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Summary

'Compliant' structures, *i.e.*, structures that undergo large deformations as part of their normal behaviour, can perform the function of a complex mechanism with just a single, or very few, components. When multistability is introduced into compliant structures, an even greater simplification can be made, with actuators and/or locking mechanisms becoming redundant. Corrugated shells are commonly encountered at all scales of engineering, providing shell structures of a dramatically increased stiffness at little extra cost or weight. What is historically less understood is the *compliant* behaviour of corrugated shells. The topic of this thesis, therefore, is the development and analysis of new categories of structure incorporating corrugations, utilising their compliancy to achieve morphing behaviours that are not otherwise possible. Three distinct categories of shell are studied:

(i) 'flat' corrugated sheets, which are multistable under the action of internal stresses, 'snapping' between their flat state and a cylindrically coiled state: these shells are also capable of developing 'twisted' stable states. An algebraic model based on internal strain energy determines the conditions for the various modes of multistability for uniform changes in curvature throughout the shell, and a plastic flow model describes the formation of the internal stresses;

(ii) 'curved' corrugated sheets, which can morph between shapes of differing Gaussian curvature without plastic deformation. Again, a simplified algebraic model describes their behaviour, as does a numerical model. These models consider the strong coupling that occurs between bending and stretching in corrugated shells; and

(iii) 'doubly-corrugated' sheets, similar to an eggbox in concept, which, again, can morph between shapes of different Gaussian curvature, and also exhibit proclastic bending behaviour. Some of the analyses performed on the curved corrugated sheets are also applied to these shells.

The qualitative behaviour of the analytical models matches, in every detail considered, the behaviour observed in prototypes. Natural-mode analyses on the category (ii) and (iii) shells demonstrate that the interesting behaviour occurs at relatively low stiffnesses, implying that this behaviour is potentially useful.

Quantitatively, however, the analyses for categories (i) and (iii) above do not prove simple to verify. Physical tests compare the internal stresses of the category (i) shells to those predicted by the plastic flow analysis: the predicted stresses exceed those measured by, typically, 50 %, but it is not established whether the discrepancy is due to the simplifications in the model, inaccuracies in the crude test method or a flaw in our understanding. On its prediction of the curvatures created, the model is more successful.

A test is more easily devised for the category (ii) shells, and measurements of the shape-change are within 4 % of both the finite-element simulations and the simplified algebraic models over 90 % of the test range. In measuring forces, to test the constitutive relations produced, the accuracy is lower, largely due to the difference between our material model and the real properties of the polymer used: there is strong agreement between the finite-element model and the algebraic model.

In conclusion, this thesis is successful in generating new varieties of structure, which have a a wide potential for application. A broad range of designs and analyses are presented, describing the behaviour of these structures well enough that our understanding of them seems justified. Nonetheless, this work merely scratches the surface of what may be achieved in this field, demonstrating some of the potential of such shells and leaving much to be done in their further evaluation and development.