Mechanical Response of Open Channel Cover Made of Concrete Foam Due to External Loadings

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Abstract. Open channel conduit is commonly constructed on side roadway, car park area, etc., with the aims to collect rainwater or seapage water. To avoid garbages following the waterflow, the conduit is equipped with adequate cover. In addition, the cover can also be functioned for temporary car park area. Thus, the conduit cover should strong enough to sustain external loading. This paper discusses the design and response of the conduit cover using finite element software ANSYS MECHANICAL version 17.5.
Keywords: Conduit cover, parking bumpers, foam concrete, impact strength, Fiber Oil Palm Empty Fruit Bunch (EFB).

1.Introduction

Open channel conduit is one of ways to reduce excess water, whether from rain, seepage, or excess irrigation water in an area, drainage is included in one of the important components of urban infrastructure in tackling the problem of flooding and waterlogging. On the roadway [1] as shown in Figure 1 and 2, open channel conduits should function the same; however conduit covers are needed.

This paper discusses the design and response of the conduit cover using finite element software ANSYS MECHANICAL version 17.5. Two types of conduit covers as shown in Figure 3 with a size of 920 × 200 × 150 mm with the use of concrete foam-fiber reinforced empty oil palm bunches (EFB) were designed, manufactured, and tested. The conduit covers were subjected to impact load using a free-fall apparatus. Results were also compared with numerical simulation using a commercial software ANSYS Mechanical version 17.5. We consider also the impact test is with the assumption that the covers are also to functioned as parking bumper at the moment vehicles bump on kerbline and jump on to the conduit cover.

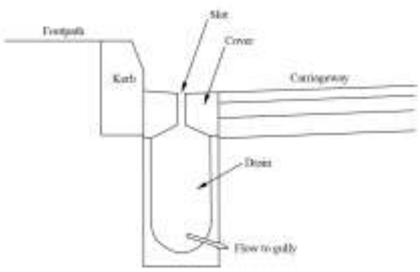

Figure 1. Slot drain

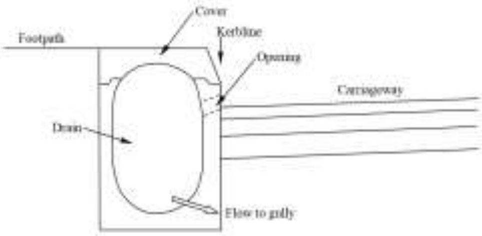

Figure 2. Kerb drain

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(a) (b)

Figure 3. Conduit covers
(a) flat cover (type 1) (b) curvy cover (type 2)

2. Materials and Methods

2.1Material

As shown in Figure 3, two types of conduit cover are used to function as walk way as well as parking bumper. Both covers should meet technical specifications, e.g. strong enough to sustain loadings from vehicles passing on it. In addition, the covers should look good and do not endanger pedestrians walking or crossing over it. To achieve the technical specs, we select the newly developed material that is lightweight and strong enough to withstand a static load and impact, i.e. concrete foam (confoam). There are several classes of materials confoam [3]. In this study we choose the type B4 [2] in which the physical and mechanical properties of the material shown in Table 1. The material has been extensively used of some light structures, such as tiles [3] and speed bump [4].

Table1.Confoam mechanical properties

Specimen	Age (day)	Berat (g)	Compressive Strength (MPa)	Tensile strength (MPa)	Modulus Elastisitas (MPa)
B4	28	4.85	5.49	0.025	43.824

2.2. Geometry and Dimensions

Geometry and dimensions of the conduit covers are shown in Figures 4 and 5, respectively.

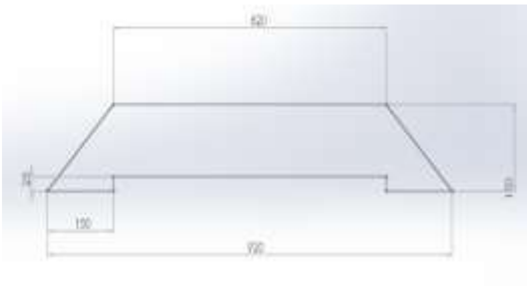


Figure 4. Flat (type 1)

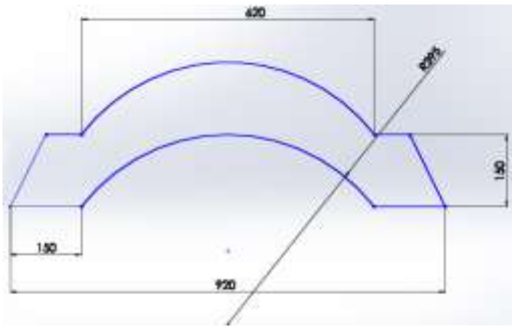


Figure 5. Curvy (type 2)

3. Numerical Simulation

3.1. Load Model

The conduit covers geometry and dimensions were modelled as shown Figure 6 and 7. The model is subjected static load of 3,290 Newton per contact area of 2.000 mm2. The impact load, applied to the parking bumber in lateral direction is focused on the calculation of the stress distribution in the x, y, and priciple direction using commercial FEM software, with a 3-D element.model; we also calculate the principle stress (σ_1). Let us observe the stress contour of the models one-by-one.

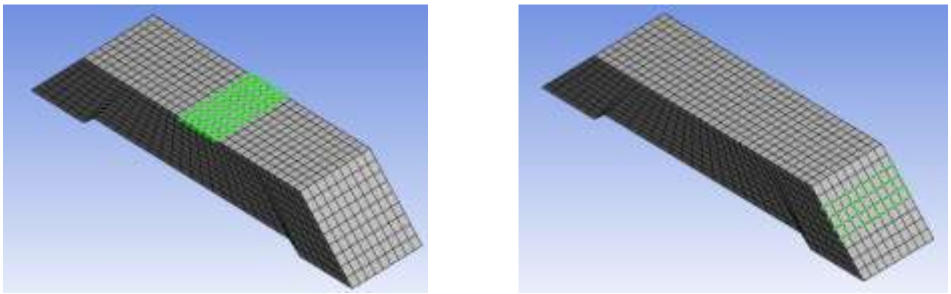


Figure 6. Cover Type 1

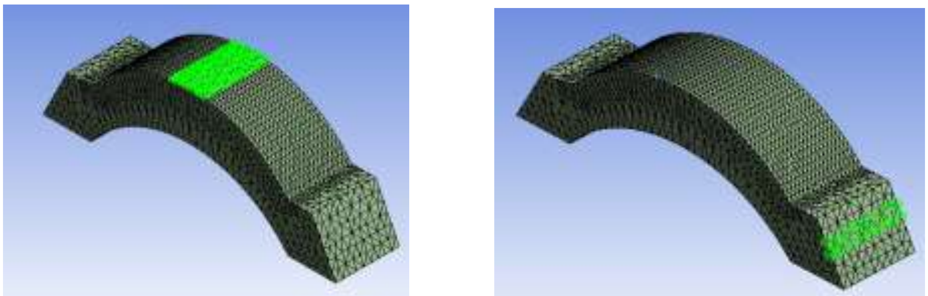


Figure 7. Cover Type 2

3.2. Stress contour

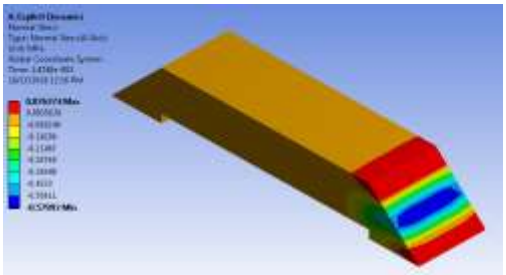
The stress distribution is presented in the x, y, and direction of the principles in the parking bumper models. All calculations are shown in Table 2. As shown, the radial load from vehicles from radial direction still cannot be accepted safely. However the covers are able to withstand impact load from lateral direction. Static and Dynamic side impact for Type 1 and 2 is shown in Figures 8 and 9, respectively. Simulation of static and dynamic in radial direction for type 1 and 2 is shown in Figures 10 and 11, respectively.

Tabel 2. Max stress in x, y, and principle direction (in MPa)

	σ_x	σ_y	σ_1
Dynamic Simulation Type 1 lateral	0.076	0.122	0.180
Static Simulation Type 1 lateral	0.082	0.020	0.118
Dynamic Simulation Type 2 lateral	0.026	0.052	0.251
Static Simulation Type 2 lateral	0.035	0.047	0.100
Dynamic Simulation Type 1 radial	0.121	0.021	0.001
Static Simulation Type 1 radial	5.867	1.872	5.869
Dynamic Simulation Type 2 radial	0.055	0.004	0.057

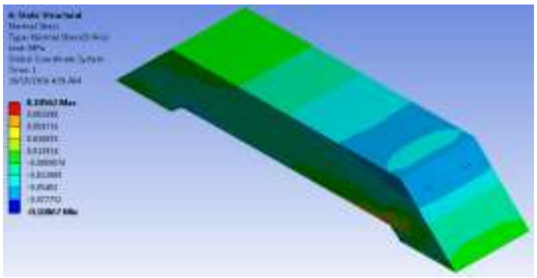
Static Simulation Type 2 radial	3.521	0.388	3.521

Side Impact Type 1 (dynamic)



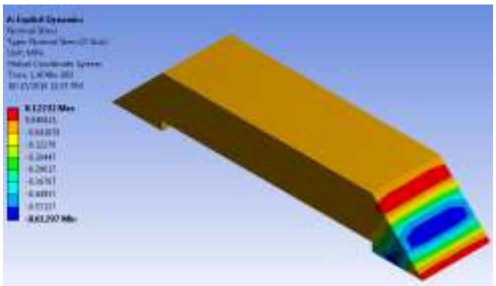
σ_x

Side Impact Type 1 (static)



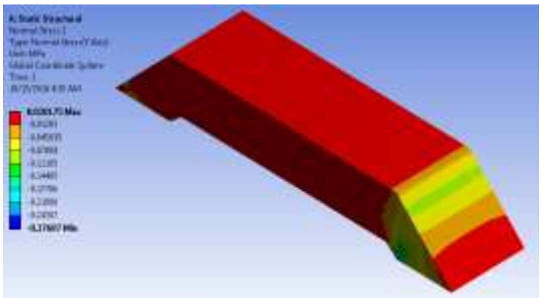
σ_x

Side Impact Type 1 (dynamic)



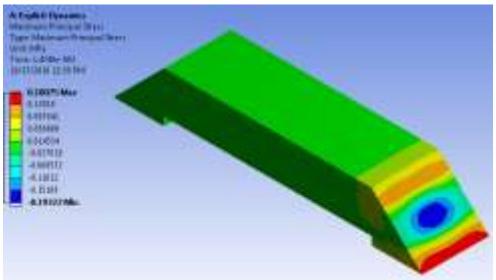
σ_y

Side Impact Type 1 (static)



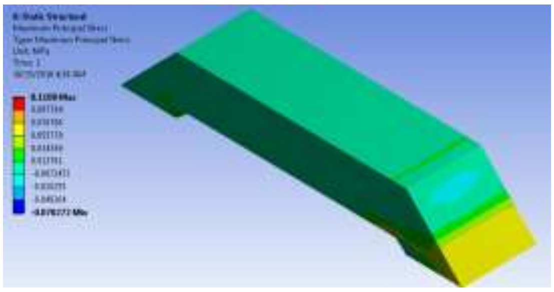
σ_y

Side Impact Type 1 (dynamic)



σ_1

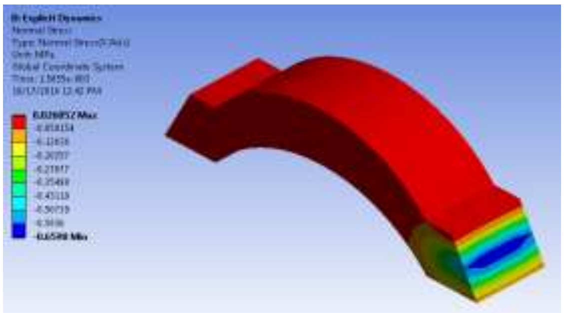
Side Impact Type 1 (static)



σ_1

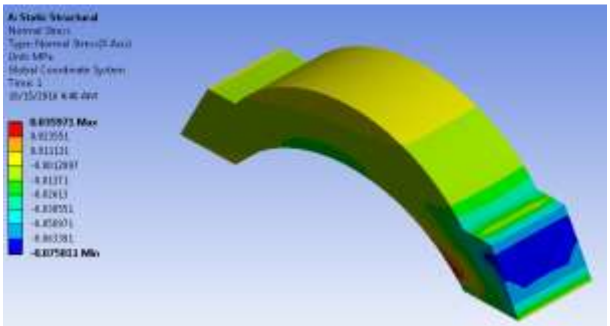
Figure 8. Static and dynamic lateral impact

Side Impact Type 2 (dynamic)



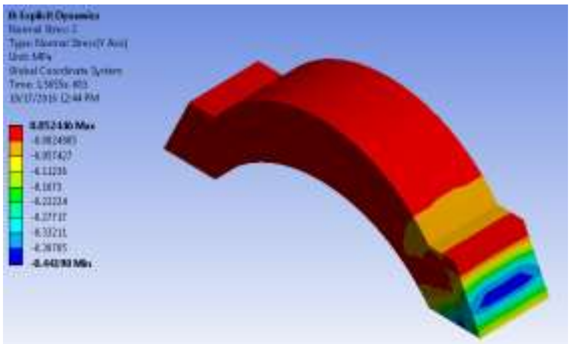
σ_x

Side Impact Type 2 (static)



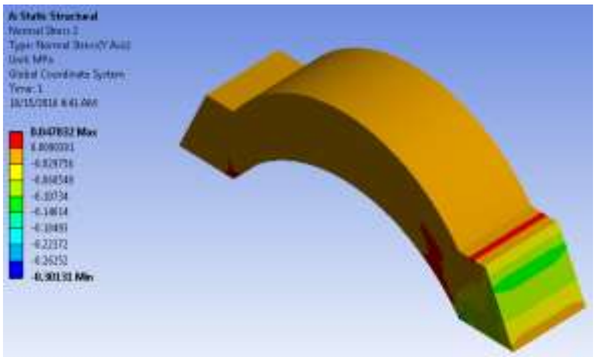
σ_x

Side Impact Type 2 (dynamic)



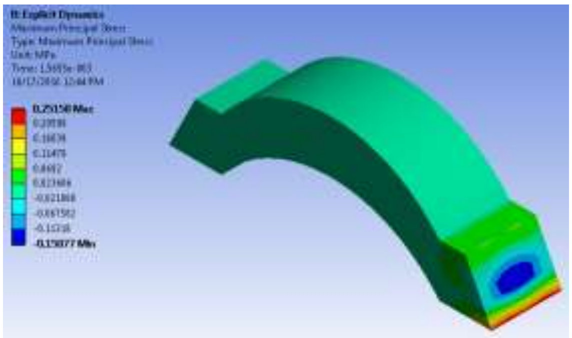
σ_y

Side Impact Type 2 (static)



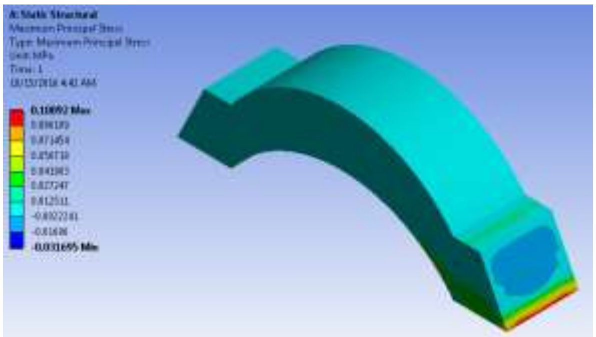
σ_y

Side Impact Type 2 (dynamic)



σ_1

Side Impact Type 2 (static)



σ_1

Figure 9. Static and dynamic lateral impact

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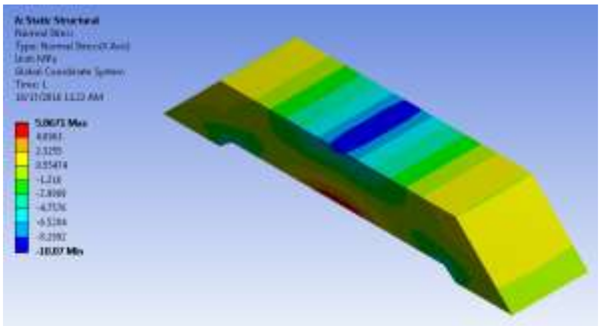
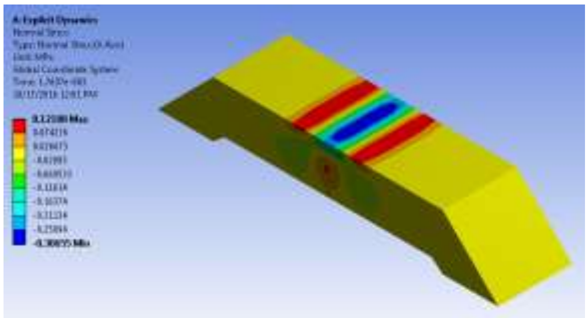
Radial Impact Type 1 (dynamic)



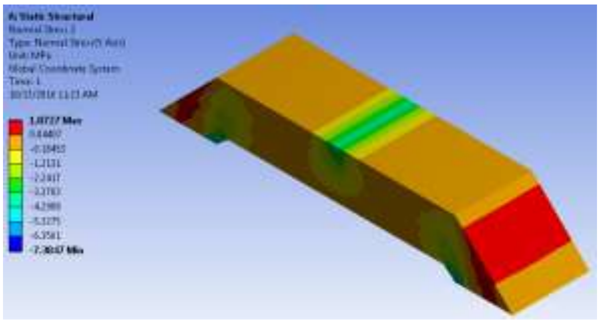
σ_x

Radial Impact Type 1 (static)



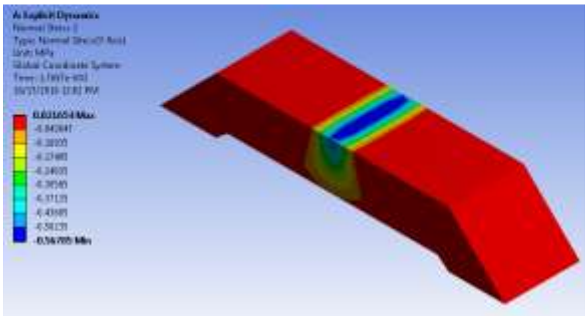
σ_x

Radial Impact Type 1 (dynamic)



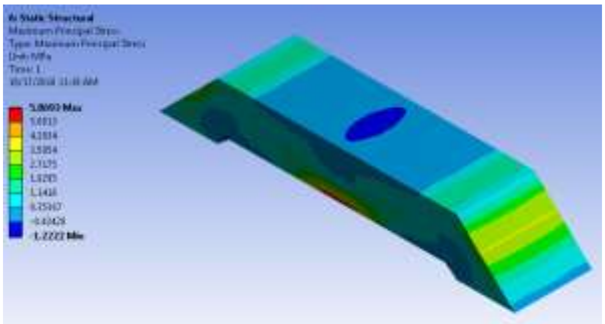
σ_y

Radial Impact Type 1 (static)



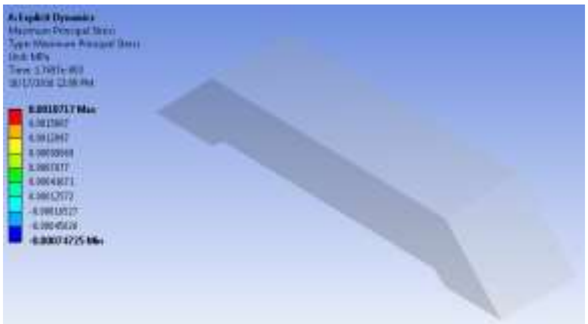
σ_y

Radial Impact Type 1 (dynamic)



σ_1

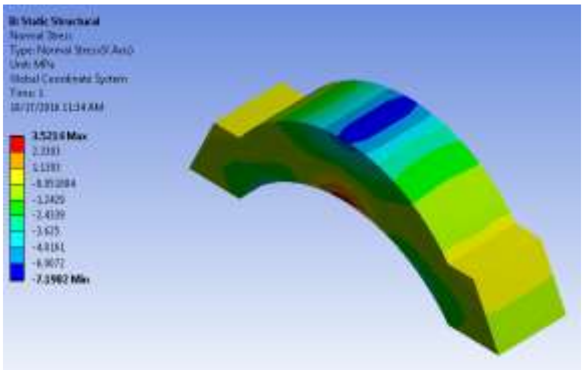
Radial Impact Type 1 (static)



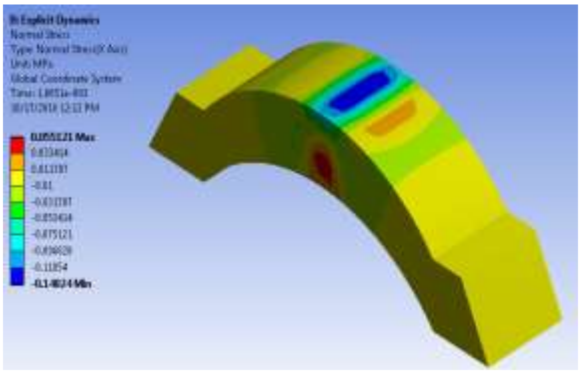
σ_1

Figure 10. Static and dynamic radial impact

Radial Impact Type 2 (static) **Radial Impact Type 2 (dynamic)**

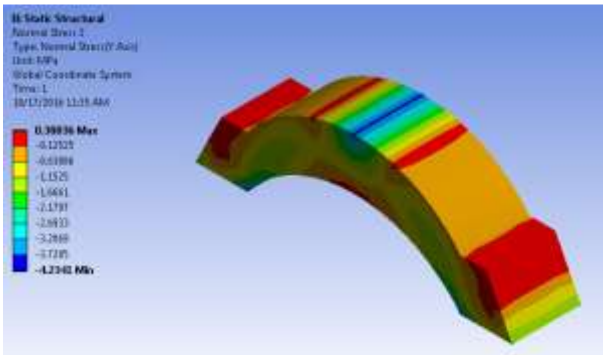


σ_x

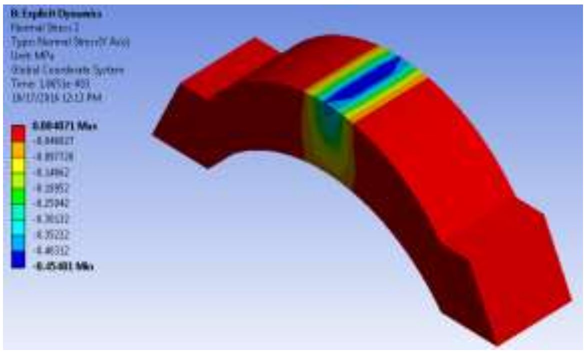


σ_x

Radial Impact Type 2 (static) **Radial Impact Type 2 (dynamic)**

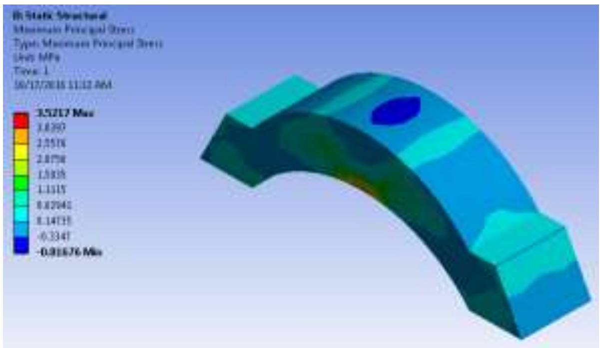


σ_y

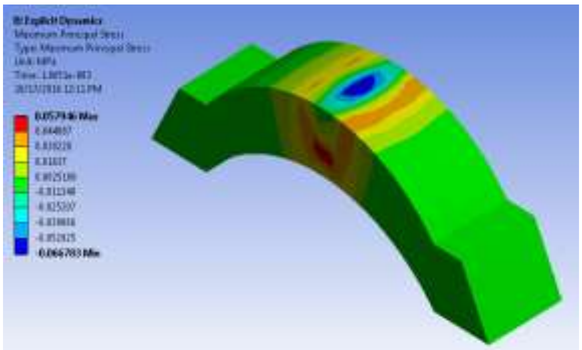


σ_y

Radial Impact Type 2 (static) **Radial Impact Type 2 (dynamic)**



σ_1



σ_1

Figure 11. Static and dynamic radial impact

4. Conclusions

Two models of covers of the open channel conduit have been designed, manufactured, tested, and simulated in our laboratory. A newly developed light weight material so called confoam was used to build the structure. The cover was sought for its structure integrity, i.e. its response when they are subjected to both static and dynamic external loading in radial and lateral directions, respectively. The conclusions that can be drawn are that the two models function well when they are subjected to lateral loading. Thus, the covers may be functioned as parking bumper. However, under radial loading both types failed to withstand the external loading. Here, redesign of the geometry and dimensions as well selecting other types of confoam materials are needed.

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