year	month	day
2013	08	19

Department	Department of Mechanical and structural system engineering.	ID	D085605
Name	Krishna Kumar Bhetwal		

Supervisor	Nakazawa Shoji

Abstract

Title	Buckling Mechanism and Effects of Initial Imperfection on Hybrid Steel/CFRP Sandwiched Cylindrical Shells.

(800 words)

To serve the common needs of the society, structural engineers should have to achieve impressive gains over high strength, light weighted, safety and economical structures. As rapid advances in the construction materials, in many situations, fibre reinforced polymer (FRP) composites provide opportunities for enhanced efficiency, primarily because of their high strength to weight ratio. They can also be combined with steels to form composites which have enhanced properties, enabling them to be used as structural members and has become an attractive option which may produce a confident retrofitting of steel structures, attracting a great deal of attention in these recent years. Carbon Fibre Reinforced Polymer (CFRP) is a comparatively new and revolutionary class of composite material manufactured from fibres and resins and has proven efficient for the development of new as well as repairing of deteriorated material. The strength properties of CFRPs jointly make up one of the ultimate reasons for which civil engineers prefer them in the design of structures. However, like most structural materials, CFRPs have a few drawbacks that would create some doubts to civil engineers to apply it for wide applications: brittle behaviour, susceptibility to deformation under long-term loads, UV degradation and temperature and moisture effects. Also, another downside to the age of these advanced composites varies fields is the relatively lower stiffness exhibited by CFRPs. As a consequence, serviceability rather than strength limit states tend to provide the controlling influence on design. In the context of thin-walled shell structures, the relatively low stiffness to strength ratio of CFRP makes that buckling driven largely by elastic buckling behavior, becomes the dominant design constraint. At times it becomes difficult to achieve the required levels of load carrying capacity by using shells constructed from just CFRP. For this reason too, the high stiffness of steel contributes to make it an attractive material for the design of shells in which buckling is likely to be an important issue. On the other hand, steel cylindrical shells when exposed to the hostile chemical on marine environments show their vulnerability to corrosion. That`s why, a novel way to protect steel shells from corrosion and to make CFRP shells strengthened is to coat them with these veneers of suitable amount of CFRP. In this context, CFRP, if collectively used with thin steel shells, the mechanical properties of the new composite material will be tremendously increased. Since, the mechanical properties of CFRP make them ideal for widespread applications in construction of civil engineering field; buckling behaviour determines the relationship between strength, life span and economy of any structures. Also, it is necessary to introduce the fibres position, direction and volume in the matrix material at highly stressed regions in certain positions, direction and volume in order to obtain the maximum efficiency from the reinforcement to a minimal amount at a region of low stressed value. For this reason too, buckling mechanism is likely to be an important issue. Although, CFRP composite materials exhibit collapse modes that are significantly different from the collapse modes of metallic materials, so that in this research, the effects of reinforcement on the buckling collapse loads have been made clear using the fully nonlinear numerical experiments as well as linear and RS buckling analysis in the case of CFRP composites. The strengthening of thin-walled metallic shells with the application of small amount of CFRP has been investigated in this research. To lower down the downside of the lower stiffness exhibited by CFRP shells and to diminish the major problem associated with steel shells, a new composite sandwich structure has been introduced in this research and the effect of CFRP reinforcements under axial as well as lateral compression has been studied through three kinds of analytical procedures; the linear eigen value analysis, the modified RS (reduced stiffness) analysis and the fully non-linear numerical experiment, presenting a novel way of strengthening thin-walled steel cylindrical shells against buckling. With these multiple treatments, valuable information for the design of CFRP-based hybrid structural elements has been predicted and suggested the influence of CFRP to increase the load-carrying capacity of the thin-walled metallic structures having complex buckling collapse behaviour. The research thesis comprises of 10 chapters. Firstly, a survey of recent FRP applications, objective of research and preliminary numerical equations has been derived. Secondly, the analytical model has been proposed and the analytical procedure related to the proposed model has been discussed. Thirdly, investigation as well as results has been predicted out for nonlinear buckling behavior, effects of reinforcement thickness and effects of angle of fibre orientation for both the lateral and axial loading conditions. Finally, these results are summarized in the conclusion part along with the suggestions for the better prediction of the result.