. As you can see in this table according to the comparison of the behavior of the specimens in four numerical and experimental methods, the first similarity in the results of four specimens are that the amount of denting load to make cracks in the specimen is less in numerical than in the laboratory. Certainly numerical values have been obtained with respect to software analyzes and according to the mechanical characteristics of the Farasan factory. However the experimental values are quite real and the error rate in the laboratory may be due to the lack of installation of measuring instruments at appropriate locations or other errors during the test.

Table 3. Comparing and results

Row	Specimen Name	R (mm)	L (mm)	t (mm)	L/R	R/t	P (n)	
							Experimental	Numerical
1	Spec-1	800	500	4	0.625	200	2180	2413
2	Spec-2	800	700	4	0.875	200	2006	2155
3	Spec-3	400	500	4	0.625	100	4810	5066
4	Spec-4	400	700	4	0.875	100	5200	5455

5. References

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