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Thermally adaptive building covering field test

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Abstract

This paper represents the first public exhibition of Thermadapt™ building coverings which were invented more than eight years ago. The paper starts with a brief overview of the field of adaptive materials and their applications in various industries. Thermally adaptive building covering sheet fundamentals are explained by laying out the basic structural mechanics of thermally induced gross shape changes in lamina. As a truncated paper, the driving theory, coupon, test chamber and subscale building data could not be included due to length constraints, but will be delivered during oral presentation. Nonetheless, data from outdoor range testing on three independent buildings is presented. These three buildings measuring 1.8m (6ft) deep x 2.4m (8ft) wide x 2.1m (7ft) high showed excellent results. The first was outfitted with Thermadapt™ siding and roofing. The second was outfitted with a variety of different amounts of insulation. The third was used as a control. The configuration of the full-scale test range buildings is shown along with performance data in all midwestern seasons. The data demonstrated that thin thermally adaptive building coverings are as effective as 27cm (10.5") of fiberglass insulation, indicating an equivalent R-value of more than 40/cm (100/in). The paper concludes with an overview of the economics of Thermadapt™ building coverings and the intellectual property landscape.

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1. Introduction and Background

1.1. Historical Building Coverings

Building coverings of many kinds have been used by humans since the first leaves were leaned against stick-shelters erected by prehistoric hominids. Since that time, materials like thatch, reed, cloth, bamboo, clay, slate, copper, aluminium, steel, tin, asphalt, plastic, concrete, sod and others have been used to shield buildings and the

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people therein from the elements. Although quite effective, they have one overarching characteristic in common: Their shapes remain essentially unchanged from season to season, day to night, hot to cold. Outside of the linear expansion and contraction of items like long runs of siding, they are basically fixed as seen in Figure 1.1.

Fig. 1.1 Typical Conventional Building Coverings

1.2. Adaptive Structures

Although the field of man-made "adaptive," "smart," and/or "intelligent" structures may seem new, it is actually quite old and draws its roots to the 1800's when Jacques and Pierre Curie (the fabled Nobel Laureate of 1903), performed experiments on Rochelle salts.[1-3] Similarly, the properties of shape-memory alloys also date to that time.[4,5] In modern times, so many technologists have investigated these "adaptive" structures that books, conferences and journals abound.[6-11] Some adaptive components have been accepted for so long that not only are they in entire fleets of aircraft like the F-14, but that fleet is so old that it is now retired. Many other branches of technology like the Aerospace industry now consider them to be standard actuators for many applications as shown in the collage below showing a small sampling of adaptive aerostructures.[10-13]

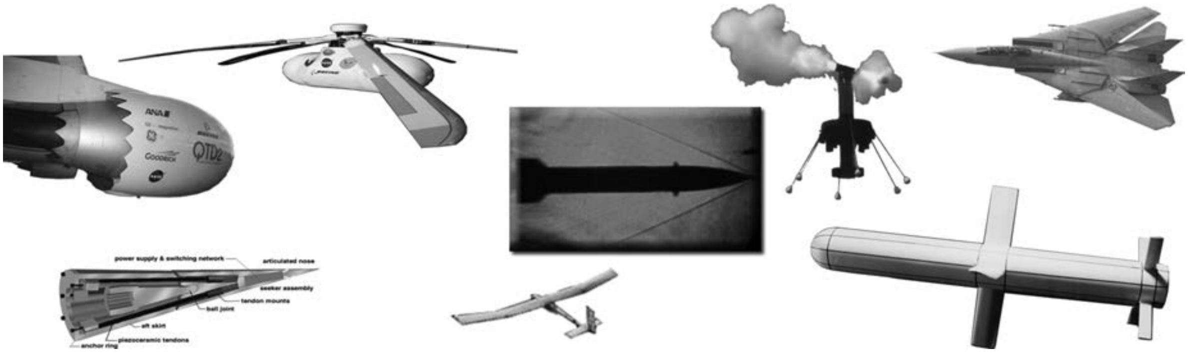

Fig. 1.2 Small Sampling of Aerospace Systems and Aircraft which have used Adaptive Structures in the Past 20 Years [10-13]

Although automotive, aerospace and medical device industries have embraced adaptive and smart structures, the world of civil engineering has yet to see widescale application. This comparatively slow pace of adoption is noted by authors like Del Grosso.[14] Even though Structural Health Monitoring with adaptive materials [15] is a subdiscipline of adaptive structures that is healthy, often involves civil structures and is an active branch of research,