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A study on the compression strength of blue crab pots

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Crab Pot Frame Simulation

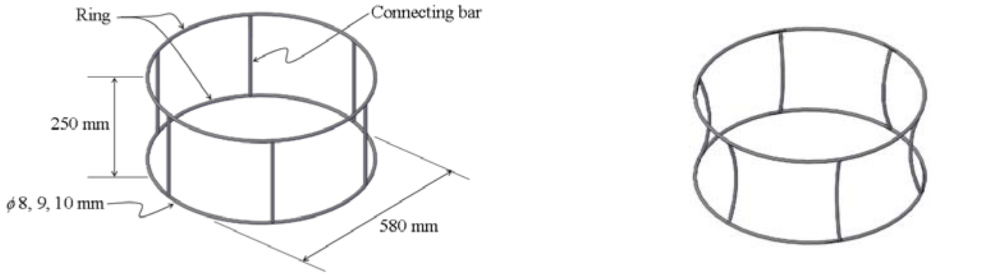
The primary goal of this simulation is to evaluate the response of various crab pots frames under predefined loading conditions. Particularly, major attention is being paid to the value of the maximum force and the deformation (indicated by the total displacement) it can create to the crab pot frame without exceeding the yield strength of the frame material.

The behavior of the crab pots under various conditions is observed through computer-aided simulation using one of the popular commercial finite element analysis software called ANSYS. During the simulation each crab pot frame model is subjected to a predefined loading and support condition. Within the yield or elastic limit of the crab pot frame material the resulting data of interest are gathered. These important data are the maximum applied force, the corresponding total displacement and stress. Based on the collected data the strength of the crab pot is analyzed. The following sections describe the simulation procedure

Materials & Methods

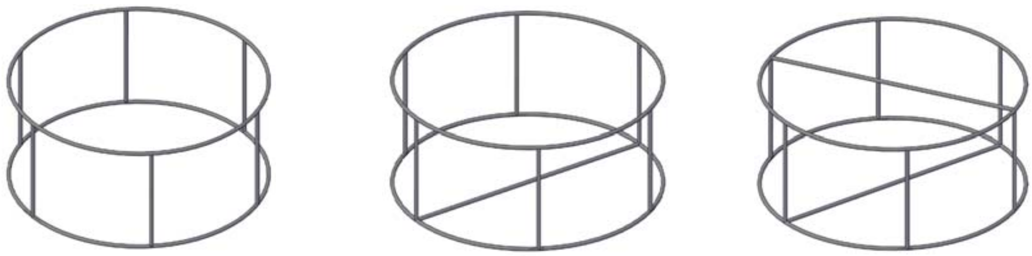
The simulation crab pot frame was constructed using carbon steel (S45C) round bars with Young's modulus of 210 MPa, yield strength of 343 MPa and Poisson's ratio of 0.3. Basically, the crab pot models can be classified into 2 major types with 3 subtypes for each. These 2 major types differ only in the orientation of the bars connecting the two rings i.e. straight and curve. Representative models of the crab pot frame are shown in Fig. 1.

The subtypes are derived by adding 1 and 2 reinforcement bars across the ring diameter as illustrated in Fig. 2. These subtypes are further classified according to loading condition.



(a) Straight-bar connected frame (b) Curved-bar connected frame

Fig. 1. The crab pot frame types.



(a) No reinforcement (RB0) (b) Single reinforcement (RB1) (c) Double reinforcement (RB2)

Fig. 2. Crab pot frame types according to number of reinforcement bars.

Naming convention is developed to systematically identify each model. The names are based on the size (diameter) of the bar, orientation of the connecting reinforcement bars, the degree of curvature for the case of curved-bar connected frame, the number of reinforcement bar across the ring diameter and the applied load condition. Fig. 3 illustrates the naming convention. Occasionally in the following sections, the model type is referred to by their respective labels.

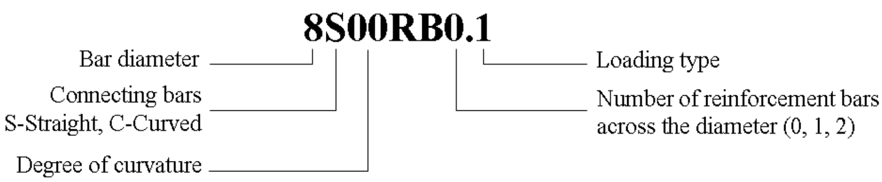


Fig. 3. Naming convention for the crab pot frame types.

ANSYS Simulation

The simulation is carried out to find for at a particular loading condition the maximum allowable force that can be applied to the crab pot frame and the resulting total displacement prior to reaching the yield point. Yield point is the maximum level at which a particular material under certain loading behaves elastically such that beyond this point the material will start to exhibit permanent deformation, ultimately will break or fail if the loading continues and linear analysis does not apply. The simulation is confined within the said limit and as such, static linear analysis is used.

Applied load is gradually increased by 1.0 N (0.1 kg) until the yield point (σ_y =343Mpa) is reached. After a number of test runs a force increase step size of 1 N is chosen as an appropriate value. The choice is based on the observation that it is not that big enough to create appreciable stress on the frame and not too low to slow down the whole simulation process. Accordingly, it was thought that the assumption would not compromise the objective of the simulation.

Strictly, the stopping point is not exactly at the same value of the yield point (limit) but very close to it such that further increase in load will result to a maximum stress value in the crab pot frame equal to or higher than the limit in which case permanent deformation will onset. Once this condition is reached the simulation is stopped and the corresponding total displacement and maximum stress are recorded. Thus the process is iterative as illustrated in Fig. 4.

To accommodate the repetitive nature of the simulation the whole finite element analysis is written in codes using APDL (ANSYS Parametric Design Language). This way the simulation is performed with minimal user-computer interaction.

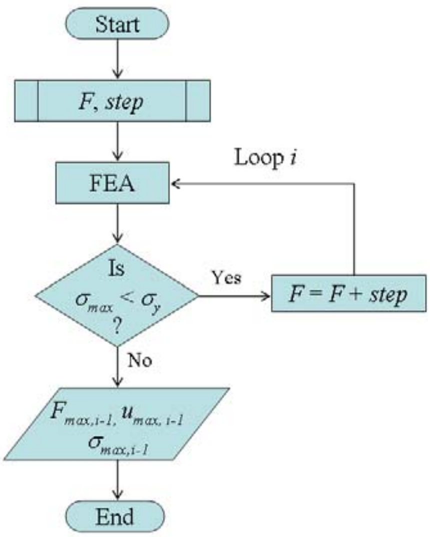


Fig. 4. Procedure for the FEA simulation of the crab pot frame.

Results and Discussion

As pointed out in the previous section, simulation was carried out for each crab pot type and data needed for performance analysis were extracted. The result for ϕ9mm crab pot frame is summarized in Table 1.

Based on the considered loading conditions, the consistent results for ϕ8mm, ϕ9mm and ϕ10mm bar in any case were quite predictable. Consider load case 1. In this case, one can easily see that based on size, the 10mm bar pot frame exhibited large resistance to deformation, thus it required large amount of load to reach the yield point. Accordingly, even for such a large applied load the total structural displacement was small compared to crab pot frames with smaller bars. For bar diameters the same results were obtained for load case 1 and 2 because looking at the configuration of both cases the effect of the reinforcement bar in load case 2 is actually negligible due to the imposed boundary condition i.e. fixed support. Further, for each bar diameter the total displacement was directly proportional to the degree of curvature of the connecting bars even with almost the same amount of applied load. The reason is obvious i.e. the straight connecting bars offered direct support to the applied load and did not easily contribute additional deformation thus the ring absorbed most of the deformation unlike the case of curved connecting bars.

Table 1. Maximum force and displacement for 9S00RB# series

Frame Type	Max. Force(N)	Displacement(mm)	Max. Stress(N/mm^2)
9S00RB0.1	523	2.17	342.84
9S00RB0.2	468	6.16	342.61
9S00RB0.3	466	13.95	342.98
9S00RB0.4	169	85.44	342.71
9S00RB1.1	523	2.17	342.84
9S00RB1.2	468	6.16	342.61
9S00RB1.3	498	12.74	342.98
9S00RB1.4	162	80.89	341.11
9S00RB2.1	532	2.15	342.74
9S00RB2.2	557	5.14	342.75
9S00RB2.3	512	10.11	342.93
9S00RB2.4	177	85.49	341.56

Reference

Kwan Soh Ko and Byeng Guk Kwon, 1987. Improvement of Sea Eel Pots. Bull. Korean Fish. Soc. 20(2), 95~105.